# Aquatic specialist inputs to proposed erosion control measures for road OP06914 on Swartvlei Lake, Sedgefield.

**Prepared by: Dr. Jackie Dabrowski of Confluent Environmental (Pty) Ltd**

**For: Garden Route District Municipality**

**April 2021, updated June 2021**

confluent
aquatic consulting & research

**Tel: +27 83 256 3159**

**Email: jackie@confluent.co.za**

**DECLARATION OF CONSULTANTS INDEPENDANCE**

This report was compiled by Jacqueline (Jackie) Dabrowski, the Director of Confluent Environmental (Pty) Ltd. Jackie holds a Ph.D. in Veterinary Science and her post-graduate studies were in the field of freshwater ecology. She has conducted research and published scientific articles on a range of topics including aquatic food webs, fish health, and trends in water quality, branchiopod diversity, and land-use impacts on water quality. Her consulting work has focussed on a range of environmental assessments of dams, rivers, estuaries, ephemeral watercourses and wetlands at various locations in South Africa.

At the time of conducting this study, I declare that:

- I am an independent specialist consulting in the field of Aquatic Science;
- I do not have any financial interest in the undertaking of the activity, apart from remuneration for work performed in terms of the Environmental Impact Assessment Regulations, 2014;
- I do not have any vested interest in the proposed activity proceeding;
- I will not engage in any conflicting interests in the undertakings of the activity;
- I undertake to disclose to the competent authority any relevant information with the potential to influence the decision of the competent authority or the objectivity of the report; and,
- I will provide the competent authority with access to all information at my disposal regarding the application, whether this information is favourable to the applicant or not.

Jackie Dabrowski (Ph.D., Pr.Sci.Nat. *Aquatic Science*)
SACNASP Registration Number 115166

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# 1. INTRODUCTION

## 1.1 Project Background

Confluent Environmental were appointed by the Garden Route District Municipality (GRDM) to provide an aquatic specialist assessment of erosion control measures proposed along road OP06914. The road is located along the eastern shoreline of Swartvlei Lake in the Garden Route National Park near the town of Sedgefield, providing access from the N2 highway to residents and Outward Bound (Figure 1). Erosion control is proposed for sections of the road between km1.5 and km 2.1. When the Swartvlei Estuary mouth is closed (such as at the time of writing) the water level is close to the surface of the road which exacerbates erosion.


Figure 1. Map depicting the layout of the area and the eroded section of road OP06914.

Erosion at the site was previously controlled by packing sandbags adjacent to the road edge. During the site visit broken bags were observed and they were not providing any level of protection from wave action. The eroding road edge has resulted in the road narrowing, and in some places, vehicles need to travel dangerously close to the eroded edge.

When the estuary mouth is open and water levels reduce, erosion of the road is presumably reduced by the receding water level. In that respect, erosion of the road is a periodic occurrence linked to elevated water levels in the estuary.

## 1.2 Proposed stabilisation method

Two methods of stabilisation have been proposed by the GRDM. These are explained in the section below. Option 1 was proposed before consultation with SANParks about what interventions they would support, and Option 2 was proposed following discussions with SANParks and more extensive erosion occurred along the road towards the end of May 2021, at which point the road had to be closed (Figure 12).

*Option 1*

The GRDM have proposed to place riprap along eroded areas and other areas of high risk to erosion (Figure 2). The specific locations were not identified but would be located between km 1.5 and km 2.1 measured from the turnoff from the N2 highway. This would involve the placement of sloping rock along the road edge into the water and is considered a hard technique.

Figure 2. Example of riprap proposed by the GRDM (image supplied by GRDM).

*Option 2: Short-term intervention*

This option would involve the placement of sandbags constructed of biodegradable material. A combination of large and small sandbags is proposed for use at various points, depending on the degree of erosion and the amount of support required for rebuilding the road where it has disintegrated. Large sandbags would measure at least 1 m x 0.4 m x 0.25 m. Sand to fill the sandbags will be obtained from windblown beach sand that needs to be removed from road 6817 in Groot Brak (Figure 3) and from the carpark in Sedgefield, both of which are manged and maintained by the GRDM.

Figure 3. Photo of beach sand on the road 6817 in Groot Brak that needs to be removed.

Sandbags will be stacked in staggered layers adjacent to the shoreline. The road will be infilled and compacted to its previous footprint behind the supporting sandbags. This option is considered a short-term option aimed at re-opening the road for users as quickly as possible. However, given that the sandbags are biodegradable, a longer-term solution will need to be implemented 12-18 months following placement of the sandbags.

*Option 2: Long-term intervention*

The long-term recommendation is to install a retaining wall constructed of gabions for steeper, more vertical edges of the road to support the road material. This would be interplanted with vegetation to create a more natural and aesthetically pleasing look. This intervention would not be needed along the full length of the road, just where the road material needs support. This would be in the vicinity of Kms 1.4 and 1.78 (Figure 11). A similar concept to that depicted in Figure 4 would be followed.

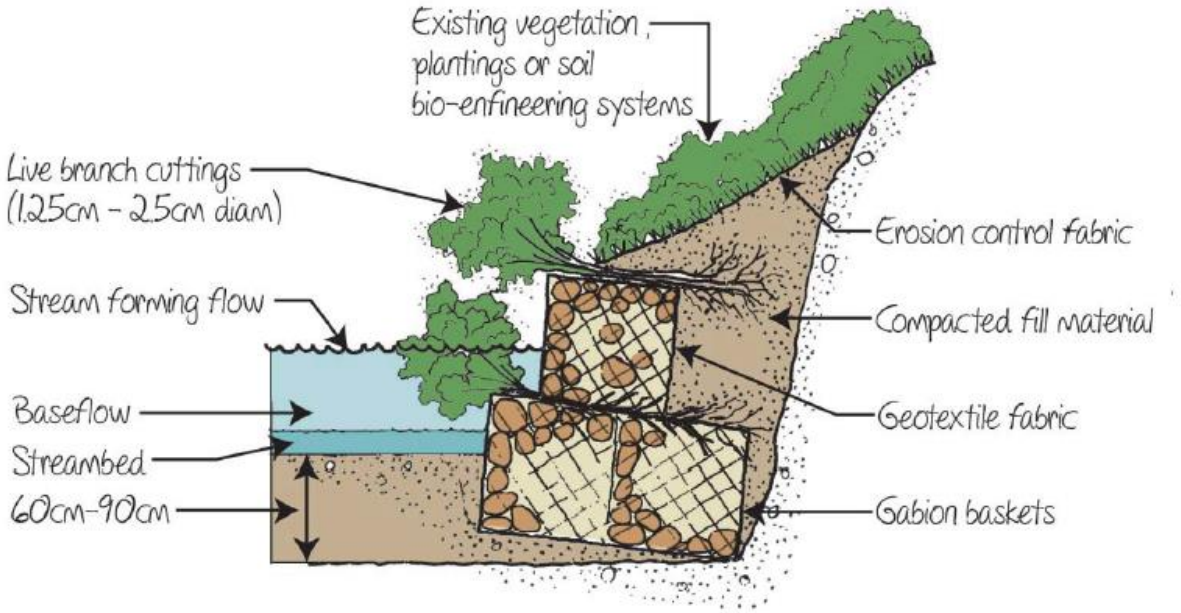


Figure 4. Cross section of a gabion retaining wall with vegetation planted through it (Day *et al*., 2016).

## 1.3 Relevant decision-making guidelines

The Western Cape Government has published a user-friendly guideline for informing coastal erosion decision-making (Western Cape Government Environmental Affairs and Development Planning, 2020). The guideline contains several sections relevant to erosion occurring along road OP06914.

*Guidelines*

- Hidden structures or soft techniques must be used rather than obvious hard techniques to solve erosion problems.
- Take cognisance of natural cycles. Once the water level reduces when the mouth opens, will deposition take place and reverse the cycle?

*Active intervention methods need to consider*

- The physical character of the site
- Cause of erosion
- Severity of erosive forces
- Frequency of events
- Recurrence of the erosive forces
- Potential for extreme events
- Future climate and weather patterns
- The degree of maintenance required
- Impacts of the intervention on coastal processes and the adjacent coastline.

The guideline also emphasises that “soft coasts require soft solutions,” and therefore hard solutions such as riprap in a sandy area would not be supported.

## 1.4 Scope of Work

The requested scope of work covers the following aspects:

- Desktop review of relevant management plans and mapping of site-specific features;
- Determine the Present Ecological State and Ecological Importance and Sensitivity (PESEIS) of the affected area;
- Provide an impact assessment of the proposed interventions for the receiving environment during the construction and operational phases; and,
- Recommend mitigation measures to reduce any anticipated negative impacts;

## 1.5 Relevant Legislation

Legislative acts in South Africa differ in their definition of estuarine systems. According to the National Environmental Management: Coastal Management Act (NEMA: CMA; 2008) and listing notices 1 (GN R. 983) and 2 (GN R. 984) published under the National Environmental Management Act (NEMA), Environmental Impact Assessment (EIA) Regulations (2014), which define an estuary as an open body of surface water-

a) that is part of a watercourse that is permanently or periodically open to the sea;

b) in which as rise or fall of the water level as a result of the tides is measurable at spring tides when the watercourse is open to the sea; or
c) in respect of which the salinity is measurably higher as a result of the influence of the sea.

