MANAGING COASTAL ACID SULFATE SOILS: THE EAST TRINITY EXAMPLE

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Between 1971 and 1975, a tropical estuarine wetland of some 700 ha at East Trinity, Cairns, north Queensland, was drained by construction of a bund wall and floodgates for the production of sugar cane (Figure 1). Crop yields were below expectation and problems were thought to be drainage and salt removal. Maximum planting of sugar cane occurred in 1981 and planting ceased in 1998. The land was sold for further development in the late 1980s and was eventually held by receivers until purchased by the Queensland government in 2000. Following the abandonment of much of the area for sugar cane production there was strong local debate on land use options through the 1980s and 1990s. There were a number of community and political divides, options ranged from full urban development to uncontrolled reflooding. The CSIRO has a long history of involvement with East Trinity, with research into both production and environmental issues. The Division of Environmental Mechanics initially investigated production problems in 1976. This study concentrated on drainage and salt removal and it was several years before acid sulfate soils (ASS) were identified. The Division of Soils and the Queensland Department of Primary Industries mapped the area including the acid sulfate soils during their joint Wet Coast soil survey. From 1995 to 1998, the area was a coastal ASS reference site as part of CSIRO's Coastal Zone Project. Following the 1995-1998 CSIRO study that confirmed the environmental hazard posed by the ASS on the site (Hicks *et al.* 1999), a workshop was held in Cairns to present the findings. This further fuelled the debate. The issue was resolved in 2000 when the Queensland government purchasing the land from the receivers and commenced the East Trinity Property Remediation and Management Project, including an "Acid Sulfate Soil Remediation Action Plan". In 2001, the Natural Heritage Trust funded a consortium to demonstrate the management and rehabilitation of the ASS (2001 to 2003). The CSIRO was part of the consortium investigating aspects of site remediation. CSIRO's role in this project was to develop the monitoring and evaluation framework and investigate the effect of reflooding on the soil chemistry and sediment, pore water interactions (Hicks & Fitzpatrick 2003). Site remediation works are ongoing.

We chose East Trinity as a coastal ASS reference site because little quantitative information was available on tropical ASS in Australia and the construction of the bund wall arbitrarily divided the existing soils and left adjacent undrained soils in their original condition, allowing paired measurements and samples to be taken. We identified wetland drainage as a significant source of carbon dioxide emission with a 20 y average emission rate of 150 t CO_2-e ha^{-1} y^{-1}. Drainage also resulted in massive acidification with about 110 ha having an average pH of 3.4 at 0.5 m below ground level (bgl) and a 20 y average acid production rate of $7x10^5$ moles H^+ ha^{-1} y^{-1} (Table 1). The site was discharging water that contained concentrations of aluminium, iron and zinc considered deleterious to aquatic ecosystems. Considerable stored acidity remained on the site. The solubility of various aluminium hydroxy sulfates controls aluminium activity. Seasonal reduction of iron resulted in increased sulfuric acid intensity, however, the pH was too low and for any decrease in acidity by carbonate formation and the system was not sufficiently reducing for sulfate reduction to occur. The net result was seasonal cycling between iron oxidation states (Hicks *et al.* 2002).

The remediation programme introduced controlled tidal exchange to the site. We found that 19 days of exchange lowered the profile redox status from a pe of >10 to <0 and decreased the acidity in the top 0.25 m of soil by displacing it to lower in the soil profile (Figure 2). Where tidal exchange was maintained over 2 years, the pH increased from around 3.2 to 4.9 and the soil profile became more reducing with the pe falling from around 4 to 0 (Figure 3). In the same area we investigated sediment pore water interactions. In waters affected by acid sulfate soil leachate, colloids and precipitates rich in iron oxyhydroxides represent a major sink for heavy metals and metalloids mobilised by the oxidation and acidification processes that occur in acid sulfate soils. When these materials are incorporated into sediments, they become reduced and the heavy metals and metalloids are mobilised and made available to sediment-dwelling biota. In the pore water profiles investigated, concentrations of many elements exceeded the ANZECC trigger values (ANZECC & ARMCANZ 2000) by orders of magnitude, so that the sediment remains hostile to benthic organisms. Figure 4 shows the pore water concentration profiles for iron and arsenic at 3 locations in the Firewood Creek catchment.

