Sedimentation impacts in Moreton Bay: a priority knowledge synthesis

SEDIMENTATION

Sources and Issues

David Brewer Consulting

THE MORETON BAY FOUNDATION

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This impact statement is drawn from

Sedimentation Impacts in Moreton Bay, a priority knowledge-synthesis

The report was commissioned by The Moreton Bay Foundation in 2025 to summarise key evidence on how sedimentation affects Moreton Bay's coastal and marine ecosystems, and the ecological and cultural values they support. The report brings together published and grey literature, conceptual models, and expert review to provide a clear, high-level understanding of sedimentation pressures, their impacts, and remaining knowledge gaps.

This standalone document can be found in the full report. Where references are made to other sections, these are indicated by this symbol: †. A full list of external citations, data sources, and methods used in this document is included in the complete report, available at **moretonbayfoundation.org**

David Brewer Consulting (DBC) has prepared this report for The Moreton Bay Foundation under the contract titled 'TMBF Priority Knowledge Synthesis: Sedimentation Impacts in Moreton Bay'. Information about the Moreton Bay Foundation can be found at: https://moretonbayfoundation.org/

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Sedimentation – Sources and Issues

Moreton Bay faces a significant challenge from sedimentation, which can profoundly impact the Bay's ecosystem health. This is primarily driven by human-induced land-use changes in its vast catchment and exacerbated during episodic flood events (Grinham *et al*., 2024; Coates-Marnane *et al*., 2020). A summary of the sediment sources, transport, deposition, remobilisation, impacts and challenges is presented below.

Sediment sources

Sedimentation involves a cycle of input (from a source or sources), transport, deposition and remobilisation of sediments. Sedimentation in Moreton Bay is predominantly catchment-derived, originating from an expansive catchment area of approximately 21,220–22,000 km^2 (Coates-Marnane *et al*., 2020) (Figure 1). Since European settlement, substantial human disturbance, including large-scale clearing of native woody vegetation for agriculture and grazing from the late 1700s, has destabilised the channel network and dramatically increased sediment supply (Coates-Marnane *et al*., 2020; Grinham *et al*., 2024; Olley *et al*., 2024). Approximately two-thirds of the native woody vegetation in the region has been cleared since European settlement (Olley *et al*., 2024).

Current sediment export rates vary and are estimated to be four to five times (Diggles, 2013), 30 times (Leigh *et al*., 2013), or even 100 times (Saeck *et al*., 2019b; Olley *et al*., 2024) greater than pre-European settlement levels, leading to a three-to-nine-fold increase in sediment accretion over the last century.

Geochemistry and fallout radionuclide research (Laceby *et al*., 2015) demonstrate that channel and gully erosion are now the primary sedimentation sources, accounting for over 90% of sediment supply, with surface soil erosion being a minor contributor (Kemp *et al*., 2019; Grinham *et al*., 2024; Olley *et al*., 2024). For example, in key sub-catchments like the Lockyer and Brisbane rivers, channel erosion contributed 99% of the sediment supply (Olley *et al*., 2013). Channel erosion also dominates sediment supply in other Bay catchment rivers, including Stanley (67%), Kobble (74%), Emu (99%), Cressbrook (99%), and North Pine (99%) (Olley *et al*., 2013). This highlights the need for management efforts to focus on stabilising the channel network (Olley *et al*., 2024).

Sediments enter the Bay from the catchments primarily in abrupt pulses during high-magnitude flood events (Grinham *et al*., 2024). The 2011 flood alone delivered an estimated 10–30 million tonnes of sediment, equivalent to at least 20–50 years of average annual delivery (Gibbes *et al*., 2014, Nielson, 2018). Following the major flood in 2022 a study demonstrated that fine sediment had been deposited across 98% of the Bay's benthic zone (Grinham *et al*., 2024).

