Returning the tide to East Trinity: an acid sulfate soil remediation case study and lessons for the future

Abstract:
What happens when you drain 700 ha of tidal wetlands/lowlands to grow sugar cane? An environmental disaster is the likely answer, if the situation at East Trinity Cairns is any indication!

There were unforseen and chronic environmental consequences when the East Trinity site was drained and tidal influence removed (by construction of a seawall) over 35 years ago. Unwittingly, potential acid sulfate soils were disturbed, resulting in a 30 year legacy of severe soil and water acidification, poor water quality and fish kills in this area adjacent to declared fisheries habitat and the Great Barrier Reef Marine Park.

Since 2001, the State government has been implementing an innovative acid sulfate soil remediation plan based on lime-assisted tidal exchange. This has led to improved water quality and aquatic health in the lower reaches of the site.

There are an estimated 2.3 Mha of acid sulfate soils along the Queensland coastline—a coastline under increasing development pressure. If similar mistakes are to be avoided in the future then continued and coordinated acid sulfate soil mapping, research, education and management are as essential as good planning.

Introduction:
The East Trinity site represents a legacy of past mistakes, made by well-meaning but ultimately misguided people. In the late 1960's/early 1970's, >700 ha of tidal wetlands and other lowlands below 5 m elevation close to Cairns CBD were drained in order to grow sugar cane. A 7.4 km earthen sea-wall was built to prevent egress of tidal water onto the site, an extensive drainage network was constructed, and tidal creeks were either cut off or floodgated. The first laser-levelling in Australia took place on the site. However, the scientists advising the sugar mill were blissfully unaware/ignorant of the potential acid sulfate soils that lurked below the surface.

Potential Acid sulfate soils are typically near-coastal soils and sediments that have formed within the last 10 000 year that also contain sedimentary pyrite or iron disulfide (FeS_2). If undisturbed/not drained, these soils remain environmentally benign, but if air is allowed in, the soil acidifies, generating copious quantities of sulfuric acid, iron and other metals. In due course, the cane failed, as did various subsequent attempts at residential development. The ultimate consequence of this oversight was the contamination of the East Trinity site (and indeed parts of the Trinity Inlet) with acid, iron, aluminium and other toxic metals, reflected in major fish kills and disease.

Objectives*:* In May 2000, the Queensland Government purchased the site with the aim of maintaining the green backdrop to Cairns, and addressing the extreme acid sulfate soil (ASS) problem on the site. The Department of Natural Resources and Water (with the assistance of site custodians, the Environmental Protection Agency) was charged with the job of remediating the site and stemming the flow of acidic water and metals from the site.

If the site had been treated using conventional techniques/approaches (involving mixing the entire acidified soil mass with sufficient agricultural lime, $CaCO_3$, to neutralise both current and future acidity), it would have cost an estimated $62 M (Smith *et al*. 2003). (This was the cost of lime only, not including the labour and capital equipment needed to mix the lime). Such an approach is both costly and impractical. It would have totally destroyed any of the site's environmental values.

Our group tested an innovative and much less expensive approach, which involved the controlled re-introduction of tidal influence on site, augmented by addition of hydrated lime (i.e. $Ca(OH)_2$), or what we have termed lime-assisted tidal exchange (LATE). A crucial step prior to implementing this strategy was a thorough and detailed site investigation and characterisation of soil, surface water and groundwater.

Policy/Legislation:
When the State Government purchased the site, calls for a temporary State Planning Policy on Acid Sulfate Soils had started, and by November 2002 a permanent SPP (SPP2/02) was in place. The position statement in SPP2/02 says “the Queensland Government considers that development involving acid sulfate soils in low-lying coastal areas should be planned and managed to avoid potential adverse effects on the natural and built environment (including infrastructure) and human health”. Our State’s SPP is the only one of it’s kind that we are aware—and an object of approbation by those we have talked to at international conferences. No doubt the State’s purchase and remediation of the site is consistent with its position statement.

Methodology:
It was vital that this strategy was implemented in a controlled and safe manner, given that the site is next to declared Fisheries Habitat and its waters flow into the nearby Great Barrier Reef Marine Park World Heritage Area. With the reintroduction of tidal water (initially in the Hill’s Creek catchment) there was risk of mobilisation of large amounts of acidity and soluble metals. Water was treated by addition of a hydrated lime slurry on both incoming and outgoing tides, using purpose-built dosing equipment. Water quality (pH, EC, dissolved oxygen, temperature) was continuously monitored in real time where it entered/exited the site, as well as at a number of other locations (e.g. drain confluences). Regular water sampling and analysis was performed to ensure that iron, aluminium and other metals were precipitated, rather that leaving the site on a soluble and/or toxic form.

Results or outcomes: Our lime-assisted tidal exchange approach has proved very successful in the Hill’s Creek catchment, with water of consistently good quality (e.g. pH >6) leaving the site, colonisation of mangroves and improvements in fish stocks and diversity. Tidal exchange in the Magazine/Firewood Creek catchment has recently begun and is being monitored in a similar fashion.

