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MAINTENANCE MANAGEMENT PLAN FOR THE KLEIN RIVER ESTUARY MOUTH UNDER SPECIFIC CONDITIONS

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Klein River Estuary

STATEMENT OF THE PROBLEM

In the past decade it has become clear that mean annual runoff (MAR) into the Klein River Estuary has been reduced by an estimated 23% through freshwater abstraction, water impoundment and alien invasive plant infestation in the catchment area (Clark et al. 2015). Dampening of flood peaks and reduced base flows resulted in insufficient scouring of the estuary causing blocking of the mouth by marine sediments. This resulted in more frequent and longer periods of mouth closure which is often the case for temporarily closed estuaries (Clark et al. 2015).

The Klein River Estuary is still able to breach naturally given sufficient rainfall, although this may not occur in extremely dry years or dry periods. Nevertheless, given the reduction in MAR and the changes to sediment dynamics caused by stabilisation of the sand dune barrier, artificial breaching may be necessary in order to maintain the ecological processes of the estuary and its value as a nursery area for fish.

OVERALL OBJECTIVE OF THE LOCAL MOUTH MANAGEMENT PROGRAMME

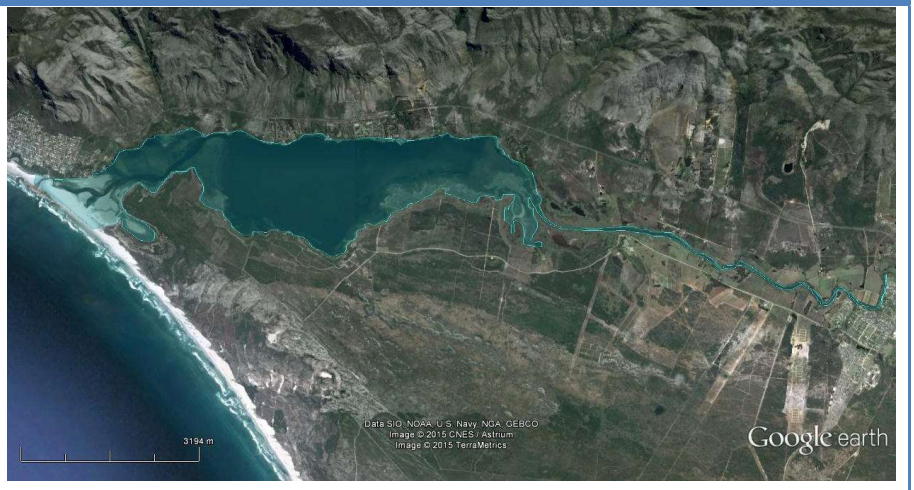
To manage the estuary mouth as an integral part of the Klein River Estuary Management Plan that will maintain the healthy functional ecological processes of the estuary.

For the Klein River Estuary this means that its assessment rating should be consistent with a B Ecological Category defined as “Largely natural with few modifications” under the Department of Water and Sanitation’s (DWS) A to F rating system. (Turpie & Clark 2007; Van Niekerk & Turpie 2012).

DESCRIPTION OF THE KLEIN RIVER ESTUARY

Table 1. Description of the estuary and its importance.

Threat	Discussion
Location	The Klein River Estuary - popularly known as Hermanus Lagoon or Kleinriviersvlei – is situated more or less midway between Cape Point and Cape Agulhas on the south-west coast within the cool temperate biogeographic region of South Africa. The geographical boundaries for the study are defined as follows (Clark et al. 2015: • Downstream boundary: Estuary mouth 34°24'58”S 19°17'35”E • Upstream boundary: 34°25'53"S, 19°27'30"E • Lateral boundaries: 5 m contour above Mean Sea Level (MSL) as depicted by the Estuary Functional Zone below in light blue.

Threat	Discussion
	
Estuary Importance	The Klein River Estuary is a large (1153 ha) estuarine lake system that closes annually from the sea. The estuary was ranked 5th most important in South Africa in terms of its botanical value, fish and bird biodiversity (Turpie & Clark 2007). The estuary is rated as "Highly important" based on its Estuary Importance Score (EIS) of 93. The EIS takes size, the rarity of the estuary type within its biographical zone, habitat, biodiversity and functional importance of the estuary into account.
Conservation status	The Klein River Estuary does not have any statutory protection status at present but is included in the subset of estuaries identified as requiring protection in order to conserve South Africa estuarine biodiversity in the National Estuary Biodiversity Plan (Turpie et al. 2012). The Klein River Estuary also forms part of the core set of estuaries targeted in the Provincial Protected Areas Expansion plan/strategies. The Klein River Estuary supports a designated Bird Sanctuary zone. A Bait Sanctuary Zone is in the process of being proclaimed as part of the EMP zonation process.
Important vegetation	The Klein River Estuary has a large open water channel comprising roughly half of the estuarine functional zone. During open mouth conditions the estuary drains, increasing the available habitat of sand/mud banks and rocky outcrops. Salt marsh is abundant on the southern banks but less so on the steep northern bank. *Salicornia meyeriana* was limited to a small patch south of the estuary mouth. Reeds and sedges, mainly the common reed, *Phragmites australis*, fringed the middle and upper reaches of the estuary where salinity was suitable for establishment. Common reed was also abundant at the Klein river inlet. A number of epiphytic microalgae and submerged macrophyte species also inhabited the estuary. These species are restricted to fringing areas where the water depth did not exceed 1.5 m. At the Klein, 28 species of plants occur in seven different habitats. Two of these species *Cotula filifolia* Thunb. and *Limonium scabrum* (L.f.) Kuntze are endemic to South Africa (National Red Data list - Van Niekerk and Turpie, 2011). De Decker (1989) reported *Cotula myriophylloides* which is classified by the IUCN red list to be 'Critically Endangered' and likely already extinct. The Klein River Estuary may still provide a refuge for these species.
Important fish nursery	Based on their distributional ranges 26 (51%) of the fish species recorded in the Klein River Estuary are southern African endemics including the Botriver klipvis *Clinus spatulatus* which has an extremely limited range being confined to the Klein and Bot estuaries. In terms of the fish importance (outlined in the RDM methodology), the Klein River Estuary has a biodiversity and overall importance score of 95% which places it within the top quintile of all estuaries in South Africa (Taljaard et al. 1999, Turpie et al. 2002). The Klein River Estuary accounts for about 12% of the total estuarine fish nursery area from False Bay to Port Alfred. Its importance lies in its size and its situation in a region of high endemicity within the warm temperate, cool temperate transition zone. The Klein, together with the Bot, account for 25-30% of the available estuarine fish nursery-area from Cape Point to Port Alfred. It is crucial that at least one of these two estuaries is open to the sea during the spring/early summer recruitment window each year. With the exception of some drought years, the Klein usually opened annually under natural conditions. In the past decade, however, drought, wastewater spills and eutrophication have placed the system and its fish under severe stress from hypoxia and high water temperatures, with mass mortalities occurring. The Bot, which has opened

