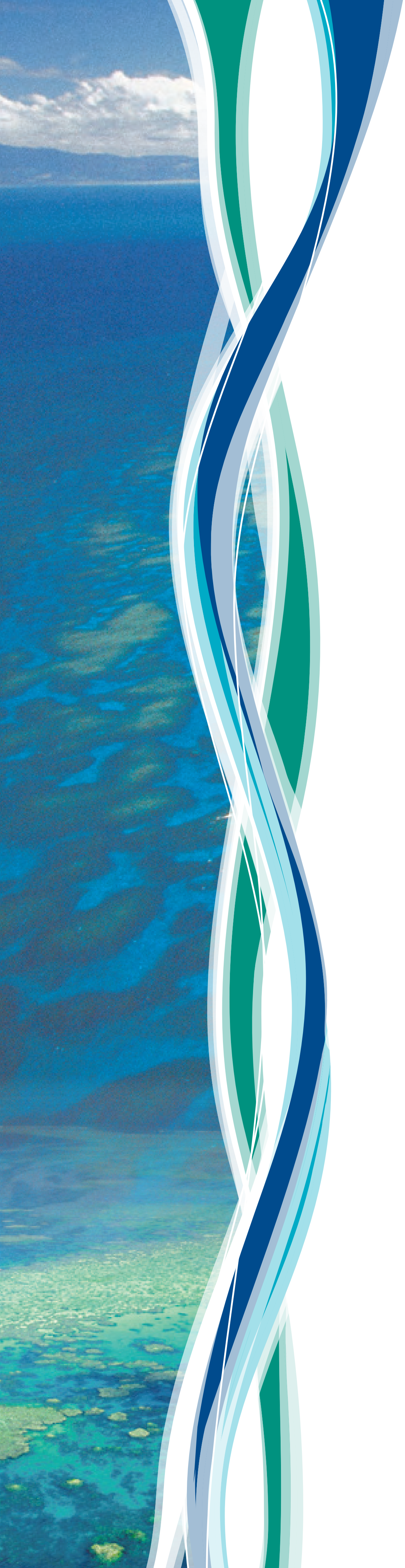
Scientific consensus statement on water quality in the Great Barrier Reef



Scientific consensus statement on water quality in the Great Barrier Reef

The establishment of the Reef Water Quality Protection Plan (Reef Plan) in 2003 by the Australian and Queensland Governments was supported by a body of evidence showing a decline in water quality on the Great Barrier Reef (GBR). A comprehensive review of the evidence available at the time, "*Summary Statement of the Reef Science Panel regarding water quality in and adjacent to the Great Barrier Reef*" was prepared by a taskforce of experts led by Dr Joe Baker.

Since that time, there have been significant advances in knowledge to support implementation of the Reef Plan. As the Reef Plan approaches the halfway mark of the 10-year plan, it is considered timely to review and synthesise this knowledge and reach consensus on the current understanding of the system.

A taskforce of scientists has prepared a discussion paper that reviews the 2003 summary statement of evidence and, where appropriate, updates the statement based on the results of more recently published and peer-reviewed articles. This scientific consensus statement is based upon the outcomes of that discussion paper.

Analysis of the latest available evidence leads us to conclude:

1. **Water discharged from rivers to the GBR continues to be of poor quality in many locations.**
2. **Land derived contaminants, including suspended sediments, nutrients and pesticides are present in the GBR at concentrations likely to cause environmental harm.**
3. **There is strengthened evidence of the causal relationship between water quality and coastal and marine ecosystem health.**
4. **The health of freshwater ecosystems is impaired by agricultural land use, hydrological change, riparian degradation and weed infestation**
5. **Current management interventions are not effectively solving the problem.**
6. **Climate change and major land use change will have confounding influences on GBR health.**
7. **Effective science coordination to collate, synthesise and integrate disparate knowledge across disciplines is urgently needed.**

The scientific consensus

1. Water discharged from rivers to the GBR continues to be of poor quality in many locations.

1.1 Pesticide residues, particularly herbicides, are present in surface and groundwater in many locations in the catchments – these substances do not occur naturally in the environment.

1.2 Concentrations of nitrate and nitrite are elevated in groundwater in areas under intensive agriculture – a portion of this groundwater is believed to enter coastal waters.