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Table 1: Soil profile stores of carbon, acidity and average annual loss over 21 and 19 years respectively for site 1 at East Trinity.

	Undrained (TM1)	Drained (TC1)	Average annual loss
Carbon ($t\ ha^{-1}$)	1 500	870	33
Acidity (moles $H^+\ ha^{-1}$)	2.6×10^7	1.3×10^7	7.0×10^5 (34 t $H_2SO_4\ ha^{-1}$)

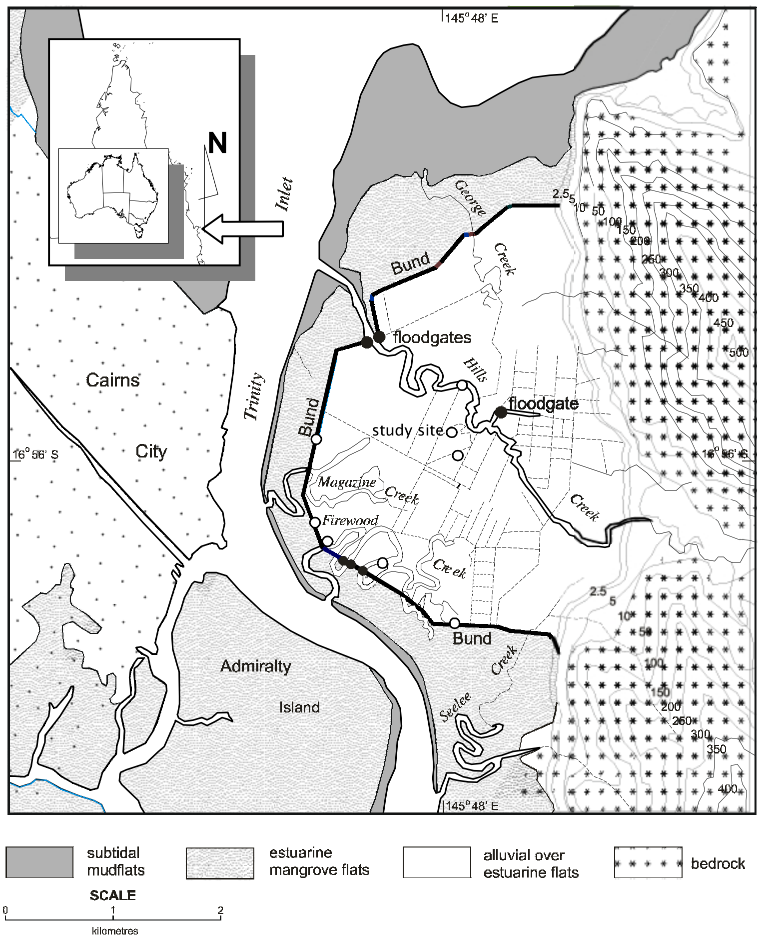

Figure 1: Map showing location of East Trinity, geomorphic features and location of study sites.

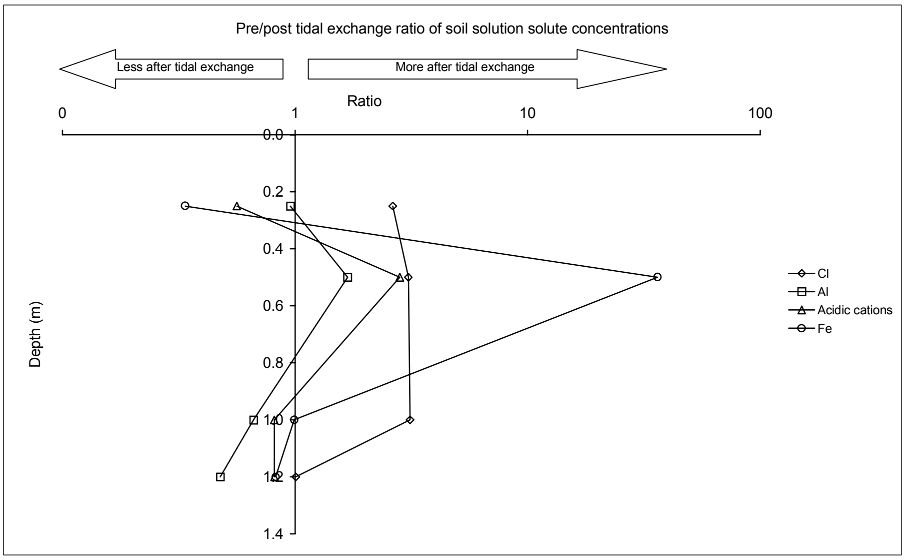

Figure 2: Change in distribution of solutes after 3 weeks of tidal exchange for a soil profile in Hills Ck., catchment.