The National Water Act (NWA; Act No. 36 of 1998) defines an estuary as "a partially or fully enclosed body of water-

a) which is open to the sea permanently or periodically; and,
b) within which the sea water can be diluted, to an extent that is measurable, with fresh water derived from land".

The definition of estuarine habitat is more extensive in terms of listing Notice 3 (GN R 985) published under the NEMA EIA regulations (2014), which define an estuary as the Estuarine Functional Zone (EFZ) as defined in the National Biodiversity Assessment: Estuary Component (van Niekerk & Turpie, 2012). The EFZ is delimited by the 5 m topographical contour surrounding an estuary, which is provided as a spatial layer in the South African National Biodiversity Institute's BGIS website (http://bgis.sanbi.org).

The road in question is located below the 5 m topographical contour and is therefore defined as part of the estuary because it is located within the EFZ.
Furthermore, the NWA defines a watercourse as:

a) a river or spring;
b) a natural channel in which water flows regularly or intermittently;
c) a wetland, lake or dam into which, or from which, water flows; and
d) any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

This definition excludes estuaries which means that, strictly speaking, activities taking place within an estuary are not subject to authorisation under the NWA.

## 2. CHARACTERISTICS OF THE SITE

### 2.1 Catchment Context

Swartvlei Lake is a large lake (9 $km^2$) which is linked to the sea by a 7 km temporarily open/closed estuary (TOCE). The lake is located at the confluence of the Karatara, Klein Wolwe and Hoogekraal Rivers.

Table 1. Summary of relevant catchment features for the eastern shore of Swartvlei Lake.

| Feature | Description |
|---|---|
| Water Management Area | Gouritz |
| Quaternary catchment | K40D |
| Mean Annual Runoff | 254 mm |
| Mean Annual Precipitation | 757 mm |
| Ecoregion Level II | 20.02, |
| Geomorphological Zone | Lower foothills |
| NFEPA area | 9022, FEPA (Freshwater Ecosystem Priority Area) |
| Vegetation Type | Non-terrestrial estuarine vegetation (reeds and sedges) |

The estuary mouth is open slightly more often than it is closed according to historical data presented in Figure 5.

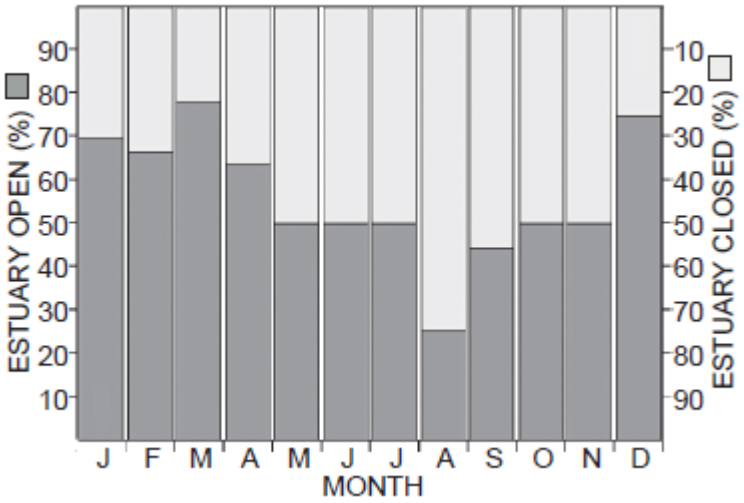


Figure 5. The percentage of time that Swartvlei Estuary was open (dark grey) or closed (light grey) by month between 1991 and 2013 (from Russell, 2015)

Rainfall around Swartvlei Lake has two distinct bimodal peaks in March (autumn) and October (spring). July is the driest month and rainfall can occur at any time of the year.

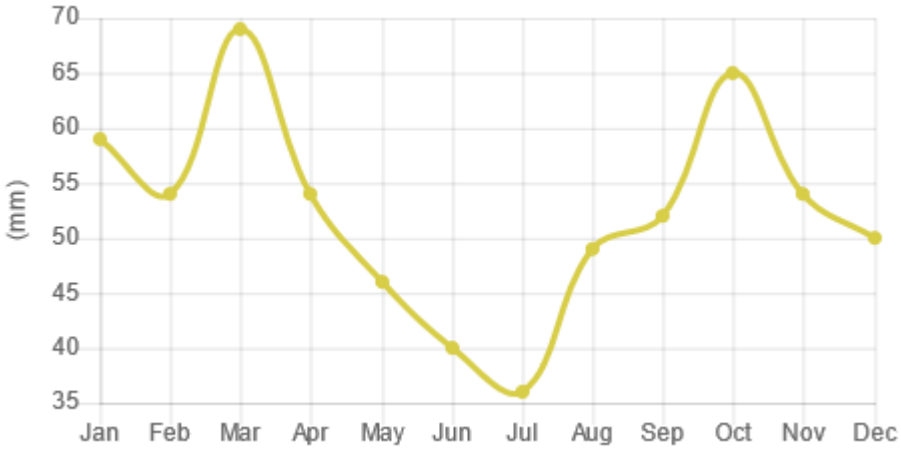


Figure 6. Mean monthly rainfall for the project area.

According to published literature, south-west winds dominate through the year, while north and north-east (Berg) winds are fairly common in winter months. In summer months, winds from the south-east are more common (Whitfield *et al*., 1983). An iWeather station located on the western shore of Swartvlei Lake indicates that generally southerly and westerly winds are most common (Figure 7). Although this data was only from one year in 2020. This is consistent with erosion occurring along the eastern shoreline in areas with a long fetch (distance travelled by the wind which generates higher waves).

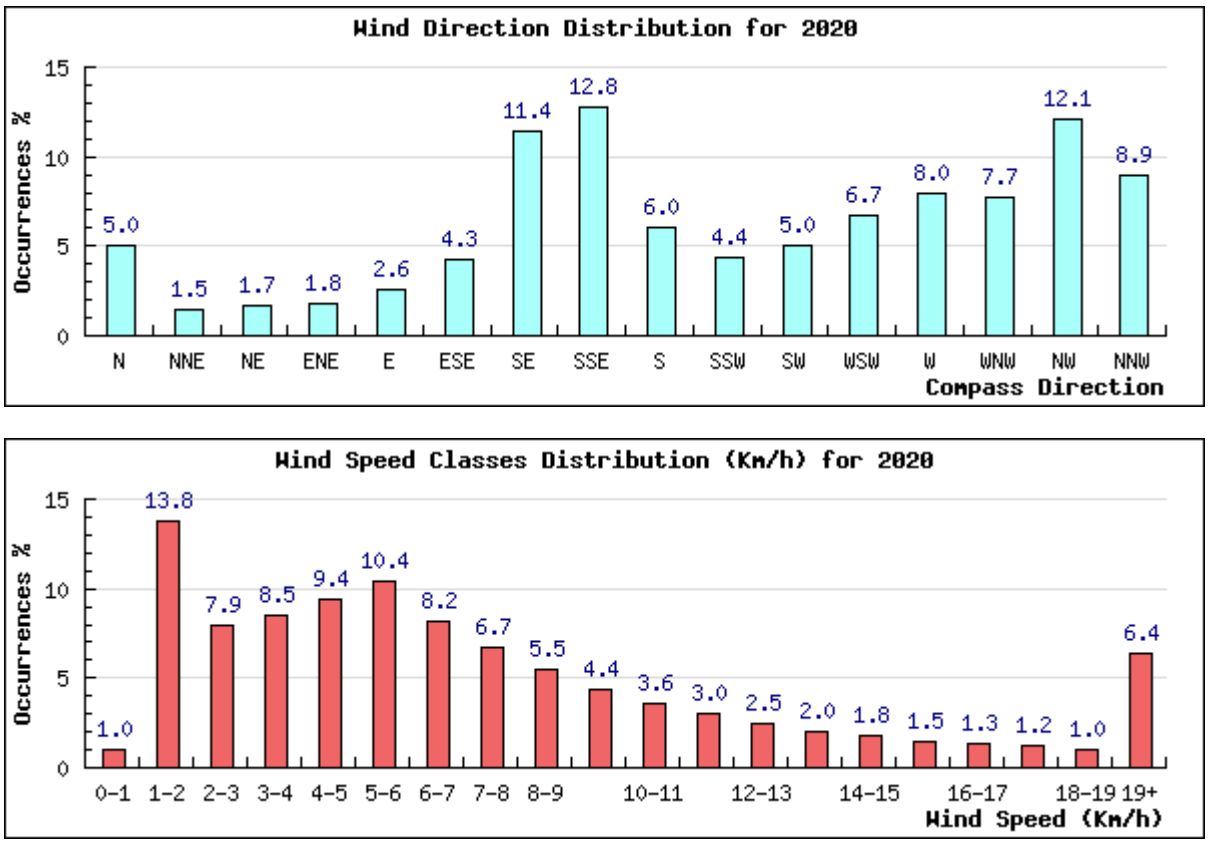


Figure 7. 2020 wind direction and speed distributions for iWeather station located at Pine Lake Marina on the western shore of Swartvlei Lake.