1.3 River loads of nutrients, sediments and pesticides are higher than in pre-European times – this is inferred from changes in land use and estimated through monitoring and modelling, although with significant model uncertainty.

1.4 Concentrations of contaminants in waterways are related to specific forms of land use – monitoring and modelling data identify the main sources of nutrients, sediments and pesticides, and show strong regional differences. Evidence includes:

1.4.1 Nitrogen – A strong relationship exists between the areas of nitrogen-fertilised land use in a catchment and the mean nitrate concentration during high flow conditions, implicating fertiliser residues as the source of nitrate. Elevated stream concentrations of nitrate indicate fertiliser application above plant requirements in sugar cane and bananas.

1.4.2 Phosphorus – Elevated concentrations of dissolved inorganic phosphorus are related to fertiliser application above plant requirements in intensive cropping and to locally specific soil characteristics.

1.4.3 Sediment – Most sediment originates from the extensive grazing lands of the Dry and Sub Tropics.

1.4.4 Pesticides – Concentrations in waterways are highest in areas of intensive agricultural activity including sugarcane and cotton.

1.5 The priority source areas of contaminants are now relatively well known for GBR catchments.

1.5.1 Analysis of data on fertiliser use, loss potential and transport has ranked fertilised agricultural areas of the coastal Wet Tropics and Mackay Whitsunday as the hot-spot areas for nutrients (mainly nitrogen) that pose the greatest risk to GBR reefs.

1.5.2 In the Dry Tropics, high suspended sediment concentrations in streams are associated with rangeland grazing and locally specific catchment characteristics, whereas sediment fluxes are relatively low from cropping land uses due to improvements in management practices over the last 20 years.

1.5.3 In the Wet Tropics sediment fluxes are comparatively lower due to high vegetation cover maintained throughout the year from high and year round rainfall and different land management practices from Dry Tropics regions within industries such as beef grazing.

1.5.4 Urban development sites can be local high impact sources of suspended sediment.

1.5.5 Of the herbicide residues most commonly found in surface waters in the GBR region, diuron, atrazine, ametryn, hexazinone derive largely from areas of sugarcane cultivation, while tebuthiuron is derived from rangeland beef grazing areas.

2. Land derived contaminants, including suspended sediments, nutrients and pesticides are present in the GBR at concentrations likely to cause environmental harm.

Considerable advances have been made in recent years to understand the presence, nature and extent of land-derived contaminants in GBR waters. The lines of evidence to support this include:

2.1 Contaminants are dispersed widely within the GBR – satellite remote sensing demonstrates the transport of river-plume-derived dissolved matter across and along the GBR lagoon and out to the Coral Sea. Particulate matter is dispersed less widely and tends to be trapped and deposited inshore.

2.2 Pesticides are present in the GBR – pesticide residues, especially herbicides, are detected in many GBR waters. Pesticides at biologically active concentrations have been found up to 60km offshore in the wet season and in low but detectable concentrations in the dry season.

2.3 Contaminants may have long residence times in the GBR lagoon – most sediment is trapped near the coast and hence has decadal residence times in the GBR lagoon. Dissolved nutrients are dispersed more rapidly and may be trapped in the lagoon by biological uptake and persist in this particulate form for years; most pesticide residues have short residence times (at most a few years) due to their chemical breakdown.

2.4 Large river discharge events (‘floods’) in the wet season are the major delivery mechanism of land-derived contaminants to the GBR – in GBR waters, concentrations of dissolved inorganic nitrogen (nitrate, ammonium), suspended sediment and dissolved inorganic phosphorus are many times higher in flood plumes than in non-flood waters.

2.5 Correlations exist between river-discharged material and water quality in the GBR lagoon – phytoplankton biomass and pesticide concentrations in the GBR lagoon are directly correlated with river nutrient and pesticide loads, respectively.

3. There is strengthened evidence of the causal relationship between water quality and coastal and marine ecosystem health.

Qualitative and quantitative understanding of the effects of land-sourced contaminants on GBR species and ecosystems has been greatly improved since 2002. Pesticides are now recognised as a greater potential threat to GBR ecosystems than was realised before 2003.