Threat	Discussion
	during this time period, would have provided some level of mitigation by allowing recruitment of juvenile fish and larvae and the export of adult fish to recruit into the marine fisheries. The latter function was probably negated by the high illicit gillnet catches in both the Klein and Bot estuaries. Connectivity between the Klein and Bot is highlighted by the fact that *Clinus spatulatus* only occurs in these two systems and nowhere else. On the other hand, the *G. aestuaria* population in the Bot is probably the most genetically isolated of this species along the entire South African coastline (Norton 2005). This can be at least partly explained by its life-history characteristics but also by the fact that fish recruitment into Walker Bay and its estuaries is limited compared to other bays in South Africa, mostly due to its relative isolation and currents bypassing the bay, deflecting further out to sea. This may also be a factor in the recruitment of estuary-dependent marine species, as it may limit the estuary recruitment window more than elsewhere along this country's coastline. Connectivity between these two estuaries occurs during regional flood events usually coinciding with cut-off-lows when both systems are open and connected via their fluvial plumes (Von der Heyden et al. 2015, Clark et al. 2015).
Important Bird site	A total of 71 waterbird species have been recorded on Klein Estuary. Across all Co-ordinated Water bird Counts (CWAC) counts during the period 2001-2012, there were a total of 60 species recorded in summer and 53 in winter. The overall abundance of birds seems to have decreased from the 1981 survey (9974 birds) until the most recent comparable summer survey (February 2002 – 2007 birds). The composition recorded during the recent summer CWAC surveys was quite different from that recorded in January 1981. In the earlier survey the community had a higher proportion of gulls and terns (89%), mainly due to very high numbers of the migratory Common Tern. The herbivorous waterfowl component of the community was the second most abundant group in 1984 but numbers have been relatively low in recent counts due to higher salinities. During 2001-2012, the avifauna of the Klein River Estuary was dominated by piscivorous gulls and terns (40%) and herbivorous waterfowl (22%) in summer (Clark et al. 2015), with the former group being dominated by the migratory Common Tern. In winter, the bird community was heavily dominated by herbivorous waterfowl (76%). These were mainly Red-knobbed Coot, which was by far the most common bird on the estuary. The numbers of waders are higher in summer due to an influx of migrants. The numbers of omnivorous waterfowl are also higher in summer, when fresh and brackwater areas are scarcer than in winter in this winter rainfall area. In 1981, both waders and herbivorous waterfowl were concentrated at the head of the estuary, whereas other waterfowl and the gulls and terns were closer to the mouth (Clark et al. 2015).
Estuary Condition w.r.t. breaching	The Klein River Estuary is negatively impacted by flow reduction (abstraction / impoundment for irrigation and alien invasive plant infestation in the catchment and riparian areas), artificial breaching at too low water levels, increased nutrient loading (waste water treatment works, septic tanks and agricultural return flow and effluent), sedimentation and illegal gill-netting of fish. The Klein River Estuary has therefore been relegated to the C category in terms of its current estuarine health but allocated a B in terms of the Recommended Ecological Category, or future health class, since it is considered worthy of rehabilitation and a priority for conservation (Clark et al. 2015, Van Niekerk & Turpie 2012). A number of initiatives are in progress to address the pressures on the Klein Estuary, including this Mouth Management Plan.
Recommended Ecological Condition	The Present Ecological State of the Klein River Estuary is a "*C Ecological Category*". The estuary is rated as "*Highly important*", and forms part of the core set of priority estuaries in need of formal protection to achieve biodiversity targets the National Estuary Biodiversity Plan (NBA 2011, Turpie et al. 2012). National biodiversity targets include, for example, the formal protection of 20% of estuarine ecosystem types. Thus the Recommended Ecological Category for the estuary is its "*Best Attainable State*" i.e. a B Ecological Category (Clark et al. 2015).

MOTIVATION FOR ARTIFICIAL BREACHING

Artificial breaching of the Klein River Estuary dates back to at least the 1860s (Coetzee & Pool 1986, cited in De Decker 1989), when nets were set in the lagoon's bays to catch trapped fish. Following a CSIR study (CSIR 1988), a breaching policy was implemented, according to which the mouth was opened when the water level reached +2.1 m MSL.