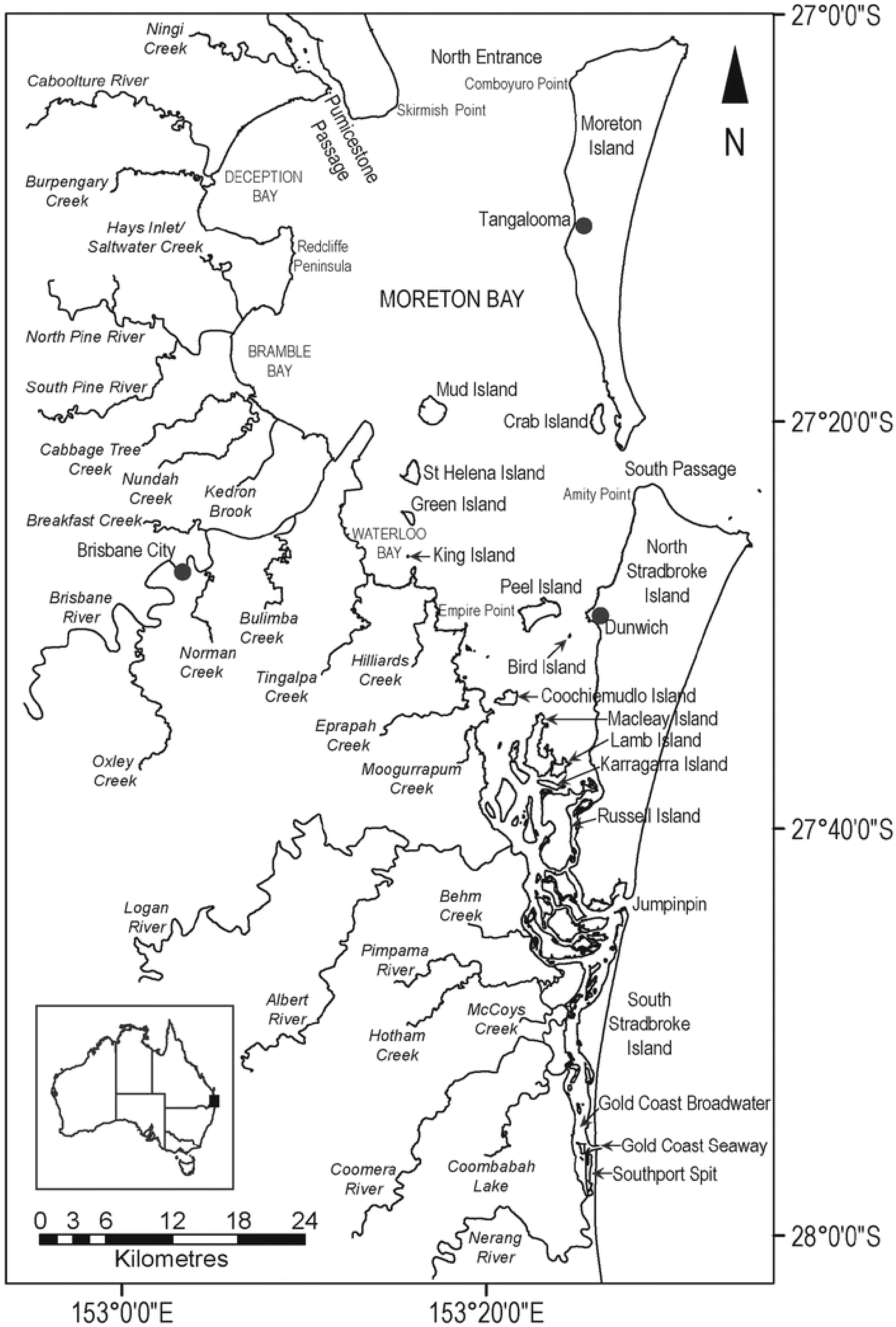

Figure 1. The Moreton Bay estuary illustrates the large catchment area, major river systems draining to the Bay and the major tidal entrances that connect the Bay to the adjacent Coral Sea (extract from Tibbetts et al., 2019).

Sediment transport, deposition, and remobilisation

Sedimentation in Moreton Bay is largely determined and controlled by major flood events, wind-wave sediment transport and remobilisation processes and tidal currents (Morelli and Gasperon, 2019, Beecroft *et al.*, 2024).

Large flood events are episodic determinants of sediment distribution into the Bay. After large floods, wind and waves rework and transport sediments from shallow coastal areas to deeper, central regions (or sediment sinks) of the Bay where they gradually accumulate (see below) (Morelli and Gasperon, 2019; Beecroft *et al.*, 2024). The Bay is hypothesised to be receiving sediment at a rate that exceeds its natural capacity to move material offshore. This is leading to the gradual infilling of deeper channels where fine sediments are more difficult to remobilise. (Coates-Marnane *et al.*, 2020; Grinham *et al.*, 2024; Saeck *et al.*, 2019a). Ongoing terrestrial sedimentation will exhaust the key sediment sinks within Moreton Bay, effectively reducing the system's ability to buffer future sedimentation events (Beecroft *et al.*, 2024).

