ASSAY
A NEWSLETTER ABOUT ACID SULFATE SOILS

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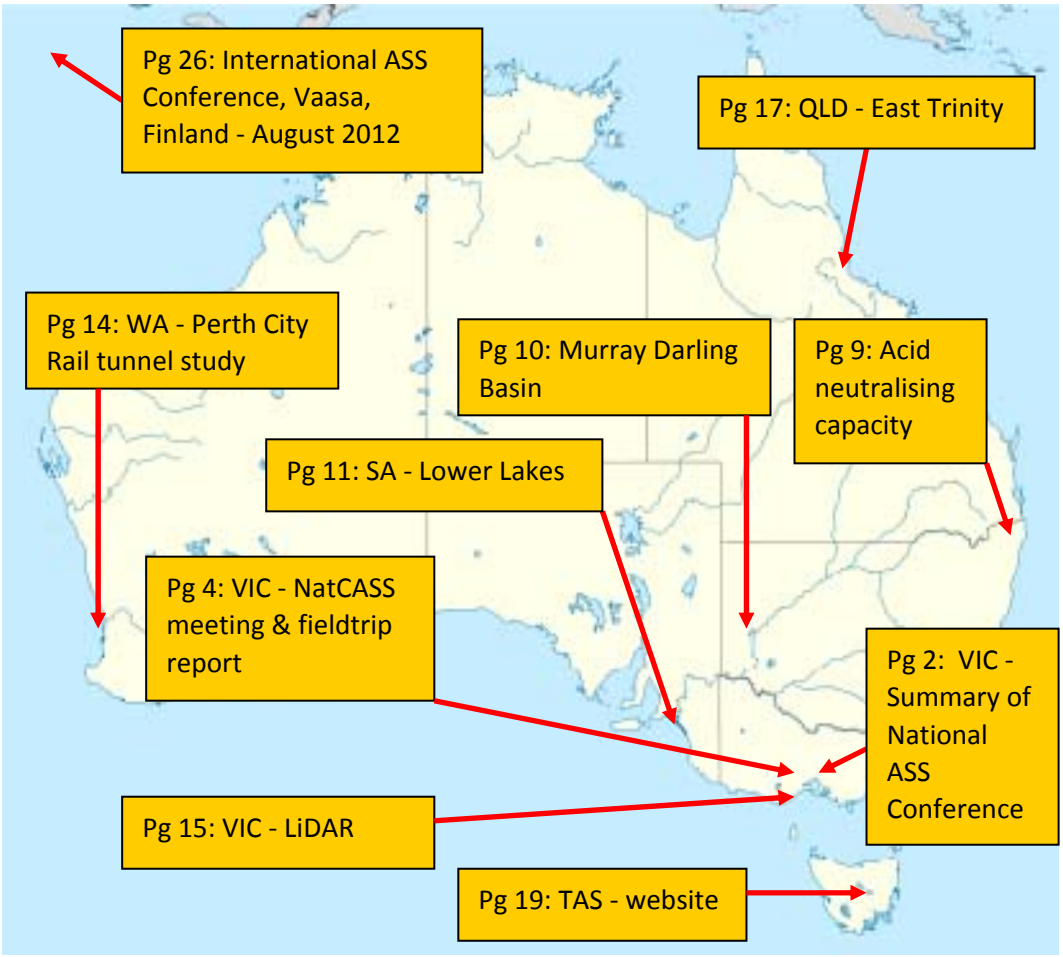
Successful National ASS Conference held in Melbourne

The 3rd National Conference on Acid Sulfate Soils was held in Melbourne earlier this month. Attracting 120 participants from around the country, the Conference was hosted by Southern Cross University's GeoScience Centre and provided an excellent benchmark for the current state of research, management and policy development in the ASS field across Australia. This issue of ASSAY will celebrate and showcase the Conference, by publishing a selection of abstracts and images from the event.

Some brief impressions from the Conference included some strong representation from the western side of the continent; understanding that the recent floods have not 'solved' inland acid sulfate soils; a range of innovative presentations on the chemistry of ASS and a very interesting field trip to Anglesea and Jarosite Beach. Details of these topics and many more are to be found inside…

Happy reading… Simon

Stories and places…



Summary of the 3rd National ASS Conference, Melbourne 6 - 7 March 2012

Bernie Powell, Chair of NatCASS

Given that 10 years has passed since the last specialist acid sulfate soil conference was held in Australia, is was timely that the 3rd National Acid Sulfate Soil Conference brought a renewed focus on a range of key issues and developments. With this in mind, the aim of the Conference was to provide a forum for federal, state and local government officers, researchers, consultants, developers, contractors, regional NRM boards and landcare groups to share experiences and knowledge of how to better understand and manage our acid sulfate soils.

Hosted by Southern Cross GeoScience, 120 enthusiastic delegates were welcomed by Conference Convenor Professor Leigh Sullivan and NatCASS Chair, Bernie Powell.

The Conference covered six program themes:

- Understanding the nature of ASS, their impacts and distribution (17 papers)
- Assessment techniques and laboratory analysis (10 papers)
- Policy, regulation and education (6 papers)
- Managing ASS and groundwater during development and mitigating the impacts (12 papers)

Delegates attending one of the plenary sessions

- Understanding inland ASS (11 papers)
- Broad acre remediation of ASS disturbance in wetlands and agricultural landscapes (9 papers).

Six plenary sessions were presented by leaders in their field on topics ranging from catchment-scale inland ASS management and reduced water flow impacts, to contaminated site issues and tunnel construction, to detailed iron-sulfur biogeochemistry. In addition there were 47 oral papers and 13 poster papers. Abstracts of the papers will be made available in the near future and publicised in the next issue of ASSAY.

The conference provided ample opportunities for networking.

The composition of Conference delegates was as follows: NSW 32, Vic 31, WA 20, Qld 18, SA 9, ACT 5, Tas 4.

Compared to previous ASS conferences, there were some clear contrasts. The Conference was organised by Southern Cross University and sponsorship was provided by industry, CRCs and a Federal Authority; whereas previous conferences were largely sponsored by Government.

By far the largest grouping of delegates were consultants (43), followed by State agencies (32) and research institutions (26). Local government authorities (6) and CMAs (4) had a presence, but impacted industries like fisheries, miners and farmers were represented by 2 or less. Only one Australian Government delegate attended. This breakup suggests that ASS activity in Australia has largely moved from being a 'political hot potato' to one of refining and implementing state and regional policies and regulations. The Conference papers in part reflected the crisis-driven priorities of drought-induced acidification in the Murray-Darling Basin and threats to groundwater in metropolitan Perth.

Plenary panel session with (L to R) Rob Fitzpatrick, David Sim, Leigh Sullivan, Bernie Powell & Stephen Wong

It was also noteworthy that R&D organisations and consultancies are increasingly working across both state and national borders to help understand and solve ASS problems.

The Conference was a great success in terms of sharing of insights, success and failures. The benefits of information sharing and collaboration were quite apparent to the enthusiastic delegates present.

It is important to recognise the leadership provided by Professor Leigh Sullivan who showed the initiative and accepted the challenges and risks that come with organising a national conference. He was ably supported by a team of officers at SCU Geoscience (in particular Chrisy Clay and Julie Burton) as well as an Advisory Committee (largely drawn from the NatCASS network).

NatCASS meeting – Melbourne, 5 March 2012

Simon Walsh & Bernie Powell

The most recent meeting of NatCASS (the National Committee for Acid Sulfate Soils) was held in Melbourne, immediately before the Conference on Monday 5th March.

NatCASS has the responsibility of facilitating implementation of the National Strategy for the Management of Coastal Acid Sulfate Soils. It also applies these same principles to the inland ASS environment. Its membership is comprised of representatives of the relevant Australian, state and territory government agencies, CSIRO, tertiary institutions and affected industries. NatCASS is chaired by Bernie Powell, the Queensland representative.