However, over a century of breachings at low levels result in inadequate scouring of the estuary, causing sediment build-up in the estuary and mouth closure shortly after a breaching. Increased

sedimentation also leads to insufficient flushing of organic material. A decision was therefore taken by the local authority that 1996 would be the final year of artificial breaching. After monitoring the effects of high water levels during mouth breaching in 1996 and 1997 (CSIR reports ENV-SC 97016 and 98031), the CSIR found that no significant damage occurred at the water level of +2.66 m MSL that resulted in natural mouth breaching on 2 July 1997. The motivation to breach in response to pressure from riparian landowners was therefore nullified. The maximum outflow of at least 500 m3/s was 50% higher than that observed in previous years and was estimated to be the same order of magnitude as that during a 1:50 year flood.

From 1997, the management approach aimed at natural breaching of the estuary during winter. Although this was supported in terms of water level, the position of the mouth remained a contentious issue. As managing authority at the time, the then Cape Nature Conservation hosted a specialist workshop at Jonkershoek in May 1999. Its main objective was to determine a future management strategy for the estuary, with the development of a short-term breaching policy - which over the long term should promote and ensure the maintenance of the associated ecosystems and ecological processes - as a secondary objective.

A set of scenario-based draft policy guidelines were formulated at the workshop, on the preliminary assumption that the present catchment runoff had not been drastically changed from its natural MAR. Scenario 1 allowed for natural breaching, Scenario 2 for artificial breaching at the lowest point in the berm only if sustained high water levels posed an unacceptably high risk to property as well as ecological processes, while Scenario 3 allowed for artificial breaching at the lowest point in the berm in the event of water levels above 1.8 m MSL and a closed mouth during early to mid-summer resulting in inundated saltmarshes, algal blooms, fish deaths and unacceptably high bacteriological counts. The workshop did not address breaching details such as the time of day, tidal cycle and depth of trench, and it was agreed that the guidelines should be revised if additional information came to light.

After monitoring the effects of mouth breachings in 1999 and 2000, the CSIR revised their recommendations. These served as the operational guidelines until the workshop in March 2010. Modelling studies conducted on the September 2001 breaching at +2.8 m MSL confirmed that breaching at higher water levels increases the effectiveness of flushing, as the discharge through the mouth increases significantly at higher water levels. Flushing towards the middle or south-east side of the berm was found to be much more effective than towards the north-west side (Beck & Basson 2008).

The Mouth Management Indaba held in 2010 identified three main breaching principles for the Klein Estuary, namely that 1) the estuary should be allowed to open naturally (or unaided) where possible, 2) that if a need for breaching was identified (i.e. flooding of property) then 2.6 m MSL berm height needed to be reached and 3) the breaching option of 1.8 m for water quality problems was not supported. This last breaching principle was especially supported by AbaGold Abalone Farm due to the impact of possible pollution on the Abalone farm. These conditions were accepted by all stakeholders (Klein River Estuary Advisory Forum and other specialists). The specific triggers for artificial breaching and the methodology for implementing the artificial breaching processes was summarised in a Maintenance Management Plan (MaintMP) submitted to the Western Cape Department of Environmental Affairs and Development Planning (DEA&DP) for approval in 2011. The MaintMP was approved for a five-year period. A new application needs to be submitted for the next five-year period.

The findings of the 2011 MaintMP was also affirmed at a public meeting held at Fernkloof Hall on 25 October 2017, under the auspices of the Western Cape Estuary Management Framework and Implementation Strategy project. An additional concern that was raised at this meeting was the importance of the Klein Estuary as a fish nursery and involvement of DFFE in the decision making process that may require ad hoc artificial breaching under emergency conditions.

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

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

Table 2: Summary of artificial breaching motivation

	Potential Threat	Relevance	
Human wellbeing and safety	Threat to human life (as a result of high water levels)	No threats to human life	
	Threat to immoveable property and infrastructure (as a result of high water levels)	Yes, there are a number of low lying properties around the edges of the Klein River Estuary.	
	Human health impact (e.g. flooding of sewage pump station, septic tanks, chemical storage yards, etc.)	No significant health issues. Many of the old houses had septic tanks. A concerted effort by the municipality and stakeholders has resulted in most of these being replaced by sealed units.	
	Potential loss of agricultural resources (as a result of high water levels)	At water levels of 2.6m there is minimal impact on agriculture practices within the estuary functional zone. In most cases properties are used for recreational use as well as grazing stock.	
	Potential impact on nearshore environment if breached (e.g. aquaculture facilities)	The abalone famers in Walker Bay have expressed a concern over the discharge of poor quality water during a breaching as it may affect the quality of the water in the abalone farms. This resulted in the option of breaching to address water quality problems at 1.8m being discarded at the last Mouth Management Indaba.	
	Loss/impaired access (e.g. roads, footpaths, cattle crossings)	Access to properties near Wortelgat becomes limited.	
	Harmful / Noxious algal blooms	During long closed phases algal blooms naturally develop along the banks in the shallow warm water. Some residents find the decaying matter to be offensive. In the past (late 1990s) this had led to pressure to breach on the east side. After breaching plant matter decays relatively quickly (weeks).	
	Impact(s) on recreational use (e.g. increase depth / surface area when mouth is closed, reduce fishing).	Recreational activities such as yachting, wind surfing and swimming are not impacted on by mouth state as the estuary is deep and has a large surface area. Launch sites are impacted on by high water levels. The local municipality is developing alternative management options for these periods. Wind surfing sites need to be moved from Maanskynbaai to the mouth area during high water levels due to lack of available launch sites.	
		Impact of artificial breaching	*Recreational fishing*: Enhanced by open mouth conditions. *Birdwatching*: More estuarine associated species such as waders present in the intertidal areas.
		Impact of NOT breaching	*Recreational fishing*: Catches are lower (number and size of fish) if the mouth has been closed for an extended period. *Birdwatching*: Waterfowl in the middle and upper reaches increase.
Ecosystem requirements	Impact on avifuana abundance, species richness/ community composition	Important bird habitat	Yes, but not as important as the Bot/Kleinmond system for water fowl (Clark et al. 2015).
		Impact of artificial breaching	Water fowl in the upper reaches benefit from closed mouth conditions (Clark et al. 2015).
		Impact of NOT breaching	Mouth closures and related high water levels has negative effect on Waders, gulls and terns as they preferred the sandbanks in lower estuary. The associated higher water levels