Our work is funded until June 2009, by which time we hope that the water no longer requires active lime treatment. During our work we have collaborated closely with other government departments (both State and Federal) as well as CSIRO and local universities. We plan to continue this collaboration within the framework of the CRC CARE (Cooperative Research Centre for Contamination Assessment and Remediation of the Environment), with East Trinity recently accepted as a National Demonstration Site.

Collaboration has been essential to the success of the project. The project’s scope was so broad that any person or group of people could not possibly possess all the experience and knowledge necessary. Continuous (as well as long-term) water quality monitoring is essential for a proper understanding of an aquatic system. Simple grab sampling will likely give you a flawed (if not even erroneous) impression of what is going on. We have learnt that despite our best intentions, it is sometimes impossible to work during a North Queensland wet season, but also that persistence pays off. We have learnt that mechanical and electrical equipment will break/rust at regular intervals and that an acidic salty environment such as at East Trinity is the ultimate test for any field equipment—if it works/survives at East Trinity it will work/survive anywhere. Conversely, a mistake we made was to rely on warranties on equipment provided by some suppliers. It got to the stage where our site was the only one in Australia where they wouldn’t supply a warranty with their products! Another miscalculation was to underestimate the time it can take to get things done in a tropical environment.

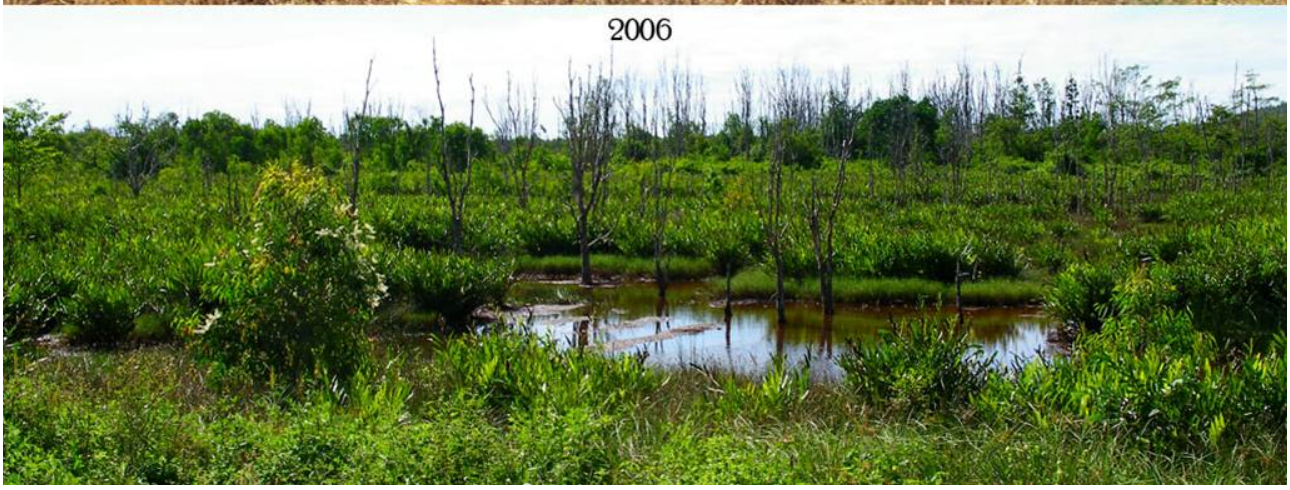
Conclusion:
Whilst our ultimate goals of improving water quality and concomitant environmental values (e.g. increased diversity in flora and fauna) are being reached at East Trinity, it has not been without considerable effort by many committed people and it has not been cheap. It should serve as a salutary lesson that while man can drastically/dramatically change an environment in a short time, unintended consequences can prove difficult, time-consuming and costly to reverse or mitigate. Development needs to be done in sympathy with the environment, and with a complete understanding of its potential impacts and effects. There are an estimated 2.3 Mha of acid sulfate

soils along the Queensland coastline—a coastline under increasing development pressure. If similar mistakes are to be avoided in the future then continued and coordinated acid sulfate soil mapping, research, education and management are as essential as good planning.

Photo 1

This water treatment machine is light-weight and highly portable making it useful for getting into boggy acidified areas to treat drains that larger equipment cannot get to. This unit also sucks acidified water from the drain and mixes it with hydrated lime [$Ca(OH)_2$] before returning the high pH slurry to the drain.

Photo 2



This area receives consistent tidal inundation and the change from the acid-affected terrestrial vegetation (*Melaleucas*, dead grass and iron staining) to marine vegetation (mangrove fern and saltwater couch) is obvious.

References:

Smith CD, Martens MA, Ahern CR, Eldershaw VJ, Powell B, Barry EV, Hopgood GL (2003) *Demonstration of Management and Rehabilitation of Acid Sulfate Soils at East trinity: Technical Report*. Department of Natural Resources and Mines, Indooroopilly, Queensland, Australia.

Powell B, Ahern CR (1999). *QASSMAC Acid Sulfate Soils Management Strategy of Queensland*. QASSMAC and Queensland Department of Natural Resources, Indooroopilly, Queensland.

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