ASS news

There were a number of significant matters noted by the participating jurisdictions including:

WA

- DEC intends to increase the extent of risk mapping coverage for the coastal northwest of the state
- In recent rehabilitation of Lake Mealup (an important Ramsar site), the pH was 2.6 six months ago and is now 7, but this still requires ongoing management to maintain permanent inundation to provide for effective bird habitat
- Adaptive management guidelines for inland acidic drains are available on the Dept, of Water website: http://www.water.wa.gov.au/PublicationStore/first/91346.pdf

SA

- CSIRO commenced ongoing monitoring of acid sulfate soils at the Lower Lakes of the River Murray in 2007. Sampling is conducted on average every six months. Although the lakes are now full, the soils that were sulfuric at depth largely remain sulfuric. The monitoring allows SA to forecast the effects of future droughts.
- There have been cattle deaths in the areas due to scouring disease (magnesium sulfate).
- The Acid Sulfate Soils Centre (ASSC) commenced in January 2012 at the University of Adelaide with Prof. Rob Fitzpatrick as Director and Prof. Paul Shand as Deputy Director.

VIC

- The Surf Coast Shire has reviewed the Anglesea Structure Plan, endorsed January 2012. Any development below 5m AHD will need to address CASS.

TAS

- Rob Moreton continues to be involved in ASS issues strategically and as appropriate. He continues to work with stakeholders to ensure that the data delivery system is up to date. Tasmania is getting a good response from local government to that information.

QLD

- Queensland is still finishing off a SE Qld map of ASS bordering Deception Bay, which is part of a broader assessment of nutrients causing algal blooms.
- A short workshop was conducted on the Gold Coast for staff involved in the Gold Coast light rail

project.

- A government appointed scientific panel released a report in January 2012 (http://www.derm.qld.gov.au/gladstone/pdf/gladstone-sap-report.pdf), which failed to clearly identify the root cause/s of the fish death and disease in Gladstone Harbour, but gave a number of recommendations. The Qld Government responded to the report with a document released on the DERM website. http://www.derm.qld.gov.au/gladstone/pdf/gov-response-to-sap.pdf)

NSW

- CMAs are reviewing catchment management plans. The focus is on reducing drainage efficiency using scientific facts, e.g. shallowing out drains and other things that have meaningful hydrological impact.
- Yarrahappini rehabilitation site, Macleay River: of five floodgates – three have been totally removed. Only one of the five gates is now fully gated.

ISO Standards for ASS analysis—ISO TC190 (Soil Quality) SC3 (Chemical methods and soil characteristics) have released ISO CD 14388 (an ISO Committee Draft on ASS comprising 3 parts, the first dealing with terminology, soil preparation and ABA, and parts 2 and 3 concerning Chromium and SPOCAS suites of analysis) for comment and voting. Once consensus has been achieved, it is submitted as a draft international standard (DIS), then as a final draft international standard (FDIS) for final voting, approval and ultimate publication by the ISO central secretariat.

Next NatCASS meeting

The next meeting will be held in Adelaide. Dates have been tentatively set for 25 - 26 October 2012.

Fieldtrip report

The NatCASS fieldtrip component was held in tandem with the trip arranged as part of the Conference. The day was organised by Southern Cross GeoScience, in partnership with the Victorian delegates. The following information is based on that provided in the fieldtrip handouts.

Anglesea estuary

The first site visited was the estuary at Anglesea. This has been the site of a series of controversial fish kills, most recently in September 2010, which have previously been reported in ASSAY (# 58 and # 54).

Fieldtrip participants visit the Anglesea estuary

The Anglesea River and its tributaries flow over coal bearing Tertiary sediments before entering the estuary at Anglesea. The estuary sits in a defined valley and is fringed with peat swamps. When open, the estuary exits to the sea over a sand bar. It is fronted by a coastal barrier of calcareous sands. The estuary's swampy flood plain was modified during the Ash Wednesday fires in 1983, i.e. canals were excavated in the peat to contain the fire.

The limit of the modern tidal influence and that of the mid-Holocene sea stand, has been modified. A concrete barrier was built across the outlet in the early to mid 20th Century. A sand bar usually covers the concrete barrier.

The estuary of the Anglesea River has a history of poor water quality. For example, there have been events where fish kills have occurred, extreme acidities have been recorded and un-natural colouration of water has been observed.

Soil pH indications taken from the lower Anglesea estuary on the field excursion

Consequently, there have been a number of studies by under-graduate students and post-graduate students from Deakin University, and by ALCOA and the Victorian EPA to understand how and why these events occurred. For example, Adam Pope and Tim Tut recently completed PhD's on research in this estuary.

The hydrology and chemistry of acidic waters generated by and entering this estuary make it a complex study area. Further information can be gained from the following hyperlinks and references:

Anglesea River water quality review – Prof. William Maher – Oct 2011

May 2011 Community update – Corangamite CMA

Documenting fish assemblages in the Anglesea River after acidification

Hermon, K. (2002). The cause/s of the acidification of the Anglesea River Victoria. BSc Thesis, Deakin University.

Lithgow, S. (2007). The Source of Acid Run Events in the Anglesea River and its Tributaries. BSc (Hons) Thesis, Deakin University.

Meyrick, J. (1999). Trace element distribution and speciation in the Anglesea River. BSC (Hons) Thesis, Deakin University.

Jarosite Beach

The second site visited on the field trip was the very appropriately named Jarosite Beach. It is located between Torquay and Anglesea, on the boundary of the Great Otway and the Port Addis Marine National Parks. The world famous surfing destination of Bells Beach is the next beach to the north-east. The cliffs at the site contain naturally-occurring segregations of jarosite, the abundance and purity of which are remarkable.

The yellow jarosite occurs in segregations up to 4 cm in size within the weathered materials. These jarosite-rich layers also contain abundant gypsum crystals existing in masses of large of large crystals, but also as vertically-oriented planes ~ 6mm in width. The pH (1:5, soil:water) of the jarositic

segregations was 6.1 which is high given that most jarosite in contemporary acid sulfate soil layers occurs in sulfuric soil matrices with pHs <4.

Iron mineral-cemented segregations and bands up to 10cm thick are also common on the exposed cliff surfaces within these jarositic-rich layers. The pH (1:5, soil:water) of the iron mineral-cemented bands was 4.1.

X-ray diffractions of the jarositic segregations indicates the dominance of natrojarosite (i.e. $NaFe^{3+}_3(SO_4)_2(OH)_6$ a sodium-rich form of jarosite (although generally natrojarosites contain K in place of the Na) along with minor amounts of gypsum and quartz (SiO_2).

In the 1920s a company called 'Jarosite Products' mined the jarosite from the exposed cliffs around Jarosite Headland. The Victorian Heritage Database states that: *"Remains of 1920s open cut jarosite mine in the cliffs on the coast. The cliff was cut down in an open cut manner and was possibly centred on a gully. A tramway in the centre of the excavated area carried the excavated material inland. Nothing remains of the line itself, but the bed is quite clear.*

There is an iron rod embedded in the rock at the end above the cliffs. At the unloading end are the concrete bases for plant machinery, whilst nearby is an in-ground concrete tank. Further inland is a small dam… Jarosite (red ochre) was used for paint but the lack of demand during the Depression caused the mine to cease operating in 1929."

Features at Jarosite Beach

A jetty at Jarosite Reef (although no longer remaining) was used to load the processed jarosite onto ships for transport. It is of interest that the information from the Victorian Heritage Database indicates that the jarosite mined was 'red ochre'. Elsewhere in the 'grey' literature relating to this mine it is indicated that these 'red ores' were used to paint Melbourne's "red rattler" trains which were

decommissioned in the 1980s. Presumably, the yellow jarosite was heat-treated at the processing site for conversion to the strongly pigmenting iron oxide, hematite.