Tide-induced resuspension is also a major driver of turbidity regimes and sediment transport within Moreton Bay. Upon entry to the Bay, fine sediments (silt and clay) suspended in the water from rivers cause elevated turbidity (a measure of suspended sediments) across central and northern Moreton Bay as buoyant, lower-salinity floodwaters spread over denser marine waters (Gibbes *et al.*, 2014; Coates-Marnane *et al.*, 2020; Grinham *et al.*, 2024).

Transport and dispersal of suspended sediments within the Bay are also influenced by an enduring northerly water movement on the western edge and tidal flushing through the north, south, and Gold Coast Seaway entrances (Gibbes *et al.*, 2014; Coates-Marnane *et al.*, 2020). General tidal circulation in the Bay is clockwise, tending south along Moreton Island and north along the landward margin of the Bay (Lybolt and Pandolfi, 2019). The dominant tidal flow and circulation in the Bay is through the northern entrance.

Sediments suspended in the water column fall through the water due to gravity and settle out or deposit on the ocean or estuary floor (Egan *et al.*, 2022). Predicting where suspended sediments will be transported and settle is complicated by the tendency for individual sediment particles to stick together, or "flocculate," which can cause them to settle more quickly. Factors like wave stress can promote floc breakup, while some biological processes may encourage floc growth (Egan *et al.*, 2022).

Fine sediments, once settled, result in higher mud content benthic areas. The western and southern parts of Moreton Bay receive the highest terrigenous (land-derived) sediment and nutrient input, leading to high mud content and consistently low water clarity (Gibbes *et al.*, 2014). The area of mud covering subtidal regions has roughly doubled since the 1970s (Coates-Marnane *et al.*, 2020). Over the last 50 years, fine sediment pollution has drastically reduced the surface area of clean sand by 93% (from 442 km^2 to 30 km^2), impacting over 98% of the benthic zone (Grinham *et al.*, 2024).

Sediments that accumulate in benthic depositional (often deeper) areas and are often referred to as 'legacy sediments' (Coates-Marnane *et al*., 2020; Grinham *et al*., 2024). Once deposited, these muddy legacy sediments, rich in organic matter and particulate nutrients, undergo microbial remineralisation, converting particulate nitrogen into dissolved ammonium (Grinham *et al*., 2024). This process creates a large standing pool of ammonium in sediment porewaters (water in the space between sediment particles), estimated at ~280 tonnes in the upper ten centimetres with concentrations typically three orders of magnitude higher than in the overlying surface waters (Grinham *et al*., 2024).

These deposited sediments are frequently remobilised through resuspension caused by tidal and wind events (Grinham *et al*., 2024). This mixes nutrient-enriched porewaters with the overlying water column, leading to episodic periods of elevated ammonium flux or movement and reduced light availability (Gibbes *et al*., 2014; Coates-Marnane *et al*., 2020; Grinham *et al*., 2024). Suspended sediments can then be transported to deeper areas or, through tidal flushing, moved outside the Bay into oceanic waters (Gibbes *et al*., 2014; Grinham *et al*., 2024).

Water residence times, which indicate tidal flushing rates, vary significantly across the Bay (Gibbes *et al*., 2014):

- Ocean boundaries: 3–5 days (highest flushing)
- Pumicestone Passage: 43–53 days
- Central Bay: 50–55 days
- Bramble Bay: 59–62 days
- Mouth of Brisbane River: 63–68 days
- Logan River: 66–75 days
- Lower Brisbane River: 110–120 days
- Middle Brisbane River: 154–162 days
- Bremer/Brisbane junction: 187–189 days (lowest flushing).

Areas with higher flushing rates and oceanic exchange, such as the ocean boundaries, experience higher rates of sediment transport out of the Bay into oceanic waters (Gibbes *et al*., 2014). Conversely, regions with longer residence times exhibit significantly reduced flushing, which contributes to these areas having the highest terrigenous sediment and nutrient input and lowest water clarity (Gibbes *et al*., 2014).

Impacts of sedimentation

The influx and remobilisation of sediments have widespread detrimental effects on Moreton Bay's ecosystem health, as outlined below:

1. Nutrient cycling and eutrophication

The remineralisation and resuspension of muddy sediments drive eutrophication across the entire Bay (Coates-Marnane *et al*., 2020; Grinham *et al*., 2024). An estimated 17,700 tonnes of ammonium (ranging from 13,525 to 21,860 tonnes) are released annually from sediments to the water column (Grinham *et al*., 2024). This constitutes about 35% of the Bay's water column nitrogen recycling budget and is 180 times higher than the annual ammonium discharge from the region's sewage treatment plants (Grinham *et al.*, 2024).