## 2.2 Vegetation

According to VegMap (SANBI, 2018) the mapped vegetation at the site consists of **non-terrestrial estuarine vegetation (reeds and sedges)**. This vegetation type is mapped as a very narrow band located along the road, which abruptly changes to Kynsna Sand Fynbos on the steeply sloping land adjacent to the road. Elements of the latter vegetation type could be found on the landward side of the road but are unlikely to be present on the lakeward side of the road as that is frequently inundated with water. Only species adapted to periodic saturation would be adapted to this habitat. The mapped vegetation type has not been allocated a code, description, or conservation status in VegMap. Dominant plants observed along the lakeward side of the road are presented in Table 2 and Figure 8. It is important to note that very few macrophytes and no seagrass was observed in the water adjacent to the road.

Table 2. Dominant plants growing adjacent to the road and in the lake.

| Common name | Scientific Name | Conservation status |
|---|---|---|
| Common reed | *Phragmites australis* | Very common |
| Blue kunibush | *Searsia glauca* | Common |
| Milkwood tree | *Sideroxylon inerme* | Protected |
| Bakbos | *Nidorella ivifolia* | Very common |
| Buffalo grass | *Stenotaphrum secundatum* | Very common |
| Bermuda grass | *Cynodon dactylon* | Very common |

Figure 8. *Searsia glauca* (left) and *Phragmites australis* (right), both dominant plants along the road.

## 2.3 Conservation status

Swartvlei Lake is located within the **Garden Route National Park**, and as such has a high conservation status. Any modifications along the shoreline will need to be approved at a national level by the Department of Environment, Forestry and Fisheries. Swartvlei Estuary is listed as the 7$^{th}$ most important estuarine system in South Africa (Turpie *et al*., 2002).

The narrow band of vegetation between the road and the lake is also identified by the Western Cape Biodiversity Spatial Plan (WCBSP; 2017) as a **Critical Biodiversity Area: Estuary**. The management objective for this category is to "*maintain the habitat in a natural or near-natural state with no further loss of natural habitat. Degraded areas should be rehabilitated. Only low-impact, biodiversity sensitive land uses are appropriate."* This band of vegetation is precisely where any erosion control measures will be situated, and the management objective is therefore directly relevant to the proposed activity.

The area of Swartvlei Lake along the road is located within a wetland cluster identified in the National Freshwater Ecosystem Priority Areas (NFEPA; Nel *et al*., 2011). The project area is also identified as a **FEPA**, which is a Freshwater Ecosystem Priority Area. FEPAs must remain in a good condition to manage and conserve freshwater ecosystems, and to protect water resources for human use. This does not mean these areas should be fenced off from humans, rather that they be supported by good planning, decision-making and management to ensure they are not degraded. The recommended condition for all estuary FEPAs is an ecological category of A or B (Nel *et al.,* 2011).

Any work undertaken at the site will need to be carefully implemented to comply with these conservation management objectives.

## 2.4 Present Ecological State

The Present Ecological State (PES) of the Swartvlei Estuary is categorised as **B, in a good state which is largely natural,** with few modifications. Recommended mitigation measures to improve this state are to restore base flows from the catchment, and to improve mouth management practices (Van Niekerk *et al.,* 2015).

Localised impacts affecting the PES of the site include the following aspects:

- Erosion of the road resulting in vegetation loss and very localised sedimentation along the shoreline.
- Stormwater runoff from steep slopes adjacent to the road which carry stormwater over the road into the lake, potentially exacerbating wave-borne erosion along the road edge at low points.
- Recreational users accessing the lake from areas with low vegetation increasing the risk of erosion as vegetation is repeatedly trampled.
- Untrimmed vegetation on the landward side of the road forcing drivers too close to the lakeside of the road which exacerbates erosion.

Despite these localised impacts, the overall PES of Swartvlei Estuary remains B, as the PES cannot be divided into small parts of one large system. Ultimately, many small impacts such as these can accumulate into general degradation of the water resource, and as such must each be managed to ensure the estuary remains in good condition.

## 2.5 Historical Context and causes of erosion

Historical imagery of the eroding section is not of sufficient resolution to identify specific locations of erosion along the road if it occurred in the past. Photos do indicate that the road has been at this location for many decades and can be seen on images as long ago as 1958. The sandy shelf indicated off the lake shore has been present at its approximate location and has not changed significantly in dimensions over several decades (Figure 9).

An important aspect which has changed over time has been well documented (Russell and Randall, 2017) and can be easily observed when comparing images between 2008 and 2010 (Figure 9). Salinity levels in Swartvlei Lake rose considerably following extended open conditions post-2007 flooding coupled with reduced freshwater inflows due to the following drought. As a result, submerged macrophytes with low tolerance to high salinity levels died off on the near-shore sand banks all around Swartvlei Lake. The macrophytes in the 2008 image can be observed as dark ‘shadows’ on the sand bank, while plain sand with no plants is evident in the image from 2010 and the present images. The dominant plant species was *Stuckenia pectinata* syn., *Potamogeton pectinatus*. This plant formed thick areas of growth which effectively dampened wave action along the shore. The loss of this submerged vegetation is likely the cause of more recent erosion due to higher energy wave action when water levels in the lake are high. This explains why erosion has not been an ongoing problem for the many decades the road has been present. It can also be seen in the image from 1958 (Figure 9).

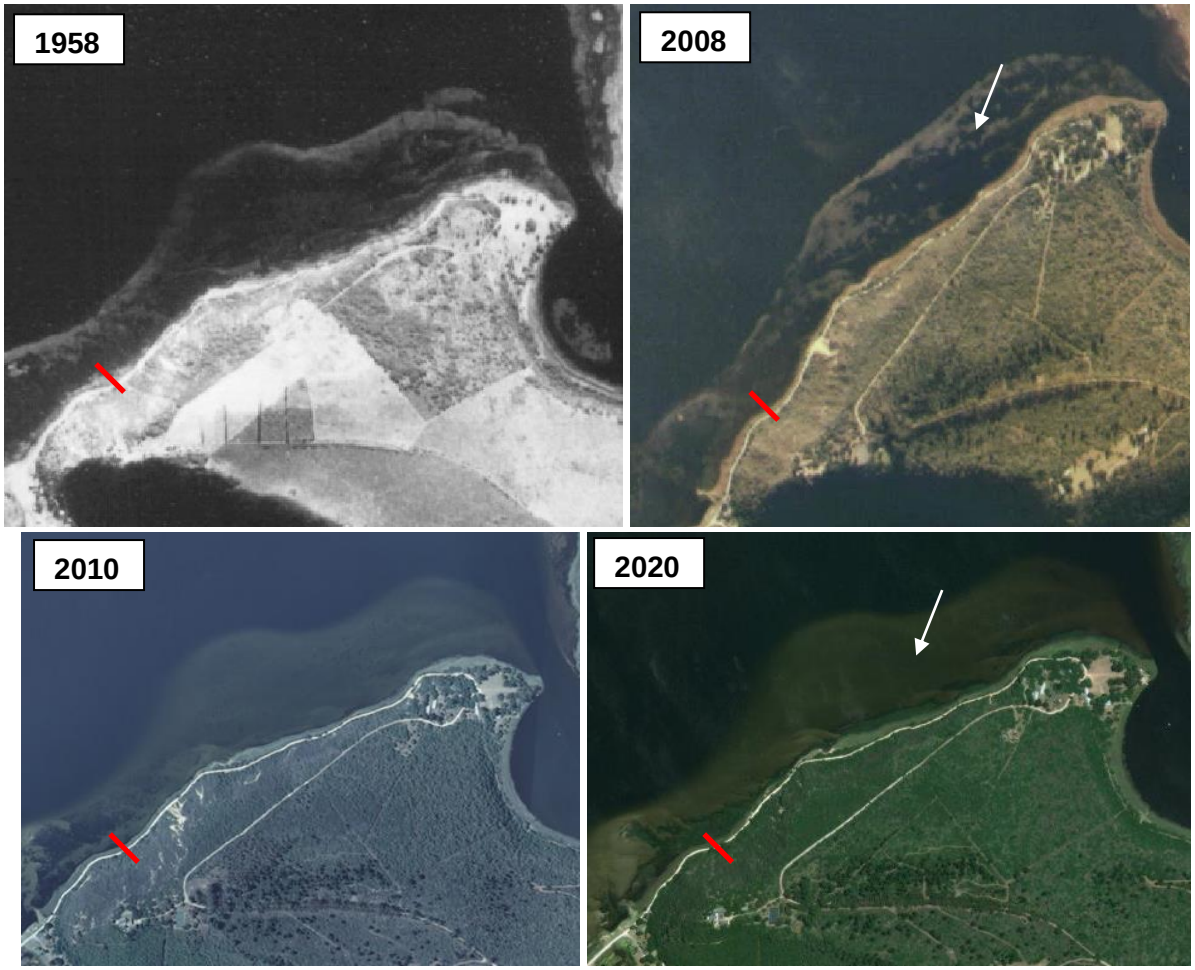


Figure 9. Historical images of the road section showing the approximate start of erosion (red line) and offshore sandbank where vegetation was historically abundant and is now absent (white arrow).