	Potential Threat	Relevance	
			and reduction in fish abundance also indirectly impact on the Cormorants, wading piscivores, kingfishers and fish-eagles (Clark et al. 2015).
		Occurrence of avian botulism	No bird deaths reported and assessed to date
	Impact on estuarine fish abundance, species richness/ community composition	Important fish nursery	Artificial breaching may be necessary in order to maintain the ecological functioning of the estuary and its value as a nursery area for fish; this being achieved by ensuring that the mouth is open to allow recruitment and emigration during the peak recruitment period during spring – early summer (August –November)
		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. Negative aspects are a temporary reduction in water volume and littoral habitat and limited mortality of resident benthic species through stranding in algal and macrophyte beds. Aggregations of fish at the mouth just prior to and during breaching are particularly vulnerable to exploitation especially by illegal methods such as gaffing and snagging with treble-hooks. (Draft legislation (in terms of the Marine Living Resources Act) has existed for the past decade that prohibits fishing of any kind in a temporarily open closed (TOC) estuary the two days before, during and one day after a breaching event whether artificial or natural)
		Impact of NOT breaching	Significant nursery area (>10%) not available to juvenile fish on the Cape south coast and eventual drop in recruitment or available biomass of exploited species to marine fisheries.
		Occurrence of fish kills	Fish kills have been recoded a number of times in this system in the recent decade. Fish kills arising from hypo / hypersalinity and / or estuarine harmful algal blooms (HABs) (e.g. *Microcystis*, golden algae *Prymnesium parvum*) may be mitigated by open mouth conditions. Fish may also escape hypoxia, ammonia toxicity etc. arising from poor WWT in the estuary and catchment. Seawater, at 35 practical salinity units (psu), will also treat pathogens such as the water mould Epizootic Ulcerative Syndrome (EUS) now prevalent in many estuaries and catchments. Nevertheless, ill-timed or inadequate breaching at low water levels and with little water movement may compromise already-stressed fishes' immunity to pathogens and exacerbate fatalities.
	Impact on estuarine invertebrate abundance, species richness/ community composition	Impact of artificial breaching	Open mouth linked to increased salinity values and opportunity for euryhaline species to increase in biomass and abundance if salinity increases from a low base (<10 psu). An open mouth is also important for the input of larvae into the estuary from the marine environment for recruitment and *vice versa*.

	Potential Threat	Relevance	
		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 Klein River Estuary which are adapted to life in a tidal system.
		Occurrence of invertebrate kills	No information available on the Klein River Estuary but invertebrate mortalities have occurred in the Breede (sandprawn *Callichirus kraussi*) ammonia toxicity and hypoxia impact benthic invertebrates and the osmotic stress arising from abrupt changes in salinity may help control pathogens and parasites.
	Estuarine Macrophytes (plants)	Impact of artificial breaching	Open mouth conditions create intertidal habitat for salt marsh and reeds and sedges. Fluctuating water levels would decrease submerged macrophyte biomass and extent. Strong tidal flows could limit the establishment of submerged macrophytes in lower reaches.
		Impact of NOT breaching (i.e. die back of saltmarsh)	Die-back of salt marsh and reeds and sedges due to inundation and high water level (>1.6 m MSL). Submerged macrophytes expand but restricted to shallower areas. Anthropogenic nutrient inputs presently encourage macroalgal growth.
	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.
		Dissolve Oxygen levels	< 4 mg/l
		Ammonia levels	Not applicable.
		Toxic substance in the context of breaching	Not applicable.
		Pollution sources include sewage pump stations that may fail during summer, and septic tanks that leak. An action plan has been developed to address these sources and is implemented by the municipality and reported on at each estuary forum meeting.	
	Eutrophication	Excessive reed growth	N/A
		Macrophyte blooms	N/A
		Harmful algal blooms	Microalgal blooms including potentially toxic blue green species have been recorded at the Klein River Estuary.
	Sedimentation	On-going sedimentation	No large scale bathymetric surveys have been carried out in the estuary. The stabilisation of the dune system in the berm area needs to be addressed in order to continue to facilitate the natural opening of the estuary mouth – stabilised dunes will result in the berm height reaching in excess of 3 m MSL for instance.
	Type	**Yes/No**	**Motivation**
	Major flood events associated with severe flood damage	Yes	Only an emergency if estuary water level is high and a severe flood is eminent (i.e. cut-off low/1:20 year flood). However, artificial breaching will not be considered to prevent water inundation of low-lying private or public properties

Potential Threat		Relevance	
	Poor water quality	Yes	Low oxygen levels throughout the system may be considered an emergency (must be verified through regular monitoring and estuarine specialist consultation) Salinity levels are not a consideration because the system is characteristically saline. Artificial breaching will not be considered to flush polluted water out of the estuary as it will pollute the nearshore and pose a significant threat to the abalone and other marine aquaculture facilities in Walker Bay (abalone farms instituted their own independent water quality monitoring of the Klein River outflow).
	Fish kills	Yes	DFFE to determine cause of fish kill and then establish if major fish kill can be remedied by breaching. Written findings to be provided to the breaching committee.
	Hazardous spill	Yes	Breaching will only be considered if the 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 Klein River Estuary can temporarily be closed to prevent oil from entering the system. Spillage of organic waste should be addressed using standard biological control measures.

