Restoration of the Lake St Lucia estuarine system

Analysis of alternatives to determine the most feasible solution to the hydrological/hydrodynamic issues of the estuarine Lake St Lucia system

and Implementation of the solution

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iSimangaliso Wetland Park
World Heritage Site
Contents

- Background
- Hydrodynamic modelling 1D and 2D of sediment dynamics
- Proposed mitigation measures
iSimangaliso Wetland Park

80s & 90s threatened by mining
  – heavy minerals
  – titanium, illemnite, rutile
  and zircon

Mining rejected by government in 1996

4th December 1999 - first South African protected area to be proclaimed a World Heritage Site

• Ecological processes
• Superlative natural beauty
• Exceptional biodiversity

iSimangaliso Authority set up to manage the Park
iSimangaliso Wetland Park Restoration Project

- Removal of 12,000 ha of invasive plants and pine and *Eucalyptus* plantations on the eastern and western shores of the St Lucia system
iSimangaliso Wetland Park
Restoration to date

- Removal of 12 000 ha of alien plants, pine and *Eucalyptus* plantations on the eastern and western shores of the St Lucia system

- A game reintroduction program - black rhino, elephant, buffalo, waterbuck, kudu, nyala and others
iSimangaliso Wetland Park
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- Upgrade of infrastructure

- Restoration of wetlands
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- Restoration of wetlands

- Restoration of estuarine function to the Lake St Lucia system – GEF funding
Restoration of the Lake St Lucia System

Why the focus on hydrological functioning and specific concern over the estuary?

- 80% of estuarine area of subtropical region of South Africa
- 60% of estuarine area of the South Africa
- 90% of the protected estuarine area of the country

- Prolonged mouth closure (2002-2012)
- High salinities – reached 300 000 mg/l
- Water surface – 10% of the 325 km²
- Collapse of line fish stocks and offshore shrimp fisheries
- Ramsar site - significant habitat – bird nesting and feeding
Restoration of the Lake St. Lucia System

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- 80% of estuarine area of subtropical region
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- 90% of the protected estuarine area of the country
- Prolonged mouth closure (2002-2012)
- High salinities – reached 300
- Water surface – 10% of the 325 km²
- Collapse of line fish stocks and offshore shrimp fisheries
- Ramsar site – significant habitat – bird nesting and feeding
Context

Very clear from the preliminary scoping studies and other scientific work that to address the issues and improve the health of the St Lucia system required a focus on the significance and role of the uMfolozi River as part of the larger estuary.
1952 the combined St Lucia and Mfolozi mouth separated
Dredging of mouth and Narrows +40 years
Mouth kept open to the sea – ‘improved estuarine functioning’
iSimangaliso Authority Management Strategy:

- Allow the uMfolozi to move northwards and rejoin with the St Lucia system
- And allow a more natural mouth dynamic to re-establish
- Required removal of the dredge spoil island (2,600,000 m³)
Field work for modelling parameters (2013)

Tidal levels
Flow velocities
Bed Sediment samples

% Silt and clay
Model layout for hydrodynamics, TDS and TSS (Mike11-1D)
Model long section at low water level

Water coverage of Lake St Lucia in December 2003 reduced to 25% of surface area (Cyrus et al., 2011; Original figure compiled by Ezemvelo KZN Wildlife).
1. **Two mouths:**
   a) Mfolozi River mouth opens when its river estuary water level > 2.435 m MSL
   b) Lake mouth opens when lake estuary water level > 2.435 m MSL
   c) River mouth closes when Q river < 1.5 m$^3$/s
   d) Estuary mouth closes when lake level at Charters Creek < 0.15 m MSL.

2. **One mouth:**
   a) Opens when upstream estuary water level > 2.435 m MSL
   b) Closes when Q river < 1.5 m$^3$/s and water level in lake at Charters Creek (southern lake) < 0.15 m MSL.

Also sensitivity tests on higher berms: 3.0 m and 3.5 m MSL
Calibration against historical data – Lister’s Point and Charters Creek water levels
Lake mass balance with observed mouth conditions for the period 1962 to 2010

### Historical

<table>
<thead>
<tr>
<th>Scenario</th>
<th>uMfolozi</th>
<th>uMsunduzi</th>
<th>Nyalazi</th>
<th>Mzinene</th>
<th>Nzimane</th>
<th>uMkhuze</th>
<th>Eastern shores</th>
<th>Narrows into Lake</th>
<th>LAKE Rain-Evap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Historical</td>
<td>150.7</td>
<td>657.9</td>
<td>42.2</td>
<td>11.0</td>
<td>26.6</td>
<td>136.1</td>
<td>64.3</td>
<td>-117.7</td>
<td>-166.1</td>
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</tbody>
</table>
Simulated minimum and mean Lake water levels for 1962 to 2010 (m MSL)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Water level</th>
<th>Two Mouth – A</th>
<th>One Mouth – A (link channel; dredged spoil not removed)</th>
<th>One Mouth – B (partial dredging dredge spoil dump)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lister’s Point</td>
<td>Lister’s Point</td>
<td>Northern Lake</td>
</tr>
<tr>
<td>“Natural”*</td>
<td>Minimum</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Historical</td>
<td>Minimum</td>
<td>-1.017</td>
<td>-0.668</td>
<td>-0.923</td>
</tr>
<tr>
<td>(calibrated)</td>
<td>Mean</td>
<td>0.339</td>
<td>0.349</td>
<td>0.410</td>
</tr>
<tr>
<td>Current</td>
<td>Minimum</td>
<td>-1.182</td>
<td>-0.668</td>
<td>-1.322</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.242</td>
<td>0.276</td>
<td>0.282</td>
</tr>
<tr>
<td>Scenario 1</td>
<td>Minimum</td>
<td>-1.194</td>
<td>-0.668</td>
<td>-1.330</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>0.160</td>
<td>0.208</td>
<td>0.214</td>
</tr>
</tbody>
</table>

Single mouth significantly improves drought conditions, decreases peak TDS, but could increase sedimentation caused by inflows from the southern rivers.