Figure 10. Section of the road where sandbags were historically placed but have now disintegrated allowing erosion to recur.

## 3. SITE VISIT

The site was visited on 24 March 2021 in the afternoon. At this point, the mouth had been closed since mid-May 2020 (almost 1 year) and the water level at the mouth was 1.76 m.a.m.s.l. The water level required for breaching the mouth is 2.0 m.a.m.s.l., so the water level needed to rise approximately 20 cm before the mouth would be breached and water levels would drop.

## 4. ROAD CONDITION (UPDATED)

The road was in a driveable condition at the time of the site visit, but much of it was suitable for a single vehicle only. The first observable point of erosion was at 33°59'56.49"S, 22°46'37.02"E, or approximately Km 1.1 measured from the N2 highway (Figure 11). Erosion was discontinuous along the road with some parts more eroded than others. At Km 1.2 sandbags have historically been placed but have sunk or moved and only wooden stakes and a few broken bags are remaining. The bags historically used were made of woven plastic which, when broken, causes pollution of the area. Several broken bags were removed from the site during the site visit. The worst affected section was at Km 1.4 where the road had eroded close to where vehicles needed to drive, leaving a vertical, undercut edge highly susceptible to further erosion (Figure 11). This section subsequently eroded more severely following strong westerly winds (> 40 knots) on 25 May 2021 (Figure 12).


Figure 11. Photos showing various sections of the road OP06914 where erosion is occurring taken 24 March 2021. Kms measured from the N2 highway.


Figure 12. Updated image of the road at Km 1.4 taken on 25 May 2021 (Photo J. Britton, SANParks).

## 5. EXACERBATING FACTORS

While it is concluded that the primary cause of erosion along this stretch of road is caused by the die-off of offshore submerged aquatic vegetation during 2009, there are several factors that may contribute to erosion. These are listed as follows:

- Unrestricted access to the lake at various points along the shoreline. The road is used for a wide range of recreational activities. Several of these activities could contribute to destabilising banks and restricting vegetation growth where people repeatedly access the lake from the road.
- Vegetation on the landward side of the road may need to be kept trimmed in places to ensure that vehicles do not need to drive closer to the lake edge of the road.
- Vehicles should be prevented from driving along the very edge of the road by the strategic placement of rocks or similar. This is to prevent further erosion such as at km 1.1 where vegetation is sparse along the edge and regrowth could be prevent by vehicles driving too close to the edge.
- Stormwater from the steep slopes above the road may contribute to erosion by flowing across the road and over the edge into the lake.
- The elevated water level while the estuary mouth is closed may exacerbate erosion along the road. If this is the case, then erosion along the road may be limited to high water periods in the lake, meaning that the impact will reduce when the mouth is breached and water levels recede from their current levels.

# 6. IMPORTANT CONSIDERATIONS

The primary purpose of this assessment is to provide an impact assessment for proposed placement of riprap along the road as an erosion control measure. Part of this assessment is to consider factors which may influence the feasibility, success, and necessity of implementing this, and the alternative proposed control measures (Option 2).

SANParks will be a commenting authority on any application to control erosion along the Swartvlei Lake shoreline. Preliminary discussions with their local representatives concerning erosion along the road have highlighted a number of perspectives that are likely to influence the preferred method of control. These include the following:

- Offshore vegetation is starting to re-establish as salinity levels in Swartvlei Lake are back to their pre-die-off levels. Once the vegetation has established the erosion effect should be significantly reduced. Therefore, any interventions may not need to be designed with the long term in mind. An intervention that lasts 5 years could be considered effective.
- SANParks will not support 'hard on soft' solutions to control erosion. It is very unlikely that riprap would be supported, which is supported by the Western Cape Government guideline which states that 'soft on soft' solutions are preferrable. The placement of riprap is included with other methods such as vertical retaining walls and is referred to as shoreline armouring. Shoreline armouring has been widely shown to increase adverse impacts
- The necessity of the road may be questionable. Properties can be accessed from the N2 (along the section that has not eroded) and over the dunes from Sedgefield. Traffic along the road could also be reduced to the minimum by allowing access to residents only.
- Alternative options should be provided and assessed for comparison to riprap so that competent authorities can make a balanced decision about the best solution. Hence the provision of Option 2 as described in Section 1.2.

## 6.1 The use of riprap

On an eroding shoreline, hard structures such as rock revetments can increase wave reflection and scour, causing localised increase in water depth. This can lead to undermining of the placed rocks resulting in them 'sinking' into the sand. It can also result in deflected erosion causing undercutting of adjacent banks. One method to mitigate this impact, is to place a geotextile blanket below the stones to prevent the below sediment from being washed away through the riprap pores. It is also recommended that rock at the foot of the structure and the toe of the structure must be of sufficient depth and length to prevent further erosion. Despite this, increased scour can still occur at the toe and ends of riprap. Riprap does not provide the same level of ecological function or aesthetic appeal as softer erosion control options such as planted marsh. This is likely to be an important disadvantage for Swartvlei Lake given its conservation status and value for tourism and recreation.

# 7. ALTERNATIVE EROSION CONTROL OPTIONS

Given the above-mentioned considerations, alternative options to riprap have been considered and are described briefly in the following section. These options can be

implemented alone or in combination, and can be used to address erosion in the short-term and long-term.

## 7.1 Land use management

Land use measures focus on active and passive measures related to planning and regulation. In that sense they are indirect control measures for erosion. These are typically managed by a local governing authority, in this case, the Garden Route District Municipality. Land use management measures would be aimed at how the road is managed and used. Where infrastructure is in constant jeopardy due to erosion, a managed retreat may be advocated (but may be an unpopular choice). In other words, the eroded section of the road could be closed and left to erode. This option can be debated internally by the GRDM, but for the purposes of this report the assumption is made that the road is necessary. Furthermore, as indicated previously, it is likely that erosion will decrease as the offshore submerged vegetation regrows.

Other measures include more managed access to the lake and signage informing people using the shoreline about erosion, shoreline rehabilitation and designated access points. Measures to reduce the number of vehicles using the road may also be feasible. By providing 'residents only' access for cars, and a small parking area at the start of the road, vehicle traffic could be reduced.

Stormwater management originating from steep land adjacent to the road must be dealt with. Currently there is no drain on the landward side of the road for stormwater. It is recommended that a small shallow drain be excavated along the length of the road to retain stormwater and prevent it from merely flowing over the road.

The necessity of interventions must be carefully considered. Not all points where the road is eroding may need to be addressed. The sections indicated at km 1.1 for instance are still some way off from eroding badly, and simply placing rocks spaced strategically to prevent cars from driving over the vegetation could be sufficient for re-stabilising the edge. Planting of additional grass and spiny plant species such as *Carissa bispinosa* along this edge may also help in protecting it from unrestricted access and the roots will help stabilise soil.

## 7.2 Sandbags

One of the simplest options is to use sandbags against affected areas of shoreline, in a similar way to what has been done in the past. However, biodegradable bags made of a product such as jute would be recommended over woven plastic bags. Their lifespan before biodegrading would be 2-3 years. In this time, they could provide cost-effective short- to medium-term protection of the shoreline until the offshore vegetation has established. If a second application is required, it is not a costly or technical exercise to repeat. Sand for the sandbags would also need to be sourced from a suitable location nearby to ensure no foreign material (e.g. building sand) is introduced to the lake (as described in Section 1.2). A biodegradable mat should be staked into the sand below the sandbags to provide a more stable surface, and the sandbags should be staked in place using wooden stakes as support.

### 7.3 Gabion retaining wall

As described in Option 2 of Section 1.2, the installation of a gabion retaining wall is recommended in the vicinity of Kms 1.4 and 1.78. Gabions should be constructed using suitably sized rock from the area so as to look as natural as possible (ie. Not from a granite quarry, and not small enough to fall out of the mesh). A geofabric such as bidim must be laid beneath, behind, and above the gabions to prevent sand from moving through the gabions which results in undermining of the structure with subsequent slumping. The fabric can be secured with cable ties. Soil pockets must be created in the structure to enable vegetation of the wall face (see below).

