

ASSAY

A NEWSLETTER ABOUT ACID SULPHATE SOILS

13
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Jon Woodworth - ASS Info Officer "poached" from National Parks

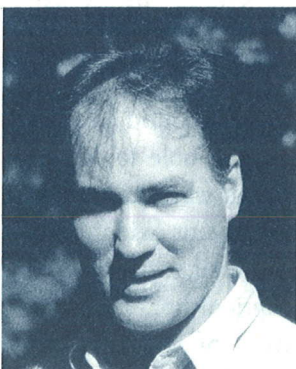
Hello, I am NSW's new Acid Sulfate Soils Information Officer and editor of ASSAY.

I am a former newspaper journalist who has worked in local and state government public relations for the past seven years. My last job was with NSW National Parks And Wildlife Services Media Unit.

I hope to utilise my PR skills to help more people understand what they can do about ASS issues.

I am very grateful to my predecessor, Rebecca Lines-Kelly who set up ASSAY and has given me such a great headstart. (Rebecca has a new position as Environmental Extension Officer with NSW Agriculture) I look forward to working closely with the Acid Sulfate Soils Management Advisory Committee, and others working in the ASS field.

My project is funded by the Federal Government's National Heritage Trust.



NSW's new ASS Information Officer and ASSAY editor -
Jon Woodworth

For further information please telephone me on 066 261 344, or fax 066 281 744. My Email address: is Woodwoj@agric.nsw.gov.au.

Hey Hey Hey! It's Queensland's ASS Information Officer

Kylie Hey is the temporary ASS Information Officer with the Queensland Acid Sulfate Soils Investigation Team (QASSIT). The Department of Natural Resources will fund the position until June 97 and has applied for National Heritage Trust (NHT) funding for three years.

Kylie will raise awareness about ASS among landcare groups, catchment management committees, consultants, land developers, farmers, fishermen, public interest groups, planners, policy makers, landholders, and councils.

She hopes to conduct workshops, field days, and seminars, as well as being a focal point for dissemination of information about ASS in Queensland. Kylie has post graduate qualifications in the soils area, has worked in the consulting industry, and has done ASS research with Griffith University.

To help Kylie with her funding proposal, or to obtain a copy of the NHT project application "Statewide Acid Sulfate Soils Information, Extension and Coordination" please contact her on telephone 07 38969819 Email: HeyK@dpi.qld.gov.au or Fax: 07 3896 9782.



Kylie Hey Qld's ASS Information Officer conducts a field peroxide test at a spoon-drain (less than 30cm deep) for Maroochy Council's mosquito control program.

Feedback on draft ASS strategy

The National Working Party on ASS management is in the final stages of drafting the National strategy document and will seek feedback from interest parties after June 30.

A draft strategy to tackle the problem of Australia's 30,000 square kilometres of acid sulfate soil (ASS) will be available on The National Working Party Chairperson John Williams says the strategy will suggest ways to:

- define ASS
- manage ASS areas to protect and improve coastal waterways
- assist governments, industry and the community identify their roles
- prevent further ASS disturbance
- establish rehabilitation methods.

Drained ASS in eastern Australia release between 100 to 300 kg of pure sulfuric acid per hectare per year. The potential acidity is more than 10,000 times that in all existing Australian acid mine dumps. For copies of the draft strategy (which will be available after June 30) please fax John Williams on 066 281 744 or email williaj@agric.nsw.gov.au.

Floodgate workshop

NSW Fisheries hosted a floodgate workshop at Wollongbar in March to explain the extent of damage which floodgates cause to the breeding cycle of commercial fish species.

A recent Fisheries audit recorded a staggering 4200 structures in NSW Rivers - many of them floodgates on coastal plains. More than 65% of commercial fish species spend part of their life cycle in estuaries.