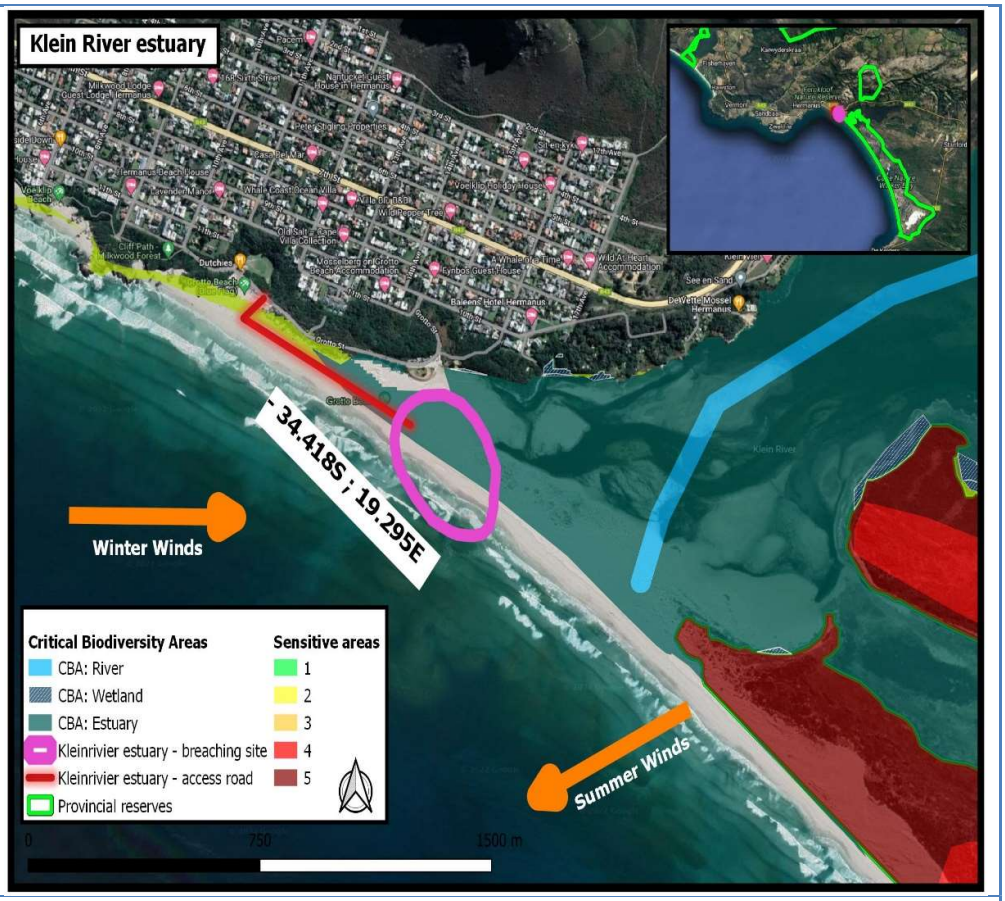
INTEGRATED ASSESSMENT

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

Table 3: Klein River Estuary Breaching Specifications

Breaching considerations	Details		
Minimum breaching level (water level should be as high as possible before breaching)	>2.6 m msl	Y/N	Level to MSL
	Natural breaching at water levels of 2.9 m to 3.1 m above MSL is preferred with no or minimal interference. Breaches at this level result in the most effective scouring of silt build-up. It is recommended that the Overstrand Municipality's department of Environmental Management cooperate with Cape Nature to patrol the berm when water levels are high and the public may attempt unauthorized breaching to ensure that this does not occur. The risk of this is high when the water level is about 30 cm below the berm height. In the absence of 'emergency' conditions (defined below), artificial breaching must not be contemplated at water levels below 2.6 m MSL. Higher levels are preferred. This requirement (i.e. breaching above 2.6m msl) may result in the Klein Estuary not breaching during extreme drought periods when the system naturally would not have reached breaching levels. If the mouth remains closed for extended periods under the above conditions, e.g. 3 to 4 years, artificial breaching should be considered under optimal existing conditions and to coincide with the breaching of the Bot Estuary.		