Vegetation is essential to reduce the impacts of scour both on the gabions as well as the sand in front of the gabions. To ensure the establishment of plants will be successful, the following steps must be taken:

- Gabions should have a slight 'step' with the lowest step buried into the sand with about 200 mm emerging from the top (See Figure 4). This should allow planted vegetation access to sufficient water to survive.
- Rock-filled gabions should be filled with sand from the site (sand excavated to install the lowest step) and covered in hessian to ensure the plants establish before the hessian rots away. In other words, the gabion basket is lined with hessian which is then filled with rocks and sand.
- Suitable plants would be *Phragmites australis* reeds which are abundant at the site and elsewhere at Swartvlei Lake.

The wire mesh must be of high-quality construction suitably galvanised and PVC coated to withstand conditions at the site.

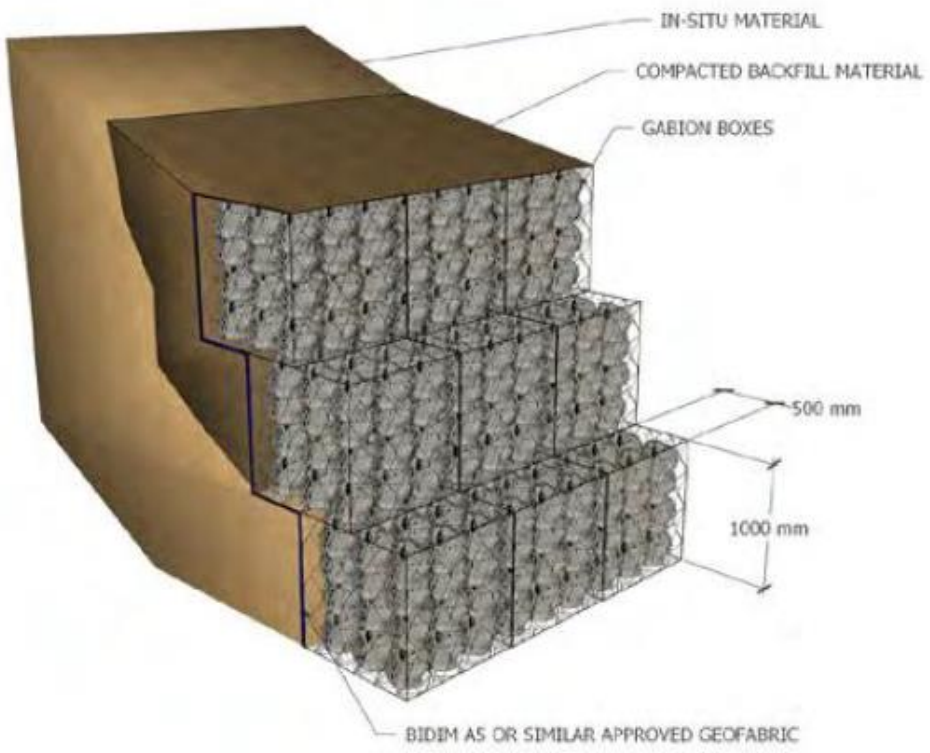

Figure 13. Typical bank protection using gabions (Groundtruth, 2020)

### 7.4 Marsh sill supported by biodegradable materials

Vegetation is a natural feature that helps to prevent erosion. The purpose of a marsh sill is to support the colonisation of suitable plants which will act to buffer the shoreline from erosion. Natural erosion does occur to an extent along the shoreline, but where vegetation is sparse erosion is more severe. This may be exacerbated by people entering the lake at these points because they provide easier access.

A marsh sill typically uses placed rock up to the high-water water mark in a line parallel to the shore. Between the rock and the shoreline, sand is used to backfill the eroded area, and suitable vegetation is then planted in the sand to stabilise it. As previously mentioned, the use of placed rock is unlikely to be supported by SANParks, and so an alternative could be to use biodegradable sandbags or fibre logs instead (Figure 14). Once the vegetation has colonised the sand behind the supporting structure, it should withstand erosion long enough for the offshore vegetation to regenerate.

Suitable vegetation should include initial seeding with *Stenotaphrum secundatum* and planted runners of *Phragmites australis*. This option could be suitable at the type of erosion shown at km 1.2 where there is a naturally low gradient. This option is described in detail by the Virginia Institute of Marine Science and examples are provide in Figure 14 and Figure 15:
https://www.vims.edu/ccrm/outreach/living_shorelines/design/index.php


Figure 14. Examples from the Virginia Institute of Marine Science showing the placement of fibre logs and matting (a), followed by infilling with sand and stabilisation with planted vegetation (b).


Figure 15. Example of shoreline protection using fibre logs with backfilled sand and planted marsh (Virginia Institute of Marine Science).

## 8. IMPACT ASSESSMENT

Methods used for the impact assessment are described in Appendix 1.

### 8.1 Construction Phase

All of the above proposed methods (sandbags, gabion retaining wall and vegetated marsh sill) have similar requirements in terms of the construction phase. In terms of access to the site, transport and delivery of materials and workers operating in sensitive habitat. Each of the impacts anticipated for the construction phase have been assessed and a list of mitigation measures have been provided which are applicable to all of the methods proposed. The majority of impacts can be mitigated to a Negligible level if all mitigation measures are implemented.

Table 3. Construction Phase: Operation and access by heavy, wide vehicles

| | | | | |
|---|---|---|---|---|
| **Project phase** | **Construction** | | | |
| **Impact** | **Operation and access by heavy, wide vehicles** | | | |
| **Description of impact** | **Additional erosion, potential collapse of the road edge, water pollution** | | | |
| **Mitigatability** | High | Mitigation exists and will considerably reduce the significance of impacts | | |
| **Potential mitigation** | **• The smallest, most lightweight construction vehicles possible should be used to transport materials and workers to the site.<br>• Vehicles should park as close to the landward side of the road as possible.<br>• Vehicles must turn around at Outward Bound at the end of the road, and not attempt to turn around on the eroded section of road.<br>• Where the road is badly eroded (e.g. km 1.4) vehicles should park and unload at least 20 m away.<br>• Wherever possible, the methods adopted should avoid the requirement for heavy vehicles or loads (< 2 Tonnes).<br>• Vehicle refuelling areas must be located at least 100m from Swartvlei Lake and refuelling cannot take place on the road.<br>• Discontinue construction during periods of high rainfall.<br>• Vehicles and machinery must be inspected for leaking fuel before accessing the site, and leaking vehicles must not be permitted to work at the site.** | | | |
| **Assessment** | **Without mitigation** | | **With mitigation** | |
| **Nature** | Negative | | Negative | |
| **Duration** | Medium term | Impact will last between 5 and 10 years | Immediate | Impact will self-remedy immediately |
| **Extent** | Limited | Limited to the site and its immediate surroundings | Very limited | Limited to specific isolated parts of the site |
| **Intensity** | Moderate | Natural and/ or social functions and/ or processes are moderately altered | Negligible | Natural and/ or social functions and/ or processes are negligibly altered |
| **Probability** | Probable | The impact has occurred here or elsewhere and could therefore occur | Rare / improbable | Conceivable, but only in extreme circumstances, and/or might occur for this project although this has rarely been known to result elsewhere |
| **Confidence** | High | Substantive supportive data exists to verify the assessment | High | Substantive supportive data exists to verify the assessment |
| **Reversibility** | Medium | The affected environment will only recover from the impact with significant intervention | High | The affected environment will be able to recover from the impact |
| **Resource irreplaceability** | Medium | The resource is damaged irreparably but is represented elsewhere | Medium | The resource is damaged irreparably but is represented elsewhere |
| **Significance** | **Minor - negative** | | **Negligible - negative** | |
| **Comment on significance** | | | | |
| **Cumulative impacts** | Provided the mitigation measures are applied, the cumulative impacts are negligible. | | | |

Table 4. Construction Phase: Management of construction materials and equipment

| | | | | |
|---|---|---|---|---|
| **Project phase** | **Construction** | | | |
| **Impact** | **Management of construction materials and equipment** | | | |
| **Description of impact** | **Traffic to and from materials, spillage of material into watercourses, dumped materials at project** | | | |
| **Mitigatability** | High | Mitigation exists and will considerably reduce the significance of impacts | | |
| **Potential mitigation** | **• Equipment and material lay down areas must be located on the landward side of the road, preferably at a wide part of the road. Alternatively equipment can be left on the vehicle.<br>• Any sand or rock stockpiles must be placed on plastic sheeting, covered with a geotextile or plastic and bunded (e.g. with sand bags) to prevent erosion of the material down slopes into the lake.<br>• Construction should be planned to avoid seasonal rainfall peaks.<br>• All construction debris, rubbish, and waste material must be removed from the site when construction has concluded.** | | | |
| **Assessment** | **Without mitigation** | | **With mitigation** | |
| **Nature** | Negative | | Negative | |
| **Duration** | Short term | Impact will last between 1 and 5 years | Immediate | Impact will self-remedy immediately |
| **Extent** | Limited | Limited to the site and its immediate surroundings | Very limited | Limited to specific isolated parts of the site |
| **Intensity** | Low | Natural and/ or social functions and/ or processes are somewhat altered | Negligible | Natural and/ or social functions and/ or processes are negligibly altered |
| **Probability** | Unlikely | Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur | Highly unlikely / none | Expected never to happen |
| **Confidence** | High | Substantive supportive data exists to verify the assessment | High | Substantive supportive data exists to verify the assessment |
| **Reversibility** | Medium | The affected environment will only recover from the impact with | High | The affected environment will be able to recover from the impact |
| **Resource irreplaceability** | Medium | The resource is damaged irreparably but is represented elsewhere | Medium | The resource is damaged irreparably but is represented elsewhere |
| **Significance** | **Negligible - negative** | | **Negligible - negative** | |
| **Comment on significance** | | | | |
| **Cumulative impacts** | Provided the mitigation measures are applied, the cumulative impacts are negligible. | | | |