The following are lines of evidence exist of causal and dose-response relationships between water quality change and coastal and marine ecosystem health:

3.1 Seagrass – There is evidence of decline in seagrass health with increasing concentrations of herbicides.

3.2 Coral reefs – The impacts of water quality on corals has been demonstrated through both field studies and laboratory experiments. Field studies have shown that:

- 3.2.1 Macroalgae increase and coral species richness decline with increasing turbidity and chlorophyll in the GBR (Lat 12 - 24º S).
- 3.2.2 Links between nutrient enrichment and crown-of-thorns starfish population outbreaks are now well supported.
- 3.2.3 Coral reef development diminishes along a water quality gradient in the Whitsunday Islands.
- 3.2.4 Coral cores from reefs off Mackay show that increasing exposure to nitrogen from the Pioneer River is correlated with poor reef condition and high macroalgal cover.
- 3.2.5 Inshore reefs off the Wet Tropics have lower coral and octocoral diversity and higher macroalgal cover than expected based on latitudinal changes.
- 3.2.6 Stress and mortality in corals exposed to sedimentation increases with increasing organic content of the sediment.
- 3.2.7 The presence of muddy marine snow increases sedimentation stress and mortality in coral recruits.
- 3.2.8 Various pesticides exert detrimental effects on zooxanthellae. photosynthesis and coral reproduction at trace concentrations.
- 3.2.9 There are synergistic effects between herbicides and sediments on crustose coralline algae.

4. The health of freshwater ecosystems is impaired by agricultural land use, hydrological change, riparian degradation and weed infestation.

Understanding of the ecosystem health of catchment waterways has been greatly enhanced by recent research in Wet Tropics streams and floodplain waterways, and on the riverine waterholes and floodplains of the Dry Tropics. Clear relationships between land use, hydrological change, riparian management, weed infestation and waterway ecosystem health have been established. The lines of evidence to support this include:

4.1 Primary factors affecting instream ecosystem health are riparian vegetation condition, aquatic and riparian weed prevalence, vegetation removal and habitat loss – these factors have been shown to be more important in reducing instream ecosystem health than water quality per se.

4.2 Concentrations of nutrients in fresh waters in many catchments are proportional to the area of land under agriculture – elevated nutrient inputs from agricultural sources are known to contribute to enhanced weed growth, vegetation change and associated changes in instream community structure.

4.3 Agricultural development has led to substantial damage to riparian and wetland health in many catchments – these influences have negative consequential effects on water quality and hence detrimental effects on instream biota.

4.4 Concentrations of pesticides in waterways are highest in areas of intensive agricultural activity – the implications of this for community structure in freshwater ecosystems are potentially severe but our knowledge is limited.

4.5 The condition of riverine waterholes in the Dry Tropics is largely determined by cattle access – cattle contaminate and disturb the waterholes causing deoxygenation from excreta, increased turbidity, and consequent loss of biodiversity.

4.6 The condition and biodiversity of floodplain waterways are adversely affected by irrigation inputs and drainage – sediments, nutrients from fertilisers and organic material have been shown to lead to oxygen depletion, enhanced weed growth, turbidity, reduced connectivity, and hence biodiversity loss.

5. Current management interventions are not effectively solving the problem.

Understanding of the effectiveness of management interventions has improved in the last five years, but there are still significant knowledge gaps that undermine our present ability to identify investment priorities and provide confidence in likely water quality outcomes. Current evidence relating to management intervention is:

5.1 Priority contaminants for intervention are known for Water Quality Improvement Plan areas – there is improved regional understanding of management practices associated with the presence of contaminants in waterways, including knowledge of variability in risks across and within catchments and industries. However, prioritisation between the regions and between industries at a GBR-wide scale is lacking.

5.2 A range of measures for managing sediment, nutrient and pesticide loss are available for implementation across industries and across regions in the GBR catchments – agricultural industry land management systems such as Grazing Land Management and fertiliser efficiency techniques are established.

5.3 Quantification of water quality outcomes of management practices is inadequate – management systems believed to be effective (based on limited information) are known for the sugar cane and grazing industries; less information is available for many of the regions' diverse horticultural industries.