Some of the implications of jarosite occurring widely in landscapes as a result of natural oxidative processes rather than human-induced oxidative processes, for the recognition of acid sulfate soils are clear.

Layers of natrojarosite at Jarosite Beach, Victoria

For example, commonly relied upon indicators of human activity-accelerated sulfide oxidation- such as the use of depressed chloride:sulfate ratios, pH, and acidity in drainage or soil waters – will be less reliable when applied in landscapes such as the Anglesea region where iron sulfide oxidation driven by natural processes has occurred throughout significant proportions of the landscape in the past (as evidenced by the widespread occurrence of abundant natrojarosite in the Demons Bluff Formation) and indeed may still be occurring in this formation and the underlying Eastern View Formation, both of which (especially the Eastern View Formation) drain into the Anglesea catchment.

Different approaches for the unambiguous recognition of acid sulfate soil disturbance 'signals' will also have to be developed and used in such regions.

Such approaches may include the possible discrimination of the sulfate deriving from sulfide oxidation of (in this region) Oligocene and older sources, from the sulfate derived from sulfide oxidation of more recent sources (e.g. Holocene sediments) by, for example, the use of stable sulfur isotopes where distinct differences exist between sources.

The occurrence of conspicuous jarosite (more precisely, natrojarosite) segregations in the cliffs adjacent Southside Beach provides a relatively rare opportunity to observe in a natural setting, minerals that commonly occur in sulfuric acid sulfate soil materials as a result of contemporary disturbance of sulfidic soils and sediments.

The presence of such materials has the potential to complicate recognition of acid sulfate soil-related issues in these regions and this will need to be taken into account when managing these issues.

Assessing acid sulfate soil neutralising capacity: a new approach

Leigh Sullivan, Kim Watling, Salirian Claff, Richard Bush, Ed Burton, Scott Johnston, Col Ahern & Angus McElnea

Acid Base Accounting (ABA) is the method accepted by industry to determine the acidity hazard of acid sulfate soil materials (Ahern, McElnea and Sullivan, 2004). The current ABA equation is:

Net acidity = potential sulfuric acidity + existing acidity – acid neutralising capacity/FF

Current methods for the assessment of acid neutralising capacity (ANC) are not well accepted by industry and regulators. One of the main aims of this study has been to provide industry with a suitable and more accurate and reliable method for ANC determination. The new ANC assessment method is as below:

ANC = Titratable Actual Alkalinity + Effective Carbonate

Titratable Actual Alkalinity (TAAlk)

The contrary measure to Titratable Actual Acidity (TAA), i.e. readily available alkalinity of acid sulfate soil materials, has never previously been measured separately. Whereas TAA is the acidity released by acidic soil materials to a 1M KCl solution and determined by titration with NaOH up to a pH of 6.5, TAAlk is simply the alkalinity released by alkaline soil materials to a 1M KCl solution and determined by titration down to a pH of 6.5.

Effective Carbonate (eCarb)

The appropriate particle size range of carbonate liming materials that can effectively neutralise either 1) the existing acidity or 2) the potential acidity production within acid sulfate soils has – prior to this study – never been determined.

Methods

Incubation/remediation trials using representative acid sulfate soil materials and nine particle size fractions of liming materials (ranging from <0.020 mm, up to 1.0–2.0 mm) were used to provide the first data on liming efficacy in acid sulfate soil materials in relation to the particle size of liming agents, and form the basis of the Effective Carbonate determination method.

Results

The results show clearly that for effective prevention of acidification:

- in neutral or alkaline sulfidic material that is subject to oxidation, liming materials need to be <0.5 mm in size;
- in acidic soil material that has already been subject to oxidation, liming materials need to be <0.25 mm to be effective in remediating soil pH within 2 weeks, and <0.5 mm to be effective in remediating soil pH within 4 weeks.

A simple method for the determination of Effective Carbonate content is suggested by these results:

Effective Carbonate content is the carbonate content (as determined by standard carbonate analytical techniques) of the <0.5 mm fraction of unground soil material.

Finally, the data shows that the present TAAlk procedure includes a small contribution from the eCarb so to avoid double counting of alkalinity the following rules for ANC derivation apply:

1. If the soil material is not calcareous, then the ANC is equivalent to the TAAlk.

2. If the soil material is calcareous, then ANC should be taken as either the TAAlk or the eCarb, whichever is the greatest.

Conclusions

The new assessment procedures outlined here show a way forward to the development of more accurate and reliable determination of ANC in acid sulfate soil materials.

Acid sulfate soils in the Murray-Darling Basin

Rob Kingham, Darren Baldwin, Lucy Paterson & Dean Ansell

Record low inflows and river levels of recent years led to the drying of many permanent wetlands in the Murray-Darling Basin, resulting in the exposure of acid sulfate soils. The impacts of these soils had previously been an issue only at localised sites, but it became clear that acid sulfate soils may present a significantly larger scale issue in some parts of the basin.

In March 2008, the Murray-Darling Basin Ministerial Council agreed to support an assessment of the spatial occurrence of, and risk posed by, acid sulfate soils at priority wetlands in the River Murray system, Ramsar-listed wetlands and other key environmental sites in the Murray-Darling Basin.

Accumulations of monosulfidic material from the Richardson River near Donald, Victoria

Melanie Watts, North Central CMA

CSIRO staff field sampling wetlands during the detailed assessment phase of the MDB ASS Risk Assessment Project

Rob Kingham, MDBA

Over the following three years, a tiered assessment program was utilised, whereby priority wetlands were screened through a desktop assessment stage, followed by a rapid on-ground appraisal, and then detailed on-ground assessment if results of previous stages indicated an increased likelihood of occurrence of acid sulfate soils.

In all, over 19,000 wetlands received desktop assessment; 1,385 rapid on-ground assessments occurred, and nearly 200 wetlands and river reaches received detailed assessment, including 14 of the 16 Ramsar-listed wetlands of the Murray-Darling Basin.

The summary project report, Acid Sulfate Soils in the Murray-Darling Basin (MDBA 2011), was released in May 2011 and is available at: http://www.mdba.gov.au/services/publications/more-information?publicationid=96. This summary report, which is supported by more than 90 detailed reports, documents the following outcomes:

- Waterways found to contain acid sulfate soils at levels of concern were located in the southern part of the Murray-Darling Basin. Acid sulfate soils were extensive throughout many wetlands

along the lower River Murray in South Australia and in the western part of the Edward-Wakool River system in New South Wales. In Victoria, the affected sites appear localised around Mildura and in some areas impacted by dryland salinity.

- Of the Ramsar-listed wetlands, acid sulfate soils were found at levels that present a medium-to-high acidification, deoxygenation and/or metal release hazard at Banrock Station wetland complex, Riverland, some lakes in the Kerang Wetlands and (in a separate study) the Lower Lakes. While acid sulfate soils in the other Ramsar wetlands were at levels that do not currently pose a substantial hazard, it is noted that many had elevated levels of sulfate, indicating the potential for acid sulfate soils to form in the future if water levels in those wetlands are kept high for unnaturally long periods.

Many of the affected wetlands were re-flooded during the extensive floods of 2010–11. The impacts on water quality through re-flooding of acid sulfate soils were diluted by the size of the flood.

Despite the floods, acid sulfate soil materials are still likely to be present in many of the wetlands previously affected.

Furthermore, the underlying conditions, which caused the formation of acid sulfate soils in the first place, have not changed. Therefore, the ongoing risk posed by acid sulfate soils is unlikely to have been mitigated and hence will need to be managed.