Table 5. Construction Phase: Construction workers in the vicinity of Swartvlei Lake

| | | | | |
|---|---|---|---|---|
| **Project phase** | **Construction** | | | |
| **Impact** | **Construction workers in the vicinity of Swartvlei Lake** | | | |
| **Description of impact** | **Increased risk of pollution and further degradation of the site** | | | |
| **Mitigatability** | High | Mitigation exists and will considerably reduce the significance of impacts | | |
| **Potential mitigation** | **• Provide bins or rubbish bags for rubbish and place them in an area designated for break-time. Ensure bins are cleaned out on a regular basis.<br>• Provide portable chemical toilets on-site. Ideally located at Outward Bound (1 toilet per 10 workers). Toilets not to be located on the road due to the risk of spillage. Waste from toilets is to be disposed of regularly, at least weekly, in a responsible manner by a registered waste contractor.<br>• All workers must be briefed that no waste is to be disposed of in the environment.<br>• All workers must be briefed that no access to the lake is permitted for the duration of construction works, unless this is related to a specific task required for erosion control.<br>• Access into the lake at eroded areas must be carefully undertaken so as to minimise further damage and erosion of the banks. The least number of workers should be in the lake, and climbing and stepping on the banks should be avoided wherever possible.<br>• For each point where erosion control is to take place, a designated access area must be identified and a ladder can be placed on the road edge where the bank is too high to step into the water.** | | | |
| **Assessment** | **Without mitigation** | | **With mitigation** | |
| **Nature** | Negative | | Negative | |
| **Duration** | Medium term | Impact will last between 5 and 10 years | Brief | Impact will not last longer than 1 year |
| **Extent** | Limited | Limited to the site and its immediate surroundings | Very limited | Limited to specific isolated parts of the site |
| **Intensity** | Low | Natural and/ or social functions and/ or processes are somewhat altered | Negligible | Natural and/ or social functions and/ or processes are negligibly altered |
| **Probability** | Likely | The impact may occur | Unlikely | Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur |
| **Confidence** | High | Substantive supportive data exists to verify the assessment | High | Substantive supportive data exists to verify the assessment |
| **Reversibility** | High | The affected environment will be able to recover from the impact | High | The affected environment will be able to recover from the impact |
| **Resource irreplaceability** | Medium | The resource is damaged irreparably but is represented elsewhere | Medium | The resource is damaged irreparably but is represented elsewhere |
| **Significance** | **Minor - negative** | | **Negligible - negative** | |
| **Comment on significance** | | | | |
| **Cumulative impacts** | Provided the mitigation measures are applied, the cumulative impacts are negligible. | | | |

Four alternative erosion control methods have been assessed: riprap, vegetated marsh sill supported by biodegradable materials (biodegradable sandbags or fibre logs), sandbags alone and a gabion retaining wall (Table 6, Table 7, Table 8, and Table 9). In all cases, the 'without mitigation' state is assessed as leaving the erosion to proceed unabated. And the 'with mitigation' state is implementation of the method as described. The impact of implementing riprap is a negligible negative impact, and the impact of implementing a marsh sill and sandbags is a negligible positive impact. The gabion retaining wall is anticipated to have a minor positive impact and is therefore the preferred erosion control method in combination with sandbags and the marsh sill where required.

Table 6. Construction phase: Implementation of the erosion control method: R**iprap**

| | | | | |
|---|---|---|---|---|
| **Project phase** | **Construction** | | | |
| **Impact** | **Implementation of the erosion control method: riprap** | | | |
| **Description of impact** | **Localised loss of vegetation and habitat, possible scouring, and deflected erosion** | | | |
| **Mitigatability** | Medium | Mitigation exists and will notably reduce significance of impacts | | |
| **Potential mitigation** | **• Minimise areas where riprap is applied to locations with no fringing vegetation (e.g. km 1.4 and km 1.78).<br>• Underlay complete area to be coverd by riprap with a filter cloth staked in place (e.g. bidim) to reduce erosion through rock gaps (resulting in sinking).<br>• The greater the revetment slope, the less scour at the toe which will unavoidably increase the footprint of the applied riprap to mitigate this factor.<br>• Tie in the sides of the riprap to the road edge at a gentle angle.<br>• The toe of the revetment must be buried beneath the mean low water level (See Figure 12)<br>• The slope must be filled with suitable sand (authorised by SANParks) to a minimum of 3:1 horizontal to vertical<br>• Riprap sizing must account for the water velocity and smaller stones can be placed between gaps to fill them.<br>• Stones must be interplanted with vegetation (e.g. Phragmites reeds) to provide further stabilisation and create a more natural look.** | | | |
| **Assessment** | **Without mitigation** | | **With mitigation** | |
| **Nature** | Negative | | Negative | |
| **Duration** | Long term | Impact will last between 10 and 15 years | Medium term | Impact will last between 5 and 10 years |
| **Extent** | Local | Extending across the site and to nearby settlements | Limited | Limited to the site and its immediate surroundings |
| **Intensity** | High | Natural and/ or social functions and/ or processes are notably altered | Moderate | Natural and/ or social functions and/ or processes are moderately altered |
| **Probability** | Almost certain / Highly probable | It is most likely that the impact will occur | Likely | The impact may occur |
| **Confidence** | High | Substantive supportive data exists to verify the assessment | High | Substantive supportive data exists to verify the assessment |
| **Reversibility** | Medium | The affected environment will only recover from the impact with significant intervention | High | The affected environment will be able to recover from the impact |
| **Resource irreplaceability** | Low | The resource is not damaged irreparably or is not scarce | Low | The resource is not damaged irreparably or is not scarce |
| **Significance** | **Moderate - negative** | | **Minor - negative** | |
| **Comment on significance** | | | | |
| **Cumulative impacts** | Moderate hardening of the shoreline tends to deflect wave energy elsewhere, which may increase the risk of minor cumulative impacts due to displaced erosion. | | | |

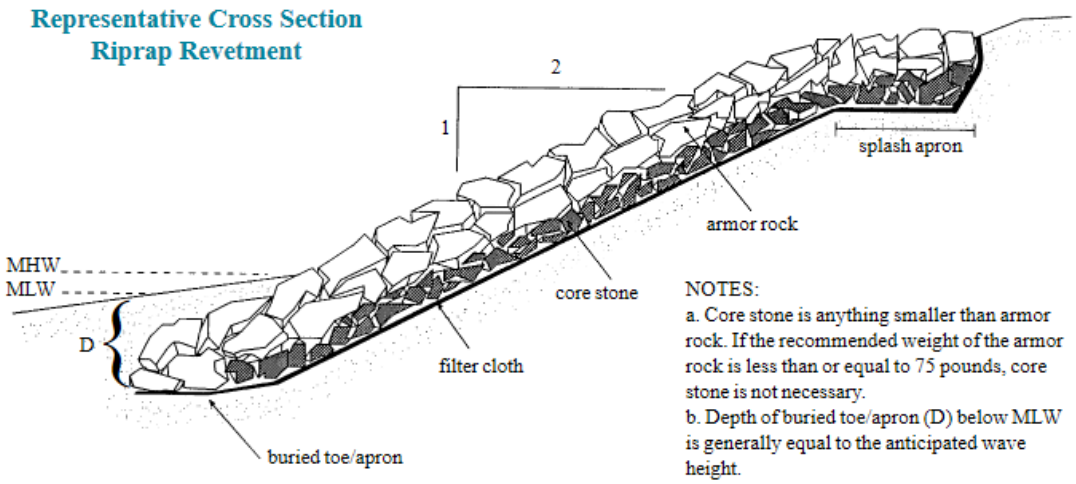


Figure 16. Example of riprap revetment (Virginia Institute of Marine Science).