5.4 There are many social and economic impediments to the implementation of management interventions – there are multiple economic and social impediments to the implementation of changes of management practices aimed at reducing contaminant loads to the GBR. While win-win scenarios exist for some management interventions such as the 'Six Easy Steps' nutrient management system in sugarcane, many practices involve net costs to producers, particularly in the shorter term. Economic and social impediments to practice change vary between regions, complicating the design of policies to achieve agricultural practice change.

5.4 Knowledge of the effectiveness of restoration techniques is insufficient to guide investment – the effectiveness of riparian vegetation and wetlands as potential filters of sediments, nutrients and pesticides is known for some cropping locations, but is limited for grazing areas.

5.5 Targets have been set at regional scales based on best available science but GBR-wide targets are lacking – the setting of targets for management actions, end-of-catchment loads and resource condition has been integral to the development of GBR Water Quality Improvement Plans. The targets are thus far more robust than previously set but still require modification in the light of new information. However, no targets have been set at the GBR scale which would allow trade-offs in management actions across the GBR region to be considered.

6. Climate change and major land use change will have confounding influences on GBR health.

The primary confounding influences related to GBR water quality are climate change and major land use change. The complex interactions between the impacts of water quality stressors and other stressors such as climate change (bleaching, ocean acidification) and fishing/harvesting and their interaction are yet to be resolved. Predicted changes in the climate both globally and for the GBR are an increase in the frequency of extreme weather events including heat periods and cold snaps, more intense cyclones, and more frequent droughts alternating with severe floods. Overall, the changing climate as observed and/or predicted within the GBR region will increase the frequency with which coral reefs are being disturbed and thus the ability of the GBR to recover from perturbations.

Current evidence for interactions between potential climate change, major land use change and water quality include:

6.1 Increasing concentrations of CO_2 in the atmosphere lead to a reduction in the pH of seawater ('ocean acidification') which reduces the ability of corals and other calcifying organisms to grow, and diminishes the capacity of coral reefs to withstand erosion and storms.

6.2 Warmer waters lead to changes in the growth rates in most species and altered food availability and ecological functions within GBR ecosystems.

6.3 Increased rainfall variability and intensity of weather events (droughts, floods etc) will make land management more difficult and increase the risks of soil erosion and loss, thus increasing loads of sediment and nutrients discharged into the GBR lagoon. Droughts reduce vegetation cover and expose soils to higher erosional losses to freshwater and marine environments during floods. Changing hydrology may have severe effects on catchment water quality.

6.4 Storm energy increases with the cube of wind speed and some forms of storm damage (e.g., the dislodgement of large massive corals) are only observed at cyclone categories three or higher.

6.5 Successful coral reproduction and recruitment is needed to compensate for the predicted increase in coral mortality resulting from bleaching, cyclones, floods and crown-of-thorns outbreaks. Good water quality is essential for successful coral reproduction and the survival of coral recruits on inshore reefs, and for keeping macroalgal cover low. Managing inputs of nutrients, sediments and pesticides is therefore considered essential to facilitate resilience during climate change.

6.6 Any reduction in the abundance and diversity of grazing fishes strongly influences the balance between macroalgal and coral cover. This has been shown to influence the rate at which coral reefs recover after bleaching events.

6.7 Increasing pressure for agricultural industries to seek alternative and viable ventures will lead to major land use change in the GBR catchments, which is likely to have implications for the amount of nutrients, sediments and pesticides discharged to the GBR.

7. Effective science coordination to collate, synthesise and integrate disparate knowledge across disciplines is urgently needed.

Effective science coordination to collate, synthesise and integrate disparate knowledge across disciplines is currently limited and inadequate, and is needed as a matter of urgency to manage GBR water quality. Science integration is the key to informing management decisions for the Reef Plan, and is required to understand and quantify the following links between the system components that determine GBR water quality and ecosystem health:

- within and across catchments of the GBR, so that the linkages between catchment actions and the health of catchments and the GBR can be quantified
- between biophysical, social and economic variables so that realistic targets and implementation strategies can be developed and assessed
- across local to regional to GBR scales, to determine whether existing and proposed activities are sufficient to achieve the Reef Plan goal of reversing water quality declines within a 10-year timeframe.

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This document was prepared by an independent panel of scientists with expertise in Great Barrier Reef Water Quality.
This document does not represent government policy.

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