Optimum breaching period (if applicable)	The Klein River Estuary naturally breached annually, with most breachings occurring in late winter or spring (June to September). Therefore, artificial breach is a consideration if annual breaching is prevented from occurring due to flow reduction. The later the breaching in the season, the better, as the incidence of high sea storms reduce from winter to summer, assisting in maintaining open conditions. As flow reduction may delay, or prevent, natural breaching, artificial breaching should preferably be considered between 1 August and 30 November if natural breaching levels are not attained. The concern is that breaching much later in the year will impact negatively on the ecology, e.g. will not coincide with peak fish recruitment periods or flowering of saltmashes. However, for practical reasons the breaching date may be shifted in consultation with the relevant authorities to accommodate the availability of human resources and earth moving equipment, weather forecast and human safety. Consideration should also be given to the mouth state of the Bot system as evolutionary/genetic processes require that both systems be open once or twice a decade.
Neap-spring breaching considerations	Preferably 3-4 days before spring tide, but priority should be given to wave conditions and water levels. Local observations are required on the degree to which waves will hinder during the planned breaching. The higher the berm, the more the system is buffered against the effects of high waves from the ocean. A calm period of 1 to 2 days is preferred. Higher water levels generate greater outflow so this recommendation can be over ruled to prevent significant seepage and evaporation losses as a result of its large surface area (Clark et al. 2015).
Timing of breaching	Breach 2 hrs 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	Breaching at the Klein River Estuary holds a risk to public safety, e.g. surfers wanting to body surf standing waves, children and dogs falling in the outflow channel. It is therefore recommended that breaching takes place in the late afternoon so that maximum outflow (and associated standing waves) occur during the night. If not possible, 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. Temporarily close the designated area in circumstances that could pose a danger to the human life or property. This must be accompanied by appropriate signage.
Breaching trench to maximize outflow	Excavate a 2m deep and 4m wide trench before breaching to maximize outflow. Consideration may be given to digging a pre-breaching trench on the inside of the berm during April / May when the water is low to increase the scouring effect. (Note that opinion remains divided on whether this will make a significant difference at the Klein as the berm is relatively low during winter and the trench likely to fill up)
Location of the breaching position.	At the lowest position of the berm, opposite the previous year's channel (these mostly coincide) to assist with the efficient removal of sediment during the breaching However, allow enough space for separate ebb and flood tidal channels to develop. Breaching too far to the sides often result in a single confined channel for both the ebb and the flood tidal flows. If possible, artificial breaching should line up with historical channels to assist with the removal of sediment during the breaching. Significant scouring potential is lost if the system has to cut new channels in the lower reaches during a breaching. This consideration may require the alignment of the breaching channel with an older historical channel configuration. Lastly, care should be taken with the breaching location to ensure that the channels do not become unnecessarily long resulting in increased bottom friction, reduction in tidal flushing and premature closure.

Propose area of breaching position	
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 on route to the excavation site. Bird nesting areas are to be avoided. Where possible existing access roads / tracks should be used. 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 The municipality 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. 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 licence and the applicant shall take measures necessary to bind such persons to these requirements.
Noise & light pollution	Noise on this site 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: Annual breaching per natural conditions
	Fish: Annual breaching per natural conditions. Not later than 31 October. Two days before the breaching, responsible authority will issue notices and erect signs placing a moratorium on fishing until after the breaching and the risk to fish aggregations has subsided.
	Invertebrates: Annual breaching per natural conditions
	Plants: Annual breaching per natural conditions. Maintain the highest possible water levels to control reed growth in upper reaches (Stanford riverine section). Annual opening of mouth increase salinity and control some of the reed growth in the lower and middle reaches.

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 DFFE in terms of the need for ecosystem maintenance.

RELEVANT AUTHORITIES

Table 4 lists the Key lead authorities involved in artificial breaching at the Klein River Estuary.

Table 4: Key lead authority involved in artificial breaching

Management authority	CapeNature	
Advisory Committee	Klein River Estuary Advisory Forum (KREF)	
Authorisation (breaching / emergency)	DFFE	
Lead authority	**Breaching sub-committee**	**Minimum consultation In case of Emergency**
Overstrand Municipality (Environment Management and Disaster Management sections)	✓	✓
District Municipality (Environment Management and Disaster Management sections)	✓	✓
DEA&DP	✓	✓
Department of Forestry Fisheries and Environment Affairs	✓	✗
Department of Agriculture	✓	✓
Department of Water and Sanitation	✗	✗
CapeNature	✓	✓
SANParks	✗	✗
Research organisation (e.g. CSIR)	✓	✗
Non-Governmental Organisations	✓	✗

The decision to artificially breach will be made by a Breaching sub-committee comprising the Overstrand Municipality's Environmental Manager, KREF Chairperson and the Cape Nature Marine and Coasts Operation Manager and Landscape Manager following consultation with at least two members of a team of estuarine ecological specialists (e.g. from the CSIR and DFFE: Inshore Fisheries Research and DFFE: Estuaries Management). These lead authorities are important role players with respect to emergency situations and administer their relevant empowering provisions (Disaster Management Act 2002, NEMA 1998, and the Integrated Coastal Management Act 2008).

Data on water level, berm height, salinity, as well as water quality parameters where feasible, will be collated by the Overstrand Municipality in conjunction with CapeNature and the specialist team.

Once the Breaching sub-committee has decided that an artificial breach must occur, CapeNature, in conjunction with the Disaster Risk Management unit of the Overstrand Municipality, shall 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

CapeNature is responsible for the operational aspects of the Klein River Estuary MMP. They can delegate this function, but ultimately they have oversight over the functioning of the Breaching Sub-committee. It is therefore recommended that the Breaching Sub-committee be established as a formal structure under the Municipal Coastal Committee. CapeNature (or its delegated structure) is required to co-ordinate the Breaching Sub-committee, which includes:

- Convening Breaching Sub-committee meetings (when listed specifications are triggered or in expected to be triggered in the near future due to inclement weather);
- Recording the minutes of the Breaching Sub-committee meetings;
- Distributing relevant information to the Breaching Sub-committee members; and
- Sharing the post-breaching incident report of the Breaching Sub-committee;
- Sharing process followed with Estuary Advisory Forum (if time permits).