Table 7. Construction phase: Implementation of the erosion control method: **Sandbags**

| | | | | |
|---|---|---|---|---|
| **Project phase** | **Construction** | | | |
| **Impact** | **Implementation of the erosion control method: Sandbags** | | | |
| **Description of impact** | **Can result in plastic pollution, introduction of foreign material, not a long-term solution** | | | |
| **Mitigatability** | Medium | Mitigation exists and will notably reduce significance of impacts | | |
| **Potential mitigation** | **• Use different sized sandbags for different areas of the eroded road. Smaller sandbags where the road is almost level with the lake and larger sandbags where the road is higher and the eroded surface is vertical.<br>• Use sandbags made from a biodegradable material so that plastic debris doesn't end up polluting the lake.<br>• As far as possible try to avoid placing the sandbags on top of natural vegetation as this will further compromise the long-term shoreline rehabilitation effort.<br>• Use suitable sand collected from an approved location (e.g. windblown beachsand on roads / parking areas) but ensure no litter is collected along with the sand.<br>• Where sandbags must be backfilled with road material, ensure a wide base of large sandbags to support the weight of road material.<br>• Wherever possible, prevent road material from entering the lake.** | | | |
| **Assessment** | **Without mitigation** | | **With mitigation** | |
| **Nature** | Negative | | Positive | |
| **Duration** | Medium term | Impact will last between 5 and 10 years | Brief | Impact will not last longer than 1 year |
| **Extent** | Limited | Limited to the site and its immediate surroundings | Limited | Limited to the site and its immediate surroundings |
| **Intensity** | Moderate | Natural and/ or social functions and/ or processes are moderately altered | Negligible | Natural and/ or social functions and/ or processes are negligibly altered |
| **Probability** | Likely | The impact may occur | Almost certain / Highly probable | It is most likely that the impact will occur |
| **Confidence** | Medium | Determination is based on common sense and general knowledge | High | Substantive supportive data exists to verify the assessment |
| **Reversibility** | High | The affected environment will be able to recover from the impact | High | The affected environment will be able to recover from the impact |
| **Resource irreplaceability** | Low | The resource is not damaged irreparably or is not scarce | Low | The resource is not damaged irreparably or is not scarce |
| **Significance** | **Minor - negative** | | **Negligible - positive** | |
| **Comment on significance** | | | | |
| **Cumulative impacts** | Because biodegradable sandbags are intended for short to medium term duration, the implication is that ongoing interventions will be required which slightly increases the cumulative impacts at the site. | | | |

Table 8. Construction phase: Implementation of the erosion control method: **Marsh sill supported by biodegradable materials.**

| **Project phase** | **Construction** | | | |
|---|---|---|---|---|
| **Impact** | **Implementation of the erosion control method: Marsh sill supported by biodegradable materials** | | | |
| **Description of impact** | **Temporary loss of habitat and vegetation for long term gain in habitat and vegetation** | | | |
| **Mitigatability** | High | Mitigation exists and will considerably reduce the significance of impacts | | |
| **Potential mitigation** | **• Lay and peg a biodegradable geotextile below area to be filled, this will contain the sand to be placed.<br>• Use biodegradable fibre logs or sandbags as the supporting 'sill'. These must be staked in position parallel to the shore and must be above the high water mark.<br>• Sand fill must be approved by SANParks and will be placed between the road and the fibre log.<br>• Sand can be contained by sandbags on the sides which tie into the shore at a gentle angle.<br>• Suitable plants must be planted including Phragmites australis and Stenotaphrum secundatum<br>• The marsh sill should be covered with light brush packing once complete to prevent trampling by people and dogs.** | | | |
| **Assessment** | **Without mitigation** | | **With mitigation** | |
| **Nature** | Negative | | Positive | |
| **Duration** | Medium term | Impact will last between 5 and 10 years | Short term | Impact will last between 1 and 5 years |
| **Extent** | Limited | Limited to the site and its immediate surroundings | Limited | Limited to the site and its immediate surroundings |
| **Intensity** | Moderate | Natural and/ or social functions and/ or processes are moderately altered | Very low | Natural and/ or social functions and/ or processes are slightly altered |
| **Probability** | Likely | The impact may occur | Probable | The impact has occurred here or |
| **Confidence** | Medium | Determination is based on common sense and general knowledge | Medium | Determination is based on common sense and general knowledge |
| **Reversibility** | High | The affected environment will be able to recover from the impact | High | The affected environment will be able to recover from the impact |
| **Resource irreplaceability** | Medium | The resource is damaged irreparably but is represented elsewhere | Medium | The resource is damaged irreparably but is represented elsewhere |
| **Significance** | **Minor - negative** | | **Negligible - positive** | |
| **Comment on significance** | | | | |
| **Cumulative impacts** | Provided the method is correctly implemented the cumulative impacts should be positive. | | | |

Table 9. Construction phase: Implementation of the erosion control method: **Gabion retaining wall**

| | | | | |
|---|---|---|---|---|
| **Project phase** | **Construction** | | | |
| **Impact** | **Implementation of the erosion control method: Gabion retaining wall** | | | |
| **Description of impact** | **Loss of stones, undermining (erosion behind and under the gabion) leading to slumping,** | | | |
| **Mitigatability** | High | Mitigation exists and will considerably reduce the significance of impacts | | |
| **Potential mitigation** | **• Use gabion retaining wall only in areas where vertical erosion of the road has occurred and backfilling is required.<br>• Arrange gabions in a stepped fashion with the lowest gabion dug below the sediment level exposing about 200 mm above the sediment surface.<br>• Construct gabions with suitable wire baskets using appropriate galvanised, PVC-coated wire that can handle exposure to UV and saltwater.<br>• Line gabions with Hessian secured with cable ties so that soil / sand can be added to them.<br>• Rocks in gabions should be locally sourced and be larger than wire holes to ensure rocks do not fall out.<br>• Gabions must be underlain and overlaid with bidim matting (secured with cable ties) to ensure sand does not fall through the gabion from the top, behind, or the sides.<br>• Add live stakes, seeds or runners of Phragmites australis and Stenotaphrum secundatum to pockets of sand in the gabions to encourage the growth of vegetation.** | | | |
| **Assessment** | **Without mitigation** | | **With mitigation** | |
| **Nature** | Negative | | Positive | |
| **Duration** | Medium term | Impact will last between 5 and 10 years | Long term | Impact will last between 10 and 15 years |
| **Extent** | Limited | Limited to the site and its immediate surroundings | Limited | Limited to the site and its immediate surroundings |
| **Intensity** | Moderate | Natural and/ or social functions and/ or processes are moderately altered | Moderate | Natural and/ or social functions and/ or processes are moderately altered |
| **Probability** | Likely | The impact may occur | Likely | The impact may occur |
| **Confidence** | Medium | Determination is based on common sense and general knowledge | Low | Judgement is based on intuition |
| **Reversibility** | High | The affected environment will be able to recover from the impact | High | The affected environment will be able to recover from the impact |
| **Resource irreplaceability** | Low | The resource is not damaged irreparably or is not scarce | Low | The resource is not damaged irreparably or is not scarce |
| **Significance** | **Minor - negative** | | **Minor - positive** | |
| **Comment on significance** | | | | |
| **Cumulative impacts** | The cumulative impacts should be minimal if all mitigation measures are implemented as this solution should last in the long-term. | | | |

## 8.2 Operational Phase

The main actions required during the operational phase relate to monitoring the progression of erosion (Figure 17) and the functionality of the erosion control interventions. If well implemented, the impact of these activities is predicted to be positive.

Table 10. Operational Phase: Monitoring and maintenance of the erosion control measures and eroding areas.

| | | | | |
|---|---|---|---|---|
| **Project phase** | **Operation** | | | |
| **Impact** | **Monitoring and maintenance of the erosion control measures and eroding areas** | | | |
| **Description of impact** | **Increased erosion in new or existing areas, collaps or failure of parts of the erosion control measure** | | | |
| **Mitigatability** | Medium | Mitigation exists and will notably reduce significance of impacts | | |
| **Potential mitigation** | **• Interventions must be inspected weekly after initial installation for the first 4 weeks, then monthly for 3 months thereafter to attend to minor failures and ensure they are functioning as intended. Thereafter the road should be inspected every 4 months to monitor erosion (see below) and check on interventions.<br>• Establish a series of shoreline erosion stake sites along the road by placing stakes on either side of erosion interventions. Wooden stakes must be hammered into the ground on the landward side of the road, and measurements must be taken perpendicular from the stake to the shoreline and recorded in cm. Measurements must be taken each time the interventions are inspected.<br>• Maintenance actions must be consistent with the initial method description and use materials originally specified. If the intervention has failed outright, then an alternative approach must be considered in consultation with SANParks and following the guidelines in this report.** | | | |
| **Assessment** | **Without mitigation** | | **With mitigation** | |
| **Nature** | Negative | | Positive | |
| **Duration** | Short term | Impact will last between 1 and 5 years | Short term | Impact will last between 1 and 5 years |
| **Extent** | Limited | Limited to the site and its immediate surroundings | Limited | Limited to the site and its immediate surroundings |
| **Intensity** | Moderate | Natural and/ or social functions and/ or processes are moderately altered | Low | Natural and/ or social functions and/ or processes are somewhat altered |
| **Probability** | Likely | The impact may occur | Unlikely | Has not happened yet but could |
| **Confidence** | High | Substantive supportive data exists to verify the assessment | High | Substantive supportive data exists to verify the assessment |
| **Reversibility** | Medium | The affected environment will only recover from the impact with significant intervention | High | The affected environment will be able to recover from the impact |
| **Resource irreplaceability** | Medium | The resource is damaged irreparably but is represented elsewhere | Medium | The resource is damaged irreparably but is represented elsewhere |
| **Significance** | **Minor - negative** | | **Negligible - positive** | |
| **Comment on significance** | | | | |
| **Cumulative impacts** | By monitoring erosion and maintaining interventions the aim is to effectively reduce any cumulative impacts associated with the selected erosion control method. | | | |