Acid sulfate soils in a Little Toolunka Flat wetland near Waikerie, South Australia *Gerard Grealish, CSIRO*

Reports produced through the MDB ASS Risk Assessment Project are being published (55 reports available as at March 2012) at:

http://www.mdba.gov.au/bpkid/index.php?searchFunction=mainSearch&searchString=&selectcatchment=0&selectchapter=0&selectbodyofwork=141&InternalExternal=external&x=39&y=21

Consequences of reduced water flows to the Lower Murray region

Russell Seaman, Alec Rolston, Liz Barnett & Luke Mosely

The Coorong, Lower Lakes and Murray Mouth region is a complex ecosystem that encompasses riverine, lentic, wetland, terrestrial, littoral, freshwater, estuarine, marine and hypersaline habitats. It exists at the terminus of Australia's largest river system (Figure 1), the Murray-Darling, and was designated a Ramsar site in 1985. It is an Icon Site under The Living Murray Initiative, and will be listed as a Key Ecological Asset under the forthcoming Murray-Darling Basin Plan.

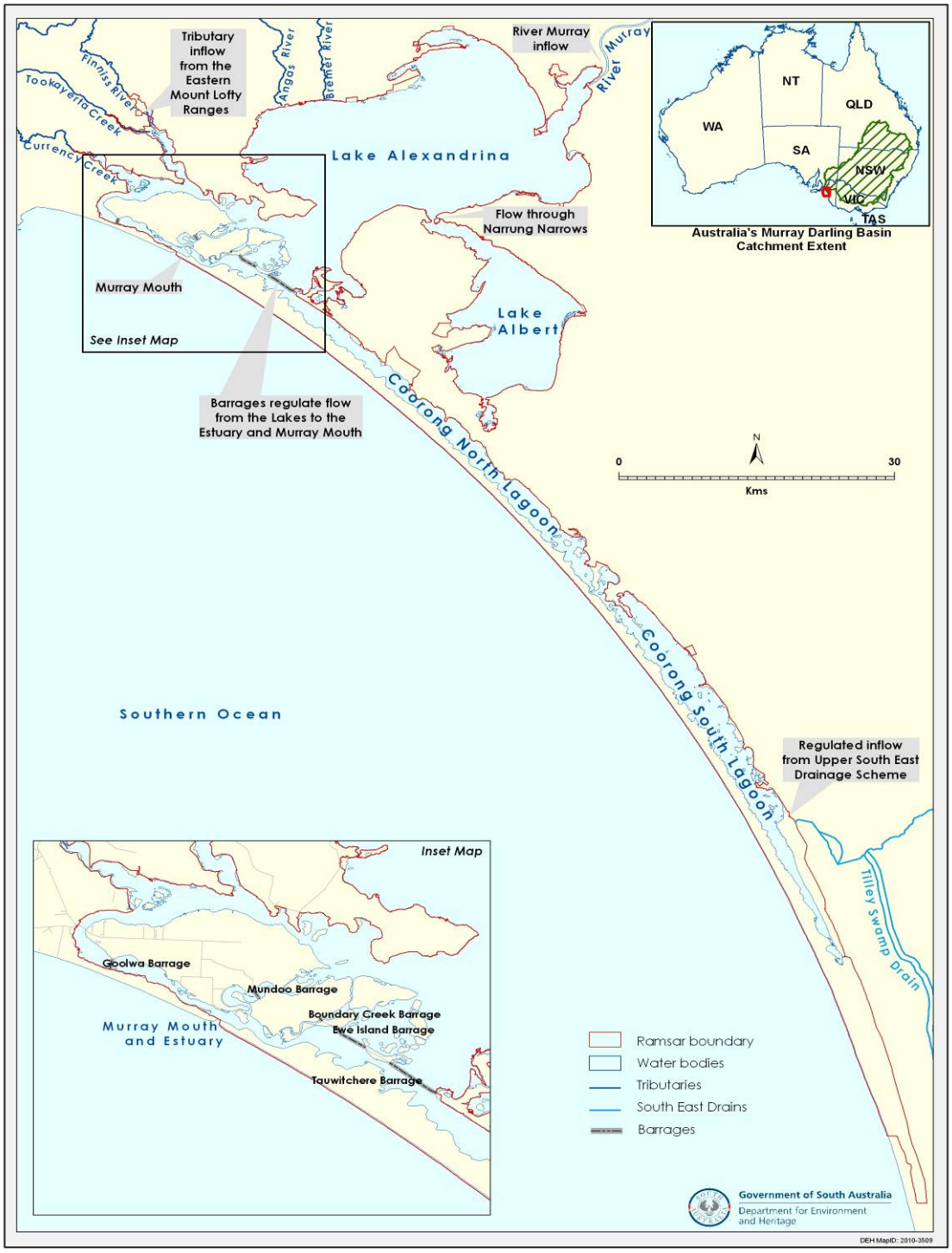


Figure 1: The Coorong, Lower Lakes and Murray Mouth region.

Between 2006 and 2010, River Murray flows were at historically low levels due to over-allocation and drought across the Murray-Darling Basin. As a result inflows into the Lower Lakes were not able to replenish evaporative losses and average lake levels dropped to unprecedented lows. In April 2009 average water levels were at their lowest in Lake Alexandrina, one metre below sea level (Figure 2). Evapo-concentration led to salinity levels in both lakes increasing beyond values normally associated with freshwater environments. At the height of the drought conditions in 2009, salinity in the Goolwa Channel region of Lake Alexandrina exceeded 25,000 EC units.

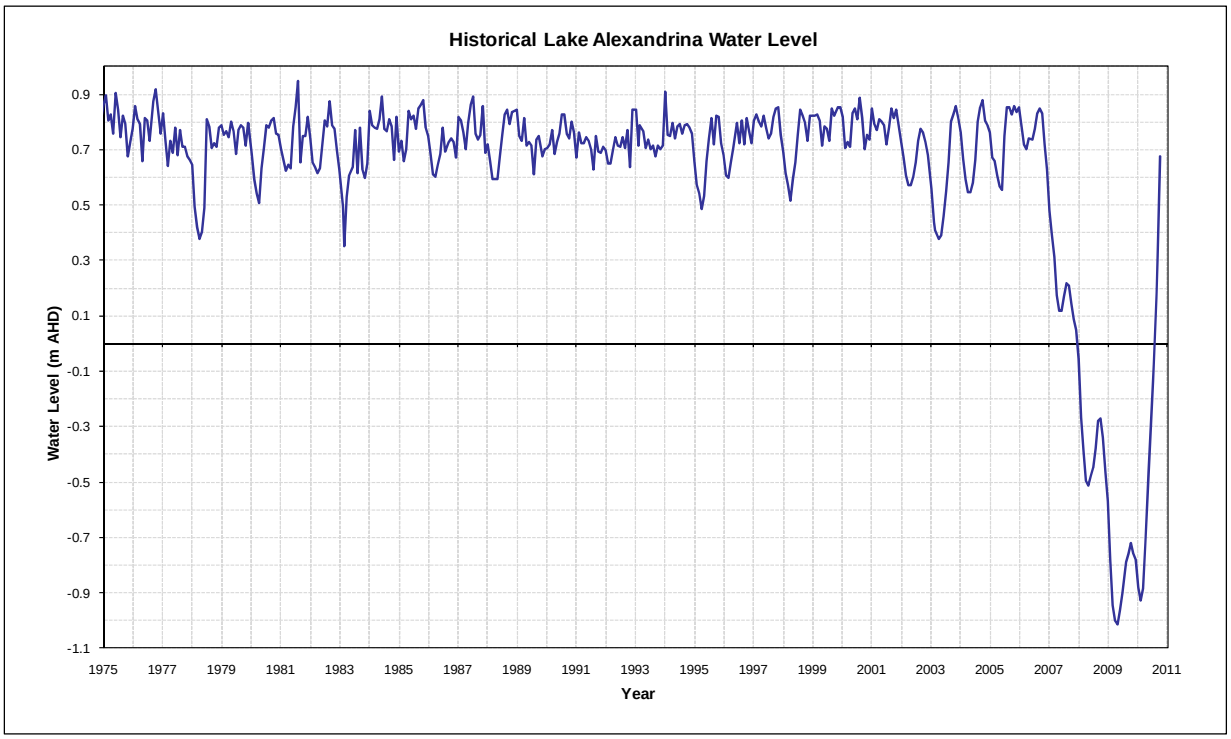


Figure 2: Lake Alexandrina water levels (1975–2011)

Low lake levels resulted in the exposure of previously submerged sulfidic sediments known as acid sulfate soils (ASS). By March 2009, over 20,000 hectares of ASS had been exposed in Lake Alexandrina and Lake Albert, posing substantial risks to the region's ecology and local communities. Acidic water of pH <3 pooled in some ASS hotspot areas, greatly impacting on hydrological condition.