CapeNature is also responsible for continuous monitoring of the conditions in the catchment when water levels become elevated (>1.5 m MSL). Communication between the different role players, i.e. the local municipality, CapeNature and key authorities (stipulated in Section 4), should take place at a regular basis. This can be done at estuary advisory committee/forum meetings or as email communications summarising critical aspects. The day-to-day monitoring should include the following aspects:

- 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;
- Water quality conditions (if applicable); and

- Biotic responses to elevated water levels (e.g. fish aggregations at mouth, formation of algal blooms, die-back of macrophytes, bird nesting behaviour).

Once the breaching criteria (see Section 5) is met, the decision to artificially breach will be made by the Breaching Sub-committee (See Section 4 for list) comprising, at a minimum, CapeNature Marine and Coasts Operations, the KREF Chairperson and the Overstrand Municipality's Environmental Manager, in consultation with at least two ecological specialists (e.g. CSIR, DFFE: Inshore Fisheries Research and DFFE: Estuaries Management, Nelson Mandela University). Note, that while the Breaching Sub-committee is tasked with executing the approved MaintMP, it should be recognized that an estuary mouth is highly dynamic and unforeseen events may require special management actions. In such an event, additional verbal (followed by written) authorisation may be required from the authorising authority (i.e. DFFE) which needs to be supported by specialist comment and suggestions.). A flow chart for a planned mouth breaching procedures to be followed by the breaching committee is included in Figure 2.

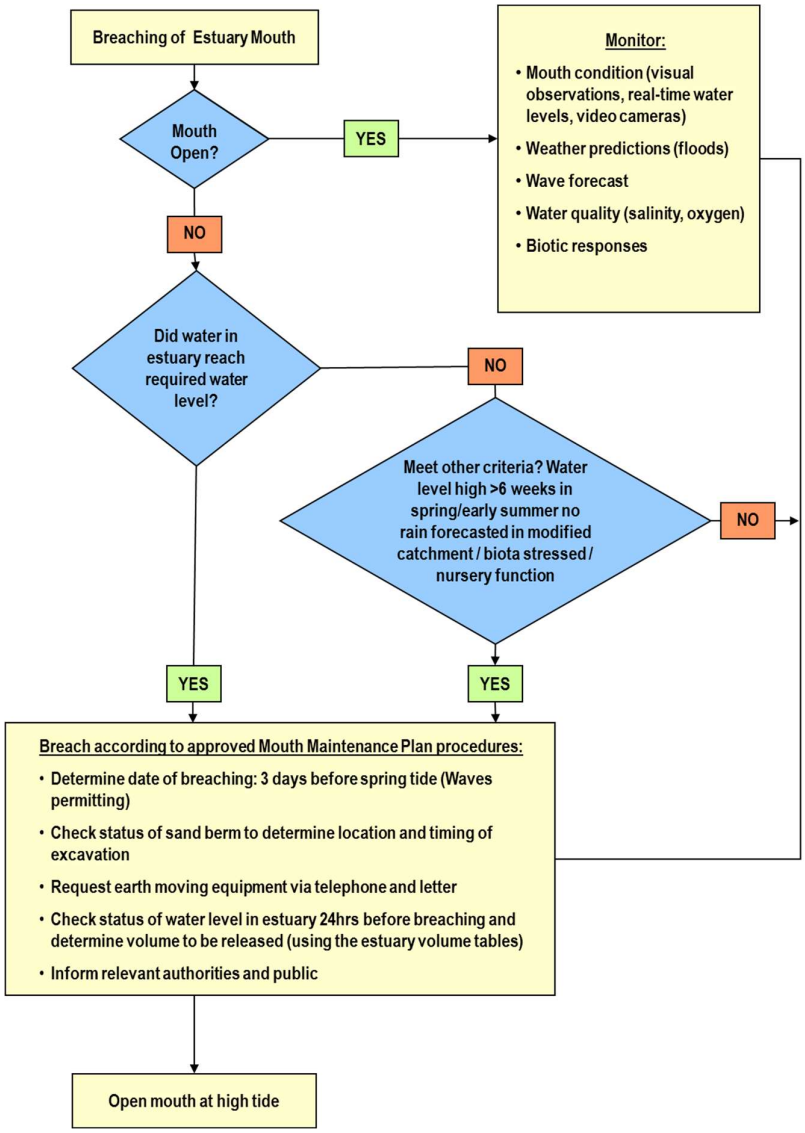


Figure 1: A flow chart illustrating the breaching plan for normal conditions

Once the Breaching Sub-committee has established that the relevant criteria have been met and that artificial breach must occur, CapeNature shall, in conjunction with Disaster Management Department of the Overstrand Municipality, be responsible for overseeing the breaching activities.

CapeNature in association with Disaster Management Department of the Overstrand Municipality is responsible for the following:

- Ensuring the availability of Earth moving equipment on day of breaching;
- Establishing the exact location and time of the breaching channel;
- Verifying that the sandberm 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 warm public of risk to safety; and
- Breaching of the estuary mouth (it should be noted that the excavations may take several hours).

Finally, CapeNature is responsible for the compilation of a Breaching Incident Report to be provided to DFFE within 14 days of the actual breaching (see Section 8 for more detail on the report).

Emergency

A flow chart for the undertaking of mouth breachings under emergency conditions is included in Figure 2. Breachings should be undertaken in the swiftest manner possible and in most cases the Disaster Management Department of the local municipality is responsible. While breaching should be conducted according to an approved Estuary Mouth Maintenance Plan, some of the general breaching principles may be waivered under emergency conditions to ensure an expedient breaching.