This elevated ammonium flux fuels the growth of phytoplankton, including bloom-forming marine planktonic diatoms (which have increased since the mid-20th century) and toxic algal blooms, such as *Lyngbya majuscula* (Leigh *et al.*, 2013). Excessive algal growth smothers vital seagrass meadows, a critical habitat for numerous marine species (e.g., dugongs and turtles), leading to biodiversity loss (Maxwell *et al.*, 2019; Grinham *et al.*, 2024).

Overall, increased siltation reduces water clarity, restricts sunlight penetration, decreases photosynthesis, smothers the benthos, and causes a shift from benthic to pelagic productivity (Saeck *et al.*, 2019a). The elevated levels of total nitrogen and organic carbon in muddy sediments mean these impacts can be sustained for prolonged periods, representing a long-term threat (Grinham *et al.*, 2024). The impacts of reduced water clarity, elevated nitrogen, and organic carbon on specific ecological groups are described in the main report **†**.

2. Contaminant mobilisation

Sediments act as a significant reservoir for trace metal contaminants such as lead (Pb), zinc (Zn), copper (Cu), cadmium (Cd), nickel (Ni), chromium (Cr), arsenic (As), and mercury (Hg) (Morelli and Gasparon, 2019). These trace metals, which can be toxic and persistent, bind to fine particles and organic matter in sediments (Morelli and Gasparon, 2019). When disturbed by natural events (such as storms and waves) or anthropogenic factors (like dredging), sediment-bound trace elements are liberated and become bioavailable, posing a threat to marine organisms (Coates-Marnane *et al.*, 2016a; Morelli and Gasparon, 2019; Townsend *et al.*, 2019).

The rising trends in Pb, Zn, Cd, and Ni are linked to Moreton Bay's catchment development, with metal concentrations increasing one to two orders of magnitude since 1920 (Morelli *et al.*, 2012). The concentrations of these trace metals in Moreton Bay are currently above natural background levels, indicating ecological deterioration (Morelli and Gasparon, 2019). The impacts of these metals, as well as pesticides, microplastics, and other pollutants, on mammals, sea turtles, and other ecological groups (e.g., see Grinham *et al.*, 2021; Yenney *et al.*, 2024; Okoffo *et al.*, 2024) are described in the main report **†**.

Challenges to recovery and future outlook

A critical concern is that large parts of Moreton Bay are not recovering from catchment sediment loads between major flood events (Lockington *et al.*, 2017; Saeck *et al.*, 2019a; Coates-Marnane *et al.*, 2020; Grinham *et al.*, 2024). The sheer volume of deposited sediments and ongoing resuspension requires extended periods of tidal flushing to reduce turbidity to average levels, resulting in relatively high turbidity levels for longer periods. This continuous cycle results in the gradual infilling of deeper areas, an increase in the extent of fine sediments, and progressively more turbid waters (Coates-Marnane *et al*., 2020; Grinham *et al*., 2024).

Future projections for population growth and climate change are likely to exacerbate the Bay's diminished capacity to recover from sedimentation impacts. Increased land disturbance, clearing and inadequate or poorly regulated catchment management associated with an increasing population in SEQ is likely to increase sediment catchment loads and increase sedimentation impacts in the decades ahead. The frequency of major flood events is also likely to increase due to climate change, thereby intensifying the delivery of sediment, nutrients, and trace metals (Grinham *et al*., 2024). This could lead to further expansion of muddy sediment classes and continued high rates of sediment ammonium flux and pollutants (Grinham *et al*., 2024).

Without effective catchment management, particularly focused on stabilising the channel network, the threat to Moreton Bay's ecosystem health from accelerated sedimentation and nutrient flux, is likely to persist or increase, especially given the projections of more frequent and intense floods (Grinham *et al*., 2024). Olley *et al*. (2006) conclude that achieving a 50% reduction in the supply of sediment and associated nutrients into Moreton Bay must be prioritised to maintain the Bay in its current condition. Deeper insights into management strategies and recommendations are dealt with in the main report (**† Section 5.17**).

Expert review

Associate Professor Alistair Grinham kindly provided an expert review of the Sedimentation sources and issues.

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This standalone document corresponds to **Section 4** of the full report. A full list of external citations, data sources, and methods used in this document is included in the complete report, available at

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Cover Images:
(Top) Raw.Exposed, photographer. (2022). Aerial view of flooding over Bellbowrie towards Riverhills, February 2022. In Aerial view of flooding over Bellbowrie towards Riverhills, February 2022. John Oxley Library, State Library of Queensland.
(Bottom) Photo credit: R. Porter

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