Significant management actions were undertaken to mitigate the impacts of exposed ASS and to further reduce ASS exposure. A three-tiered approach was developed which included prevention measures to keep soils submerged, bioremediation to facilitate sulfate reduction and neutralisation to treat acid water.

The development of these management techniques required collaboration with many partners across Australia. The South Australian Department for Environment and Natural Resources and the South Australian Environmental Protection Agency coordinated research efforts and trialled recommendations on the ground. The process of going from scientific understanding to on-ground actions occurred rapidly. Modifications of management response were reviewed weekly subject to monitoring results and a truly adaptive management approach was undertaken.

The acid sulfate soil crisis within the region divided the community, however through active communication and involvement in defining the issues, community groups formed a critical loop in understanding the complexity of ASS in the region. One initiative involved an extensive community soil monitoring program developed with CSIRO that involved 85 people, undertook 51 surveys and collected 486 soil samples.

The use of vegetation to combat acidification by stabilising exposed lake beds and facilitating sulfate reduction through carbon addition, has provided other benefits aside from the management of ASS. The bioremediation project has now developed into a 5-year restoration program that utilises community nurseries and employs community members to undertake restoration actions.

The underlying principles of acid sulfate soil management underpin the majority of the future management of this region. The Murray Futures Program, funded by the Australian and South Australian

Governments has ensured that a legacy of a resilient community and a resilient environment will be achieved.

Editor's note

Part of Russell's presentation at the Conference included a short, but fascinating, YouTube video highlighting some of the impacts following the drying out of the Lower Lakes in 2009. The link to the video is here.

Case study of the City Rail Project, Perth 2003-2007

Eric Hudson-Smith

The City Rail project involved excavations and dewatering for 2.6 km length of twin track underground stations, bored tunnels and cut and cover tunnels and dive structures through Perth. These sites extended across a river foreshore reclamation, beneath the CBD and through a reclaimed shallow peat swamp which had become Perth Rail Yard, adjacent to the Perth Central Station.

Over 300,000 m^3 of soil was removed to build the tunnels and underground structures, of which around 200,000 m^3 turned out to be ASS, substantially more than expected.

Some of the ASS also incorporated contaminated soil, requiring disposal at Class 1 to 4 licensed landfills.

Major groundwater dewatering was required for excavations up to 17 m deep in 3 site areas involving a network of 70 dewatering bores with peak pumping at around 60 L/sec, together with 100 recharge wells required to limit drawdown in ASS areas and to prevent settlement damage to buildings.

Cut and cover tunnel construction through Perth's Swan River foreshore

The presentation discusses project planning ahead of construction, ASS and groundwater characteristics on site, ASS excavation, and spoil and dewatering management within the confines of a CBD environment.

The project involved a steep learning curve for many participants, including the author who was the client's Geotechnical Manager for the project duration. Technical challenges arose in managing spoil (235 soil "lots", involving some 15,000 semi trailer truckloads in about 18 months), groundwater dewatering, treatment and disposal, including managing the chemistry and operation of recharge wells.

Difficulties in administering commercial aspects of the contract relating to ASS and contaminated soil and groundwater will be discussed which resulted in disputes and litigation between project participants which were eventually settled before heading into court. Lessons learnt by the author regarding ASS and groundwater management on this challenging civil engineering project will be presented.

Tunnel Boring Machine at 17 m depth below CBD entering underground station at William Street.

Using high resolution DEM data to map Victoria's coastal acid sulfate soils

Doug Crawford

It is intended to show in an oral presentation, how expert interpretation of coastal geomorphology has been enhanced by new data from digital elevation models (DEM) derived from high resolution LiDAR sensors, and information on how Holocene sea-levels have varied (Sloss *et al*., 2007), to enable more accurate mapping of coastal acid sulfate soils (CASS) in Victoria.

CASS are difficult to map using traditional soil survey approaches. These approaches apply models based on surface features to map the upper solum. However, in CASS, the modern solum in the upper part of the soil profile typically overlies a relict soil which contains the sulfidic or sulfuric material.

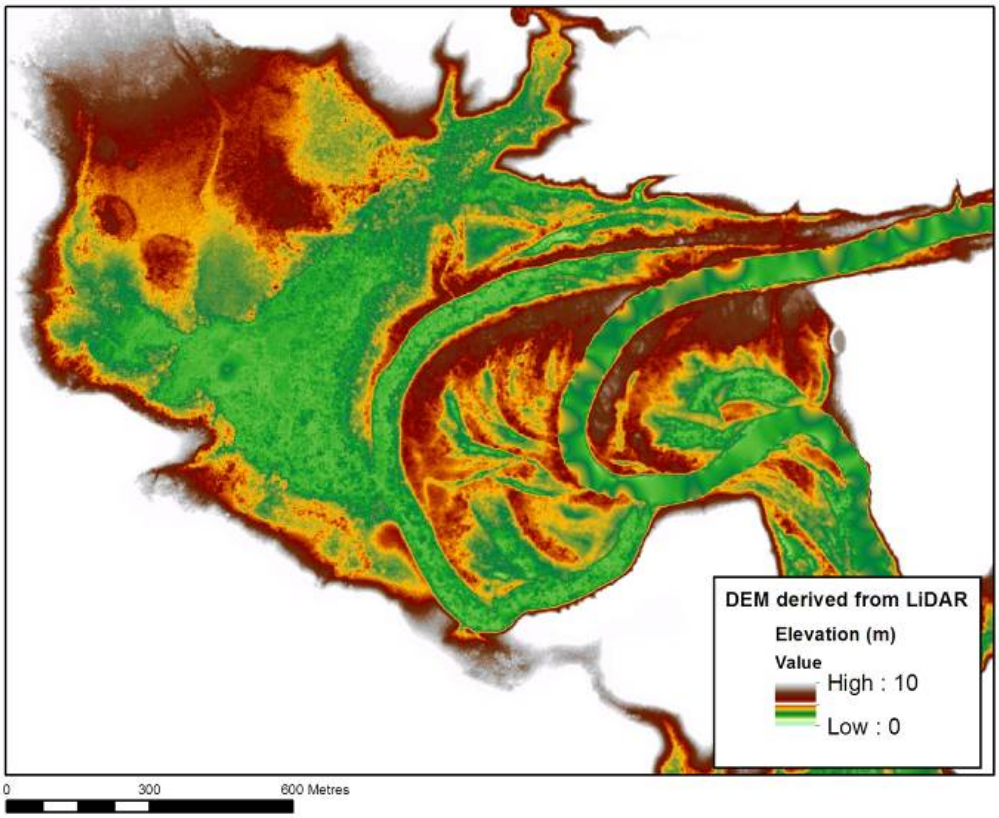
A key event for mapping coastal geomorphology, was the recent release of DEM data from high resolution LiDAR sensors collected along the length of Victoria's coast. This data included land from 0 m AHD to a height of at least 10 m AHD, at 1 m resolution and accurate to 10 cm elevation. This was used to identify features not previously detectable in the field or from other spatial information.