A paper by Dave Pollard and Rob Williams, from the NSW Fisheries Research Institute at Cronulla, explained how floodgates restrict commercial fish species, such as yellowfin bream, dusky flathead and mullet from their nursery habitats. Ian White from Australian National University says floodgates prevent brackish water from neutralising acid drainage from soils. Estuarine water can have up to three times the neutralisation capacity of freshwater. Work on the Tweed River shows that brackish water from leaky floodgates neutralises small acid events without making productive canelands salty. The saline front had extended less than one metre into

the soil after four years due to the low permeability of soil. Richard Hagley (Department of Land and Water Conservation, Alstonville) explained how floodgate management at Rocky Mouth Creek and Roberts Creek, reduces acid levels and improves fish habitat. Farmers support this work because it improves pasture production (at Rocky Mouth Creek) and gives better water quality (Roberts Creek).

NSW Fisheries Conservation Manager, Northern Region, Craig Copeland, says funding is available under the NSW Government's Estuary and Floodplain Management programs to improve floodgate management. If you want to arrange a workshop, or want details about this story please telephone Craig Copeland direct on 066 261 391.

Computer model to manage ASS.

ASSMAC technical committee member, Bruce Blunden has started a three-year PhD position at Wollongong University doing ASS research. Bruce is on long service leave from the Environmental Protection Authority (EPA) at Grafton which hopes to fill his Program Officer position by June this year.

University of Wollongong civil engineering senior lecturer, Buddima Indraratna, will supervise Bruce and the \$160,000 ASS project. The project will manipulate the groundwater table - via temporary weirs - to reduce the acid production in potential ASS soils at Berry, near Nowra. Bruce will develop a computer-aided geo-hydrological model calibrated from field data (eg using rainfall data, distribution of creeks and drains, ground geology and hydrology). The model may be able to predict fluctuating pH changes in soil and water to manipulate the groundwater table to prevent oxidation of potential ASS. Shoalhaven Council, University of Wollongong (UoW), NSW Agriculture, EPA and the Federal Department of Education, Employment, Training and Youth Affairs are funding the project.

Angela Toniato, who is an undergraduate student with the project, can travel to study other ASS areas if requested. The project is part of the research program undertaken by UoW's Centre for Geo-environmental and Mine Engineering (GEM). For information, please telephone Buddima Indraratna on 042 213 046. Bruce Blunden's email address is bgb05@uow.edu.au or telephone 042 836765.

Laboratory methods update

“Peroxide Oxidation - Combined Acidity and Sulfate (POCAS)”

POSAC was the named used for this method in the last issue of ASSAY. POCAS is the new name for the method - the old acronym sounds too much like PROSAC (a drug).

The method aims to standardise laboratory procedures for determining the potential acidification of acid sulfate soils by combining two commonly used peroxide oxidation methods - peroxide oxidisable sulfuric acidity or POSA (Lin and Melville, 1993) which follows the ‘sulfur trail’; and the double oxidation method of Dent and Bowman (1996) that follows the acidity trail, measuring total actual acidity (TAA), total potential acidity (TPA) and by difference, total sulfidic acidity (TSA). The proposed method is essentially the ‘combined peroxide method’ introduced by Pam van Oplo in her 1994 University of NSW honours thesis and modified by Ahern et al at the second National Conference on ASS. (September, 1996). It was slightly modified in response to the ASSMAC Technical Committee Methods Workshop, October, 1996.

The current version of this method is Prelim. Draft 1.5 and is now being used by a number of government, university and commercial laboratories.

If you need the current versions, or the updated revisions of the guidelines or laboratory methods, please email Kylie Hey at HeyK@dpi.qld.gov.au for your free electronic copy.

NB. At the next ASSMAC Technical Committee meeting the DRAFT method will be finalised. Your feedback is welcome and can be emailed, faxed, or posted to Col Ahern c/o Kylie Hey. The method will be published in the updated ASSMACTC Laboratory Methods Manual.

“Total Oxidisable Sulfur (TOS)”

This method aims to provide a standardised, low-cost (laboratory test) of total oxidisable sulfur (Total sulfur minus 4M HCl extractable sulfur) for ASS. It is a useful screening test for evaluating the potential environmental risk from acid produced by the oxidation of sulfides, predominantly pyrite or iron disulfide (FeS₂).

Depending on the laboratory’s procedures and equipment models; e.g. Leco, Xray, ICP, gravimetric, the TOS method may lack sensitivity for sam-

ples below 0.1 to 0.05 % S.