Emergency conditions could develop when an estuary mouth is closed/constricted for extended periods of time 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 a dam wall. 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, CapeNature 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 breachings relate to floods Section 3 lists some additional events that can constitute an emergency at the Klein Estuary.

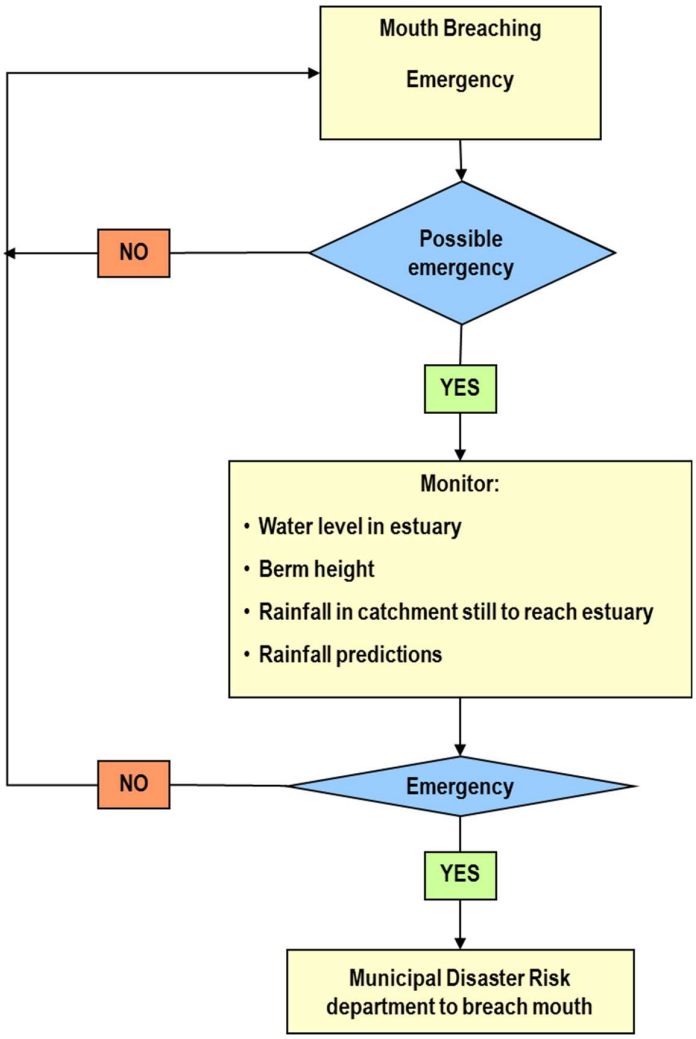


Figure 2: A flow chart illustrating the breaching plan for emergency conditions

MONITORING PROGRAMME

The following monitoring programme supports the responsible management of artificial breaching (Table 1):

Table 1: Monitoring programme for Klein Estuary

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 / Topography surveys	Every 3 years	Yes	CapeNature

Salinity (quarterly)	Monthly (and day before and after, and 5 to 10 days after a breaching)	Yes	CapeNature
In situ 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 behaviour (e.g. invertebrate kills)	Quarterly (and just before breaching)	Yes	CapeNature
Fish surveys Distribution, abundance, movement and behaviour (e.g. recruitment, aggregations, fish kills)	Bi-annually	Yes	DFFE
CWAC	Bi-annually	Yes	CapeNature

REPORTING

Following an estuary mouth opening a Breaching Incidence Report needs to be compiled and provided to DFFE within 2 weeks of breaching. This report should contain as much as possible information on the breaching motivation and the process followed during the breaching.

In addition to the Breaching Incidence Report, the Managing authority needs to compile an Annual Mouth 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 2 below summarises the minimum content of a Klein River Estuary Breaching Report. The initial Breaching (incidence) report should be complied within two weeks of breaching, with data gaps (e.g. duration open) addressed after mouth closure.

Table 2: Content of Klein River Estuary breaching report

ACTIONS	LOCAL REQUIREMENT - YES/NO	AGENCY RESPONSIBLE
Met-ocean information • State of the tide (spring-neap/ high-low tide) • Sea conditions (calm/stormy)	Yes	CapeNature
Breaching specifications that triggered the event: • Indicate which of section 5 specification necessitate the breaching (include supporting specialist communications where need be)	Yes	CapeNature

ACTIONS	LOCAL REQUIREMENT - YES/NO	AGENCY RESPONSIBLE
Estuary Information • 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) • 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 lying properties. Distinguish between short-term and long-term measures. • Date since last breaching	Yes	DWS, CapeNature & Overstrand Municipality
Location of channel • Align with historical position of channels (photographs and GPS location) • Reduce channel length	Yes	CapeNature
Period for which the mouth stayed open (not required in initial incident report if mouth remain open)	Yes	CapeNature
Bathymetric surveys	Yes	CapeNature
Salinity measurement before and after breaching	Yes	DWS and CapeNature
Observations on macrophyte conditions	No	
Fish recruitment survey	Yes, in summer after breaching	DFFE
Avifuana counts (CWAC)	Yes	CapeNature
Other		
Assessment record compiled by: Name: Organization: Date: Contact details:		

Feedback on breaching activities

Table 3 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 3: Minimum information required on breaching feedback sessions

ACTIONS	LOCAL REQUIREMENT - YES/NO
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 of presentations)	

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