Sloss *et al.* (2007) presented data from which it can be interpreted that the mean sea-level was some 1.5 m higher than it is today, during the period 9,000 to 2,000 years ago. Therefore, we used a geomorphic understanding of how this change has affected coastal landscapes and water scapes together with new high resolution DEM data, to identify relict fluvial and littoral features that can potentially have CASS.

Reference

Sloss CR, Murray-Wallace CV, Jones BG (2007) Holocene sea level change on the southeast coast of Australia: A review. *Holocene* **17**, 999-1014.

Aerial photo, Cann River, Victoria – showing key geomorphic features.



LiDAR-derived image of the same location – showing greater level of interpretive detail such as relict channels (with potentially higher risk of CASS occurrence).

East Trinity case study

Doug Smith, Angus McElnea & Michelle Martins

The tidal exclusion and drainage of 700 hectares of mangroves and samphire plains for sugar cane production at East Trinity, Cairns was carried out in the 1970s – before any widespread awareness of acid sulfate soils (ASS).

The next thirty years witnessed inevitable environmental consequences of this ignorance, including the death of plants and biota (including several documented fish kills). The resultant landscape was characterised by acidic (pH<3), iron-stained soils, in which *Melaleuca* sp. thrived, at the expense of mangroves that had once grown there.

A CSIRO study in the late 1990s (Hicks *et al.* 1999) estimated that 68 000 tonnes of sulfuric acid had leached from a 130 ha section of the site since drainage. Subsequently, the Queensland State Government purchased the site with funding given to a remediation plan involving daily controlled, lime-assisted tidal exchange (LATE).

A crucial prerequisite to implementing the LATE strategy was to gain a thorough understanding firstly of the site's soils, stratigraphy, groundwater and surface water system, surface elevation, and tide dynamics. Secondly, equipment to treat and monitor tidal waters, as well as a means of controlling tidal volumes had to be put in place. The level of tidal inundation also had to be decided, considering a number of criteria, but predicated on the necessity for effective ASS remediation.

Practical issues, such as the need to protect neighbouring sugar and banana farms from salt intrusion, as well as the removal of large volumes of sand blocking one of the major creeks, also had to be addressed prior to commencing LATE. These practical challenges were the first of many that have continued to be encountered and overcome over the course of a remediation approach that had never been attempted on such a grand scale.

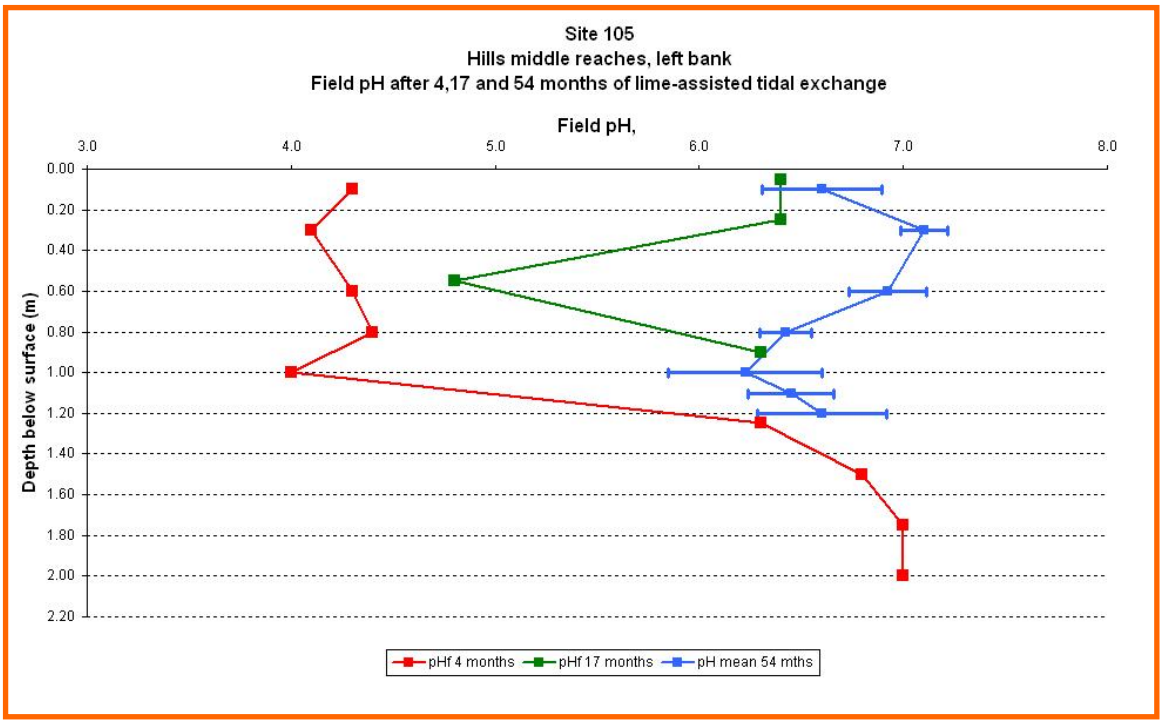
Given that LATE on this scale was to some extent heading into, if not uncharted, perhaps unfamiliar territory, it was decided to stage the implementation across the site, beginning with a part of the floodplain that was reckoned to have a less severe acidification problem – and hopefully a less steep learning curve. This proved to be the case up to a point, but there were still unexpected lessons. Stage 2 of the remediation, in the more highly acidified sub-catchment onsite, was arguably a more daunting task, but not necessarily for the reasons anticipated.

As the active phase of remediation comes to an end – the remediation will continue in a passive way for many years to come – a vast body of data has been collected that attests to the success of the approach. This evidence includes soil and water quality data, vegetation changes, and improvements in biota including aquatic and avian species.

Crucial to the success of the project has been the part played by the Queensland Parks and Wildlife Service (QPWS) in controlling weeds and feral pests, and providing general site maintenance. Their contribution has been an integral part of a holistic approach towards tidal wetland restoration.

Before remediation – Firewood Creek in the early 1980s

After remediation – Firewood Creek in mid 2006



Response in pH after 4, 17 and 54 months of lime-assisted tidal exchange (LATE)

References

Hicks WS, Bowman GM, Fitzpatrick RW (1999). East Trinity Acid Sulfate soils Part 1: Environmental Hazards. Technical Report 14/99, April 1999, CSIRO Land and Water.

Tasmanian acid sulfate soils information (TASSI) project

Rob Moreton

Introduction

In 2009 a major NHT-funded project was completed by the Department of Primary Industries, Parks, Water and Environment (DPIPWE) in partnership with the three Tasmanian NRM regional bodies. It mapped and identified areas that have the potential to contain acid sulfate soils (ASS), raised awareness of the ASS issue and provided guidance to stakeholder groups. This project aligned with three of the four National ASS Strategy objectives which aim to identify and define ASS areas, avoid the disturbance of ASS and minimise the extent of disturbance where disturbance is unavoidable.

Project objectives

To produce:

- Management guidelines for the management of acid sulfate soils (ASS) in Tasmania
- A predictive ASS map of the state using GIS cartographic modelling techniques
- A range of information products that target stakeholder groups

- An information delivery system designed to make this information freely available.

Regan Parkinson assessing Ramsar wetlands on the NE coast in Tasmania ***Rob Moreton***

Spatial prediction of ASS areas

Best available scale data as well as newly derived spatial data generated by the project was used within a predictive cartographic model that can effectively predict the likelihood of encountering ASS in the coastal, subaqueous and inland environments. This mapping has identified > 700 000 ha that will require careful and preventative management into the future.

Field calibration of the model and soil characterisation and classification to Australian Standards occurred in parallel to model development and sampling was undertaken according to nationally accepted sampling standards and full soil descriptions were recorded at each site. ASS field tests and NATA accredited laboratory analysis were performed on samples taken, including metals analysis for selected pore waters and soil layers.