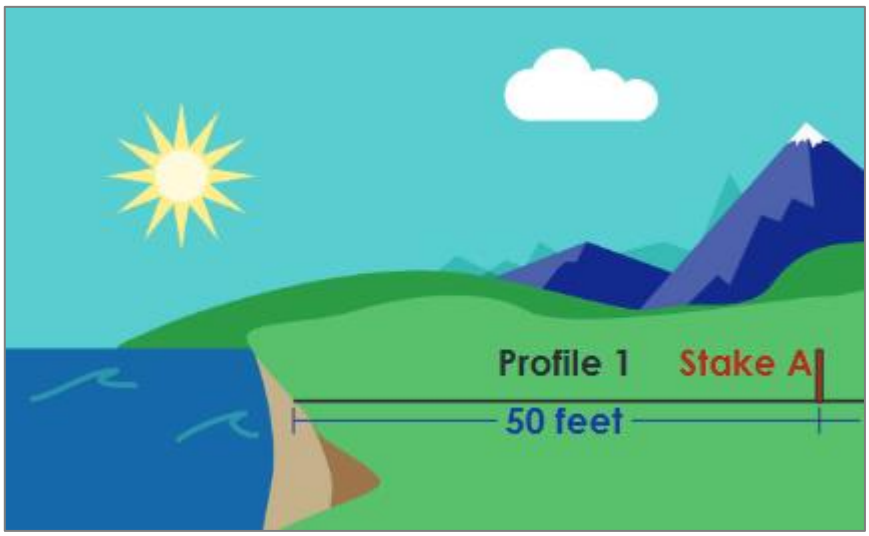


Figure 17. Example of a shoreline erosion stake site used for monitoring the progression of erosion at points along the shore (Alaska Division of Geological and Geophysical Surveys).

## 9. CONCLUSIONS

Erosion along the lakeward side of OP06914 could mostly be considered mild but a few isolated areas have become severely eroded since high winds exacerbated the situation on 25 May 2021. Fortunately for the road, the Swartvlei estuary mouth was breached on 26 May 2021 leading to lower water levels in the lake, which will reduce the urgency of the situation in the short-term. However, as the road remains closed, a short-term and long-term solution may be necessary in order to re-open the road to residents as soon as possible.

Erosion along the road edge is unlikely to last longer than 3-5 years because of two factors. Firstly, when lake levels rise to the point that the mouth is breached, then water levels will reduce, and erosion will decline. The second factor is the re-establishment of offshore aquatic vegetation that will recolonise the sandbank now that salinity levels are within the suitable range to support regrowth. This is a slow process, but in 3-5 years the plants will hopefully provide sufficient cover to resume their wave dampening effect. The caveat to this assumption is that the seedbank is still sufficient to support widescale regeneration of the plants.

Given that erosion control methods are likely only required to last the medium term, and that SANParks will only support a limited number of soft interventions that support and enhance natural habitat, the use of riprap revetments is not recommended. Alternative methods using sandbags in the short-term, and gabion retaining walls combined with planted marsh sills supported by biodegradable materials (sandbags and fibre logs) is proposed as an alternative approach.

Effective land use management practices as explained in Section 7.1 should be adopted in combination with the direct erosion control interventions. These include measures and signage to control traffic, access points, and stormwater on the road.

The interventions recommended will require monitoring and possibly maintenance to ensure their effectiveness. Recommended monitoring and maintenance actions must be implemented.

The installation of erosion control interventions must be overseen by an Environmental Control Officer (ECO) to ensure they are correctly implemented.

# 10. APPENDICES

## 10.1 Impact Assessment Methods

Criteria are ascribed for each predicted impact. These include the intensity (size or degree scale), which also includes the type of impact, being either a positive or negative impact; the duration (temporal scale); and the extent (spatial scale), as well as the probability (likelihood). The methodology is quantitative, whereby professional judgement is used to identify a rating for each criterion based on a seven-point scale (refer to Table 11); and the significance is auto-generated using a spreadsheet through application of the calculations.

For each predicted impact, certain criteria are applied to establish the likely **significance** of the impact, firstly in the case of no mitigation being applied and then with the most effective mitigation measure(s) in place.

These criteria include the **intensity** *(*size or degree scale), which also includes the **nature** of impact, being either a positive or negative impact; the **duration** (temporal scale); and the **extent** (spatial scale). These numerical ratings are used in an equation whereby the **consequence** of the impact can be calculated. Consequence is calculated as follows:

**Consequence = type x (intensity + duration + extent)**

To calculate the significance of an impact, the **probability** (or likelihood) of that impact occurring is applied to the consequence.

**Significance = consequence x probability**

Depending on the numerical result, the impact would fall into a significance category as negligible, minor, moderate or major, and the type would be either positive or negative.

Table 11. Assessment criteria for the evaluation of impacts

| Criteria | Numeric Rating | Category | Description |
|---|---|---|---|
| Duration | 1 | Immediate | Impact will self-remedy immediately |
| | 2 | Brief | Impact will not last longer than 1 year |
| | 3 | Short term | Impact will last between 1 and 5 years |
| | 4 | Medium term | Impact will last between 5 and 10 years |
| | 5 | Long term | Impact will last between 10 and 15 years |
| | 6 | On-going | Impact will last between 15 and 20 years |
| | 7 | Permanent | Impact may be permanent, or in excess of 20 years |
| Extent | 1 | Very limited | Limited to specific isolated parts of the site |
| | 2 | Limited | Limited to the site and its immediate surroundings |
| | 3 | Local | Extending across the site and to nearby settlements |
| | 4 | Municipal area | Impacts felt at a municipal level |
| | 5 | Regional | Impacts felt at a regional level |
| | 6 | National | Impacts felt at a national level |
| | 7 | International | Impacts felt at an international level |
| Intensity | 1 | Negligible | Natural and/ or social functions and/ or processes are negligibly altered |
| | 2 | Very low | Natural and/ or social functions and/ or processes are slightly altered |

| Criteria | Numeric Rating | Category | Description |
|---|---|---|---|
| | 3 | **Low** | Natural and/ or social functions and/ or processes are somewhat altered |
| | 4 | **Moderate** | Natural and/ or social functions and/ or processes are moderately altered |
| | 5 | **High** | Natural and/ or social functions and/ or processes are notably altered |
| | 6 | **Very high** | Natural and/ or social functions and/ or processes are majorly altered |
| | 7 | **Extremely high** | Natural and/ or social functions and/ or processes are severely altered |
| **Probability** | 1 | **Highly unlikely / None** | Expected never to happen |
| | 2 | **Rare / improbable** | Conceivable, but only in extreme circumstances, and/or might occur for this project although this has rarely been known to result elsewhere |
| | 3 | **Unlikely** | Has not happened yet but could happen once in the lifetime of the project, therefore there is a possibility that the impact will occur |
| | 4 | **Probable** | Has occurred here or elsewhere and could therefore occur |
| | 5 | **Likely** | The impact may occur |
| | 6 | **Almost certain / Highly probable** | It is most likely that the impact will occur |
| | 7 | **Certain / Definite** | There are sound scientific reasons to expect that the impact will definitely occur |

When assessing impacts, broader considerations are also considered. These include the level of confidence in the assessment rating; the reversibility of the impact; and the irreplaceability of the resource as set out in Table 12, Table 13, and Table 14, respectively.

Table 12. Definition of confidence ratings.

| Category | Description |
|---|---|
| **Low** | Judgement is based on intuition |
| **Medium** | Determination is based on common sense and general knowledge |
| **High** | Substantive supportive data exists to verify the assessment |

Table 13. Definition of reversibility ratings.

| Category | Description |
|---|---|
| Low | The affected environment will not be able to recover from the impact - permanently modified |
| Medium | The affected environment will only recover from the impact with significant intervention |
| High | The affected environmental will be able to recover from the impact |

Table 14. Definition of irreplaceability ratings.

| Category | Description |
|---|---|
| Low | The resource is not damaged irreparably or is not scarce |
| Medium | The resource is damaged irreparably but is represented elsewhere |
| High | The resource is irreparably damaged and is not represented elsewhere |

## 11. REFERENCES

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