Low Lake levels lead to hyper salinities of 200 000 mg/l observed.
Mean annual sediment loads entering Lake St Lucia and the uMfolozi river for different scenarios

Scenario 1
Scenario 2
Scenario 3
Scenario 4

Mean sediment load (Mt/a)

From south
From north

Scenario
Mfolozi
Msunduzi
Mkuze
Mzinene
Nsimane
Nyalasi

From north
Simulated average suspended sediment concentrations on the Msunduze and uMfolozi Rivers, at Honeymoon Bend and at the Narrows (Scenario A)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>uMfolozi and uMsunduzi Rivers combined average TSS concentration (mg/l)</th>
<th>Honeymoon Bend average TSS concentration (mg/l)</th>
<th>Narrows average TSS concentration (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 mouth/2 mouths</td>
<td>1 mouth</td>
<td>2 mouths</td>
</tr>
<tr>
<td>“Natural”</td>
<td>28</td>
<td>17</td>
<td>-</td>
</tr>
<tr>
<td>Historical</td>
<td>40</td>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td>Current</td>
<td>112</td>
<td>68</td>
<td>44</td>
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</tbody>
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Single mouth increases the sediment transport, but concentrations relatively low
Flood flow patterns by 2D hydrodynamic model (Mike21C)

<table>
<thead>
<tr>
<th>Recurrence interval (years)</th>
<th>Sea level (m MSL)</th>
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<tbody>
<tr>
<td>100</td>
<td>1.71</td>
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<tr>
<td>50</td>
<td>1.59</td>
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<tr>
<td>20</td>
<td>1.41</td>
</tr>
<tr>
<td>10</td>
<td>1.28</td>
</tr>
<tr>
<td>5</td>
<td>1.23</td>
</tr>
<tr>
<td>2</td>
<td>1.15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>River</th>
<th>Q100</th>
<th>Q50</th>
<th>Q20</th>
<th>Q10</th>
<th>Q5</th>
<th>Q2</th>
</tr>
</thead>
<tbody>
<tr>
<td>uMfolozi</td>
<td>7487</td>
<td>5638</td>
<td>3719</td>
<td>2619</td>
<td>1704</td>
<td>731</td>
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<tr>
<td>Nzimane</td>
<td>3408</td>
<td>2680</td>
<td>1977</td>
<td>1309</td>
<td>811</td>
<td>324</td>
</tr>
<tr>
<td>Nyalazi</td>
<td>3334</td>
<td>2196</td>
<td>1790</td>
<td>1037</td>
<td>652</td>
<td>250</td>
</tr>
<tr>
<td>Mzinene</td>
<td>2334</td>
<td>1528</td>
<td>1351</td>
<td>829</td>
<td>571</td>
<td>247</td>
</tr>
<tr>
<td>uMkhuze</td>
<td>5344</td>
<td>4278</td>
<td>3191</td>
<td>2181</td>
<td>1421</td>
<td>625</td>
</tr>
<tr>
<td>uMsunduzi</td>
<td>2364</td>
<td>1743</td>
<td>1311</td>
<td>796</td>
<td>540</td>
<td>213</td>
</tr>
</tbody>
</table>

2D Model bathymetry shown to elevation 5 m MSL
Simulated flow depth during the 100 year flood near the peak of the flood on the Mfolozi and Msunduzi Rivers
Simulated sediment concentrations of uMfolozi and uMsunduzi Rivers

5 year flood

100 year flood
Simulated 100 year flood sediment concentrations showing deepest penetration into Lake St Lucia

Flushing of Narrows after flood as Lake level drops
Mitigation measure: partial or complete removal of the dredge spoil dump at the mouth

The maximum elevation of the spoil is 12.5 m MSL. The total volume of the dredged spoil dump is about 2.6 million m$^3$.

Peak of 100 year flood flow depth and velocity vectors (before removal of dredged spoil dump)
Dredge spoil removal scenarios (blue: Scenario B; blue and red: Scenario C; green, blue and red: Scenario D shown with the 2013 survey contours and the 2013 aerial photograph

Proposed order of removal: B, C and D. B is most important; C & D helps scour of channel near beach berm
Conclusions and Recommendations

* Study of 2013-2015 proposed: Single mouth operation:
  * without artificial breaching of the beach berm,
  * remove floodplain levees,
  * with at least partial removal of the north eastern side of the dredged spoil dump (implemented during 2017/18)
  * Sedimentation of the Lake expected to be limited
  * With higher water levels in the lake and normal salinities
Questions?