Information delivery system

A new web page was added to the DPIPWE website (www.dpipwe.tas.gov.au/acidsulfatesoils) to house general information about ASS as well as information products created by the project targeted to the different stakeholder groups to help them better identify and manage ASS.

The acid sulfate soil probability map layers are held on the publicly accessible Land Information System Tasmania (LIST) www.thelist.tas.gov.au. This system is available to all stakeholder groups. It includes functionality such as: viewing site information, interrogation of the ASS mapping layers, combining maps with other spatial datasets on the website and overlaying it with Google Earth imagery.

Outcomes

The project's information products have proved to be an invaluable data source and tool for councils, planners, engineers, consultants and other associated stakeholders. The project has raised the awareness of the ASS issue within these stakeholder groups so that ASS management is now increasingly being addressed in land management planning.

Acknowledgements

Thankyou to the three Tasmanian regional NRM organisations – Cradle Coast NRM, NRM North and NRM South for financial support via the National Heritage Trust funding; the National Committee for Acid Sulfate Soils members for technical advice; Southern Cross University's Environmental Analysis Laboratory (EAL) and Analytical Services Tasmania, for laboratory services; and land managers and farmers who provided access to their land.

Contributing to ASSAY

Simon Walsh

ASSAY is the national acid sulfate soils newsletter. It provides a valuable service by distributing information between the various stakeholders that have a keen interest in the ASS issue and emerging developments. By continually seeking to improve ASSAY, we collectively enhance communication and further develop knowledge-sharing opportunities within the national ASS arena.

At ASSAY we are always looking for interesting stories to include in forthcoming issues. While these can follow the established format of 1-2 page articles, we are also looking to include other types of updates that may be shorter in length.

As long as they are relevant for the field of ASS, you might think of sending through some anecdotes, thoughts or musings etc. Perhaps you have an unusual / interesting photograph to share? How about some experiences in the field or back in the lab? Alternatively, maybe you have a bigger story that could be split into parts and run over two or more issues of ASSAY.

Now that ASSAY is distributed electronically, we can include hyperlinks to key websites, detailed documents and reports. If you are keen to publish some new information, the use of images, graphs and photographs is also encouraged to add a user-friendly dimension to straight text. Some ideas for photos that work well include aerial overviews of landscapes; fine detail with macro close-ups; images of 'people doing things'; or time sequences such as 'before and after' remediation works etc.

The opportunity is there to inform the rest of the acid sulfate soil 'family' of some of the perspectives that YOU have about ASS. If you have an idea for a contribution for a future issue, then just send me an email (simon.walsh@dpi.nsw.gov.au) or pick up the phone (02 6626 1256) and we'll make it happen.

Latest publications

Amaral V. Cabral HN. Bishop MJ. Effects of estuarine acidification on predator-prey interactions. *Marine Ecology-Progress Series.* 445:117-127, 2012.

Short-term experiments exposing calcifying organisms to acidification have revealed altered growth and strength of their exoskeletons.

We tested the hypothesis that multi-generational exposure to sustained estuarine acidification from runoff from acid sulfate soils (ASS) would: (1) reduce the shell strength of sessile or relatively immobile

wild benthic invertebrates and (2) as a consequence render these invertebrates that rely on armour for anti-predator defence more susceptible to generalist benthic predators.

First, we compared the force required to break the exoskeletons of *Saccostrea glomerata, Bembicium auratum*, and *Heloecius cordiformis* between replicate south-east Australian mangrove forests close to (acidified) and away from (reference) major ASS outflow drains. Second, we assessed differences in the susceptibility of oysters from acidified and reference forests to predation by the generalist muricid gastropod *Morula marginalba*.

Mollusc shells were significantly weaker at ASS-affected than at reference sites, but the strength of crab carapaces was not influenced by acidification. Oysters from acidified sites were consumed by *M. marginalba* at a faster rate than oysters from reference sites in choice and no-choice experiments because *M. marginalba* required less time to drill through weaker shells.

Many other predators such as crabs are generalist feeders that consume prey at rates inversely proportional to their shell strength. Hence, in the absence of effects of acidification on the ability of these predators to consume prey, molluscs at acidified sites may also be more susceptible to other such predators. This study highlights how human stressors can rapidly alter predator-prey interactions that have evolved over many years.

Amaral V. Cabral HN. Bishop MJ. (2012). Moderate acidification affects growth but not survival of 6-month-old oysters. *Aquatic Ecology.* 46(1):119-127.

Oyster populations periodically exposed to runoff from acid sulfate soils (ASS) are of depressed abundance and have fewer smaller individuals than unaffected populations, despite having similar recruitment levels to unaffected sites during dry periods.

We examined how the timing and duration of exposure to ASS runoff influences the growth and survival of successfully settled oysters. We predicted that among 6-month-old oysters, growth and survival would be (1) lower among individuals continuously exposed to ASS-acidified waters than those that are episodically exposed, and (2) most negatively affected during rainfall events, which enhance transport of ASS runoff to estuaries.

Six-month-old Sydney rock oysters, *Saccostrea glomerata,* were deployed at ASS-affected and unaffected sites within each of two south-east Australian estuaries. After 10 weeks, oysters were transplanted within and across sites in an estuary and maintained in situ for another 10 weeks. Oysters that remained for 20 weeks at ASS-affected sites grew at just over half the rate of oysters at reference sites. Oysters transplanted from acidified to reference sites grew more than oysters transplanted from reference to acidified sites or oysters that remained at reference sites.

Unexpectedly, overall oyster mortality was low. Greater rainfall, and hence a lower pH, is likely to have accounted for the greater impact of acidification on growth during the second 10 weeks. Where oysters recruit to a 6-month age cohort, they may be able to tolerate subsequent, moderate, acidification events. Reduced growth during acidification periods may be offset by positive growth during intervening dry periods.

Baker A. Fitzpatrick R. (2011). A web-based approach to improve collation and communication of complex soil-landscape data with examples relating to agricultural production, environmental degradation and mineral exploration. *Soil Use & Management*. 27(4):550-559.

This paper provides examples of how to use web-based techniques to organize and communicate large quantities of complex and varied soil and landscape data.

It describes a straightforward method for creating an interactive, web-based data site that can be used to facilitate more rapid and effective communication between project staff (scientists and managers) and clients (farmers and land managers). This can facilitate teleconferences between team members and be used to communicate information and ideas. Consequently, it reduces costs associated with travel and makes it easier to interpret data during collection.

The web-based data site can be used to deliver easily understood final reports to clients that may have limited background knowledge in a particular area. Additionally, it provides a sufficiently logical and intuitive user interface for use by a wide range of end-users including farmers, land managers, policy makers and the general public.

This approach has been used successfully to provide a framework to coordinate and report on the large quantities of complex data generated during the following three diverse projects:

(i) a study of base metal exploration methods in an area impacted by mining and land clearance in the Mount Lofty Ranges in South Australia,

(ii) acid drainage issues impacting on agricultural production in the Wheatbelt of Western Australia and;

(iii) inland acid sulfate soils impacting on land degradation and water quality in wetlands adjacent to the River Murray in the Riverland region of South Australia.

Baldwin DS. Mitchell A. (2012). Impact of sulfate pollution on anaerobic biogeochemical cycles in a wetland sediment. *Water Research.* 46(4):965-974.

The impact of sulfate pollution is increasingly being seen as an issue in the management of inland aquatic ecosystems.

In this study we use sediment slurry experiments to explore the addition of sulfate, with or without added carbon, on the anaerobic biogeochemical cycles in wetland sediment that previously had not been exposed to high levels of sulfate. Specifically we looked at the cycling of S (sulfate, dissolved and particulate sulfide - the latter measured as acid volatile sulfide; AVS), C (carbon dioxide, bicarbonate, methane and the short chain volatile fatty acids formate, acetate, butyrate and propionate), N (dinitrogen, ammonium, nitrate and nitrite) and redox active metals (Fe(II) and Mn(II)).