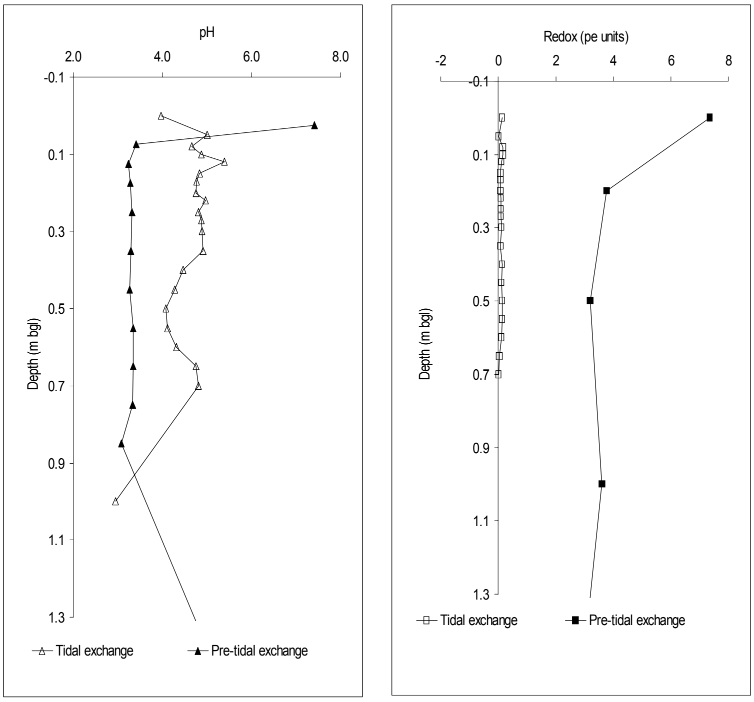

Figure 3: Soil pH and redox profile for upper Firewood Ck. contrasting pre-exchange 1995 and 1998 conditions with those following regular tidal exchange.

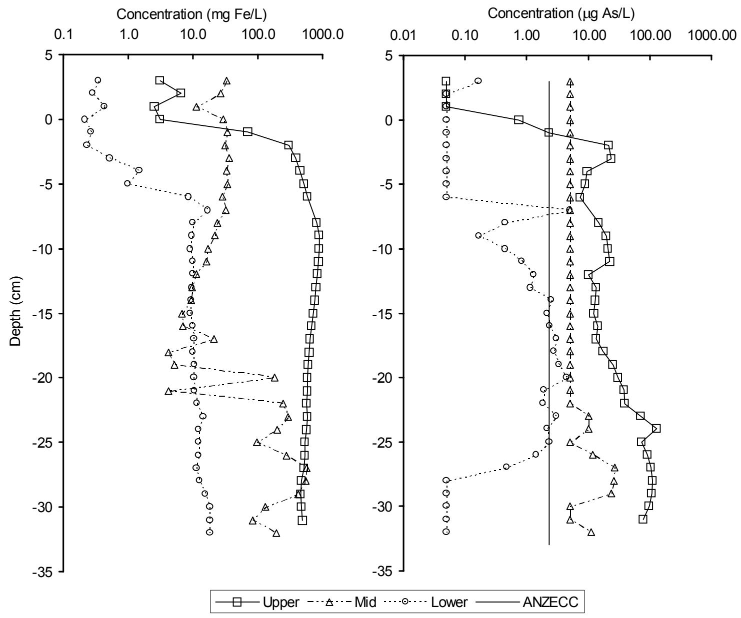

Figure 4: Pore water concentration profiles of iron (mg/L) and arsenic (µg/L) for three sites in the Firewood Ck., catchment following 2 years of tidal exchange. ANZEEC trigger level is shown by the vertical line. Straight (vertical) sections of the profile represent the detection limit.