The Inlet Water Quality Background Paper is the Stokes Inlet Condition Statement

Answers to the following questions are provided in the condition statement:

- What is the present condition of the Inlet? How has it changed over time?
- What are the main influences on water quality condition in the Inlet?
- What are the nutrient cycles within the Inlet? (some information provided) How could these be determined?
- How are nutrients cycled within the Inlet?
- What are the salinity dynamics within the Inlet?
- What are the phytoplankton assemblages? What are their seasonal trends? Does the Inlet experience toxic algae blooms? What impact could toxic species have on Inlet fauna?
- What are the likely impacts of climate change on the Inlet? (some information provided)
- What resource condition targets could be used for the Inlet?
- What recommendations should be included in the management plan to improve the Inlets water quality?

There was not enough information to answer the following questions:

- Is the presence of algae increasing? Are the species changing?
- What are the ocean-estuary interactions/exchange when the bar is open and when it is closed?
- What are the likely impacts of more frequent bar breaking?
- What is the likely impact of artificially breaking the bar on both the recreation and environment of the Inlet?
- Is the Inlet becoming shallower?
- How much sand is moving into the Inlet from the surrounding dunes?
- What are the impacts of sedimentation on the Inlet? What was the rate of sedimentation pre and post-clearing? Do we know where most of the sediment is coming from? What is the best way to measure the rates of sedimentation?
- What mitigation and adaptation strategies is there, that could be used to counter the impacts climate change?

The following information has been taken from the Condition Statement

A list of environmental conditions of concern for the Young and Lort River catchments that drain into Stokes Inlet.

Conditions of concern	Example
Nutrient loading	Agricultural and pastoral activities are likely to contribute to nutrient input from catchment to the estuary. Management actions should aim at reducing nutrient inputs from the wetter sub-catchments, namely the Young River.
Salt loading	Salinities of the Young and Lort Rivers range from 6 to 17 ‰ (almost half the salinity of seawater (35 ‰). Management actions should aim to revegetate areas along waterways to reduce the affects of salinisation.

Sediment loading	Vegetation loss has increased surface drainage. The loss of vegetation along streams also promotes erosion. Management actions should aim to revegetate areas along waterways to reduce sediment loss.
Fringing vegetation	Visible stretches of the Lort and Young below the highway are choked with vegetation. These areas promote sediment trapping.
Climate change	Climate change (drying climate and changing rainfall patterns) broadly impacts a number of conditions described for the catchment that are affected by a reduction in river flow volumes. Management actions will require that flow to the Lort and Young Rivers is maintained to preserve the ecology of the riverine pools. An example would be restrictions on groundwater abstraction.

A summary of environmental conditions of concern for Stokes Inlet

Condition	Example
Strong salinity stratification and **deoxygenation**	Salinities of the surface and bottom waters can vary by up to 20 ‰ in the deeper basin (> 5 m water depth) Bottom waters are frequently anoxic in the deeper basin.
High nutrient concentrations	Since the 1970s median concentrations of total nitrogen have doubled and total phosphorus has tripled.
Harmful algal species	Harmful algal species namely *Gymnodinium complex* have been found to occur in the Inlet.
Phytoplankton blooms	Phytoplankton blooms are infrequent, but a concern given the nutrient concentrations available for primary production.
Sedimentation rates	Sediment deltas that extend into the Inlet appear to be increasing.
Climate change	Climate change (drying climate and changing rainfall patterns) may result in a reduction in river flow to the Inlet and / or a change in the frequency of flood events to the region. Reduced flow may result in drop in Inlet water levels which would be accompanied by changes in water quality such as increased salinities and poor oxygen conditions. More frequent flooding may increase the frequency of bar opening events and tidal intrusion. Depending on duration this could have dramatic effects of the salinity of the Inlet.

The following knowledge gaps have been highlighted:

- **The scale of water quality monitoring:** There is currently four water quality monitoring sites in Stokes Inlet. Some consideration needs to be given to additional sites in the estuarine reaches of the Young and Lort Rivers to monitor the inputs of nutrients and organics into the Inlet from the catchment.
- **The frequency of water quality monitoring:** The frequency of water quality monitoring may also need to be revised to include more frequent sampling e.g. fortnightly, in particular to capture the effects of high river flow events into the Inlet.
- **Additional water quality parameters:** While the water quality monitoring program includes analyses of inorganic nutrient concentrations, there is no data to indicate contributions of allocthonous organic nutrients. Other parameters to consider would be total suspended solids (TSS) which could give an indication of the weight of suspended material in the water column: this would be a useful measure of particulate loading from the Young and the Lort Rivers during periods of river flow.
- **Sediment nutrient exchange**: To date, sediment quality data has been captured on one occasion. The data has highlighted some of the processes that may be active in terms of nutrient cycling, for example whether the sediments act as a source or sink for nutrients in the deep or shallow parts of the Inlet. Benthic chamber experiments would contribute to this understanding by measuring the release of nutrient species into the water column and the rates at which nutrients are removed from the water column e.g. denitrification efficiency.
- **Sedimentation:** There is no data that can assist in the management of sedimentation processes in the Inlet. Sediment cores, site differential levelling surveys and / or bathymetric surveys are required to monitor the movement of sediments in the Inlet, in particular sedimentation processes around the flood tidal delta at the meeting of the Inlet and the Young and Lort Rivers.
- **Macrophyte / macroalgal growth**: There is presently no current or routine macrophyte / macroalgal surveys of the Inlet that enable monitoring of the distribution (depth presence / absence) or biomass of species in the Inlet. Submerged aquatic vegetation provides an important habitat to estuarine fauna and is important to the ecology of the Inlet**.** It is also important to monitor the presence and distribution of harmful species.
- **Macrofauna:** There is presently no current or routine macrofauna survey data. Macro-invertebrates are a commonly used indicator of estuarine health. Typically estuarine species complete their life cycle within the estuary and so changes in community structure can provide insight to marked changes in the condition of the sediments and water column and the ecology of the estuary.
- **Fringing vegetation:** At present there are no routine surveys of the health and distribution of fringing vegetation along the estuarine reaches of the system to monitor change in this habitat.

Capture of this information is required before the current condition of the Inlet can be adequately defined.

Possible water quality indicators for Stokes Inlet

Management objective	**Resource condition**	
	Indicator	**Target**
Reduce spatial extent and frequency of hypoxic/anoxic events	Dissolved oxygen in surface waters	[O_2 mg/L]
Reduce nutrients feeding phytoplankton blooms in estuarine reaches of the rivers	Nitrogen Phosphorus	[TN] [TP]

Reduce frequency of potentially toxic phytoplankton blooms (e.g. cyanobacteria and dinoflagellates)	Phytoplankton cell counts; number of recorded blooms; chlorophyll *a*	[Chl *a*]
Reduce nutrients leaving catchment to estuary	Nitrogen Phosphorus	[TN] [TP]
Reduce sediment leaving catchment to the estuary. Improve water clarity.	Total suspended solids (TSS) Turbidity	TSS Turbidity (NTU)

Possible sediment quality indicators for Stokes Inlet

Management objective	**Resource condition**	
	Indicator	**Target**
Reduce organic content of surface sediments	Organic content of surface sediments	Total organic content (µg/g) in top 2cm (%)
Increase/maintain sediment denitrifying activity	Summer denitrification rates of sediments	Sediment denitrification rates (mmol $N/m^2/d$)
Reduction of indicator species (eutrophication / anoxia)	Abundance and distribution	The numbers of *Capitella capitata* per m^2

Possible sedimentation indicators for Stokes Inlet.

Management objective	**Resource condition**	
	Indicator	**Target**
Maintain elevation along a fixed transect	Depth	Elevation along transect (cm)
Aerial extent of flood tidal delta	Area	Differential levelling / positioning (ha)

Possible aquatic macrophyte indicators for Stokes Inlet.

Management objective	**Resource condition**	
	Indicator	**Target**
Increase seagrass distribution in the Inlet	Seagrass presence & density	Aerial coverage, Percent cover
Increase seagrass depth limit in the Inlet	Seagrass presence	Depth of *Ruppia* (m)
No increase in macroalgal biomass in the Inlet	Macroalgal biomass	g dwt/m2

Possible fringing vegetation indicators for Stokes Inlet.

Management objective	Resource condition	
	Indicator	**Target**
Maintain spatial extent and distribution of fringing vegetation	Area of fringing vegetation; community composition	Fringing vegetation area (ha) Species diversity & abundance (per m^2)

Recommendations arising from the steering group based on the above information:

- *Reduce the nutrient to the Inlet from the catchment (particularly the wetter sub-catchments)*
- *Reduce sediment input to the Inlet from the catchment (maintain current extent of flood tidal delta)*
- *Revegetate areas along waterways*
- *Carry out Benthic Chamber studies to determine if sediments act as a source or a sink of nutrients in the Inlet*
- *Carry out sediment cores to determine historic sedimentation rates in the Inlet*
- *Determine movement of sediment in the Inlet through bathymetric surveys and site differential levelling*
- *Set up a long term monitoring project to look at the sediment in the main tributaries of Stokes Inlet to determine loads and movement. It has been suggested that photo points or sediment traps would be one way of gaining a better understanding of this.*
- *Survey and monitor the macrophyte / macroalgal of the Inlet to determine distribution (depth presence / absence) or biomass of species as well as the presence and distribution of harmful species*
- *Determine and monitor the macrofauna of the Inlet*
- *Determine and monitor the health and distribution of fringing vegetation along the estuarine reaches of the system.*
- *Maintain spatial extent and distribution of fringing vegetation*