Sulfate had the largest effects on the cycling of S and C. All the added S at lower loadings was converted to AVS over the course of the experiment (30 days). At the highest loading (8 mmol) less than 50% of consumed S was converted to AVS, however this is believed to be a kinetic effect.

Although sulfate reduction was occurring in sediments with added sulfate, dissolved sulfide concentrations remained low throughout the study. Sulfate addition affected methanogenesis. In the absence of added carbon, addition of sulfate, even at a loading of 1 mmol, resulted in a halving of methane formation.

The initial rate of formation of methane was not affected by sulfate if additional carbon was added to the sediment. However, there was evidence for anaerobic methane oxidation in those sediments with added sulfate and carbon, but not in those sediments treated only with carbon. Surprisingly, sulfate addition had little apparent impact on N dynamics; previous studies have shown that sulfide can inhibit denitrification and stimulate dissimilatory nitrate reduction to ammonia.

We propose that because most of the reduced sulfur was in particulate form, levels of dissolved sulfide were too low to interfere with the N cycle.

Claff SR. Sullivan LA. Burton ED. Bush RT. Johnston SG. (2011). Partitioning of metals in a degraded acid sulfate soil landscape: Influence of tidal re-inundation. *Chemosphere.* 85(8):1220-1226.

The oxidation and acidification of sulfidic soil materials results in the re-partitioning of metals, generally to more mobile forms.

In this study, we examine the partitioning of Fe, Cr, Cu, Mn, Ni and Zn in the acidified surface soil (0-0.1 m) and the unoxidised sub-soil materials (1.3-1.5 m) of an acid sulfate soil landscape. Metal partitioning at this acidic site was then compared to an adjacent site that was previously acidified, but has since been remediated by tidal re-inundation. Differences in metal partitioning were determined using an optimised six-step sequential extraction procedure which targets the "labile", "acid-soluble", "organic", "crystalline oxide", "pyritic" and "residual" fractions.

The surficial soil materials of the acidic site had experienced considerable losses of Cr, Cu, Mn and Ni compared to the underlying parent material due to oxidation and acidification, yet only minor losses of Fe and Zn.

In general, the metals most depleted from the acidified surface soil materials exhibited the greatest sequestration in the surface soil materials of the tidally remediated site. An exception to this was iron, which accumulated to highly elevated concentrations in the surficial soil materials of the tidally remediated site. The "acid-soluble", "organic" and "pyritic" fractions displayed the greatest increase in metals following tidal remediation.

This study demonstrates that prolonged tidal re-inundation of severely acidified acid sulfate soil landscapes leads to the immobilisation of trace metals through the surficial accumulation of iron oxides, organic material and pyrite.

Furian S. Mohamedou AO. Hammecker C. Maeght JL. Barbiero L. (2011). Soil cover and landscape evolution in the Senegal floodplain: a review and synthesis of processes and interactions during the late Holocene. *European Journal of Soil Science.* 62(6):902-912.

The aim of this paper is to summarize the successive biological, pedological, hydrodynamic, geomorphological and geochemical processes that have occurred in the Senegal valley, and to describe how their interactions during the late Holocene conditioned soil cover formation and landscape evolution.

Potential acidity accumulated as pyrite in the floodplain sediment during the last marine transgressions, and was expressed during the following regressions because of oxidation. Soil acidification was mitigated by the soil buffer capacity and by the interaction with the slightly alkaline continental freshwater of the river.

Two pedogenetic transformation processes that resulted from the succession of acidic and neutral conditions, transformed unripe muds with pyrite (potential Acid Sulfate soil) to actual Acid Sulfate soils, and then to Vertisols. Geochemical modelling with PHREEQC quantitatively confirmed the feasibility of the processes involved. These two pedogenetic processes also controlled two independent salt accumulation processes: (i) the transformation of shell accumulation beds into gypsum layers and (ii) aeolian deflation and formation of clay dunes.

The study shows that pedogenetic effects on alluvial material can lead to contrasting horizons that cannot be explained stratigraphically. It also shows that the presence of saline areas in the Senegal middle valley results from much more complex processes than a simple salt deposition during transgressions.

Nystrand MI. Osterholm P. Nyberg ME. Gustafsson JP. (2012). Metal speciation in rivers affected by enhanced soil erosion and acidity. *Applied Geochemistry*. 27(4):906-916.

Dissolved (<1 kDa), colloidal (1 kDa-0.45 mu m) and particulate (>0.45 mu m) size fractions of 30 elements were determined for four rivers Sirppujoki, Laajoki, Mynajoki and Paimionjoki), including 12 low-order inflow streams, largely affected by soil erosion and acidity in SW Finland. In addition, geochemical modelling was used to predict the formation of free ions and complexes in these rivers.

Total metal concentrations were relatively high but most of the elements occurred mainly in a colloidal or particulate form and even elements expected to be very soluble occurred to a large extent in colloidal form. According to geochemical modelling these patterns could be explained by in-stream metal complexation/adsorption only to a limited extent. Instead there were strong indications that the high metal concentrations and dominant solid fractions were largely caused by erosion of metal bearing phyllosilicates.

A strong influence of acid sulfate (AS) soils, known to exist in the catchment, could be clearly distinguished in Sirppujoki river as it had very high concentrations of dissolved metals, while in the two nearby rivers (Laajoki and Myna joki) the influence of AS soils was largely masked by eroded phyllosilicates. In Paimionjoki river the colloidal and particulate fractions dominated very strongly, indicating that total metal concentrations are almost solely controlled by erosion of phyllosilicates.

Consequently, rivers draining clay plains sensitive to erosion, like those in SW Finland, have generally high "background" metal concentrations due to erosion of relatively non-toxic colloidal/particulate phyllosilicates. Thus, relying on only semi-dissolved (<0.45 mu m) concentrations obtained in routine monitoring and/or speciation modelling can lead to a great overestimation of the water toxicity in this environment.

Reid RJ. Butcher CS. (2011). Positive and negative impacts of plants on acid production in exposed acid sulfate soils. *Plant & Soil.* 349(1-2 Special Issue SI):183-190.

This study examined the impact of plants on acid sulfate soils with the aim of determining whether plants are able to reduce acid production.

The study was conducted with clayey acid sulfate soil under controlled conditions with treatments lasting up to 24 weeks and measurements made in the top 0–60 mm of soil. pH profiles in the soil were strongly dependent on soil moisture and the pattern of irrigation. When bare soil was allowed to dry down without further irrigation, there was very little acidification of either the surface or subsurface layers.

Planting of *Phragmites* accelerated soil drying and caused extensive cracking and acidification of the subsoil under simulated drought conditions. Under a wetting and drying regime, both *Phragmites* and a surface spreading grass *Paspalum* increased soil acidification, while a surface spreading herbaceous shrub *Cotula* had little effect on acidification.

There was no evidence that live plants could ameliorate acid sulfate soils. However, application of dead plant matter to the surface of the soil was effective in reducing acidification, especially if submerged.

Conferences and workshops

7th International Acid Sulfate Soil Conference

Theme: *"Towards Harmony between Land Use and Environment".*

Conference: **August 26 - 30**
Excursions: **August 31 – September 1**

2nd Circular and call for abstracts:

http://projects.gtk.fi/export/sites/projects/7iassc/2nd_Circular7IASSC.pdf

Registration:

Those interested in participation are kindly requested to register on-line (open from December 2011) via 7th IASSC webpage, www.7iassc.fi.

ASSAY contact details

Previous issues of ASSAY are available from:
http://www.dpi.nsw.gov.au/aboutus/resources/periodicals/newsletters/assay/

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