It is usually necessary to use the POCAS method on such samples, particularly low sulfur content sands which require detection limits of <0.02% oxidisable S.

The current draft version is 1.1 and still awaits some promised inputs on alternative total sulfur approaches other than Xray, fluorescence and Leco.

Sample exchange program

ASSMACTC will establish an ASS sample exchange program to assist laboratories produce consistent and reliable results.

Initially, the Qld ASS Information Officer (Kylie Hey) will administer the scheme while QASSIT members, Col Ahern, Dennis Baker, and Angus McElnea handle technical inquiries and statistical analysis.

For information about the ASS sample exchange program contact Kylie Hey on telephone (07) 3896 9819, Fax: (07) 3896 9782 or email: HeyK@dpi.qld.gov.au.

If you registered an interest previously please re-register as Col’s computer file is corrupted.

Queensland analysis guidelines

“Sampling and Analysis Procedure for Lowland Acid Sulfate Soils in Queensland” have been in operation for over a year and are updated when necessary. These test guidelines are providing a state-wide standard sampling and analysis regime for accurate assessment of environmental impact before disturbance of ASS.

The current version is **Version 3.2, 29 January 1997** which will be updated to Version 3.3 this month. You can get updates, and be put on an email list for future updates by contacting

Kylie Hey at HeyK@dpi.qld.gov.au.

Bruce Blunden (Wollongong Uni) and Col Ahern (DNR) are attempting to incorporate the Queensland and NSW (Environmental Planning Act) guidelines into one publication. The booklet is due later this year but depends on the compatibility of NSW and Qld environmental legislation requirements.

Geophysical method to test for ASS

Testing for ASS traditionally involves a time consuming and relatively expensive chemical analysis

of soil samples from the field. Now a Sydney company is developing a much cheaper geophysical method to test ASS. It uses electrodes placed in the soil to measure the conductivity. (Pyrite, a metal found in potential and actual ASS conducts electricity.)

Keeva Vozoff, of HarbourDom Pty Ltd, hopes to reduce the cost of ASS testing by 75 per cent or more by using just a single chemical test control site for every 10 geophysical test sites. He says geophysical testing for ASS is difficult because pyrite comprises only about one per cent of thick clay in ASS. However, Macquarie University Honours student Rebecca Denne successfully used geophysical-physical methods to test six ASS sites in the Shoalhaven River district, near Nowra in 1994.

Keeva hopes to expand Deene's work and develop a method with commercial application for ASS sites around the world. 'We are currently using laboratory equipment but need funds to develop sturdy field instruments,' he said. For further information telephone Keeve Vozoff or Jim Tayton on (02) 9922 1383.

NSW cane farms to have ASS survey

The NSW sugar industry is testing all of the State's 660 cane farms for acid sulfate soils (ASS) in a bid to reduce acid runoff.

A University of Queensland graduate, Julian Collins, will invite farmers to watch the soil sample and chemical tests take place as a way to help them understand more about ASS. An average of three tests, to a depth of about 1m to 1.5m will be done on each farm. Farmers with ASS will get free farm management plans to prevent ASS disturbance. ASSMAC publications, such as 'Guidelines for Drain Construction and maintenance in ASS' will be distributed to all cane farmers. Sugarcane productivity boards and the Bureau of Sugar Experimentation Stations will fund the \$120,000 project.

The Federal Government and the sugar industry recently spent \$100,000 to build an ASS research laboratory at the Broadwater Mill. It enables detailed analysis of ASS samples from NSW farms. For further information please telephone Peter Nielsen, Manager Agricultural Services with NSW sugar mills, on 066 208 257.

Pasture trials on Taree ASS soils

The Manning Catchment Management Committee is funding a \$12,000 project to help farmers increase pasture growth on acid sulfate soils.

NSW Agriculture's Taree District Agronomist, Dave McCoy, has just planted seven hectares of pasture with paspalum, kikuyu, setaria, perennial rye and annual rye to test grass performance on soil with a pH of 3.8 to 4.2. Dave says the existing pasture is couch and carpet grass. He has limed half of the area of the three experimental plots which are situated at Oxley Island, Moto and Cooperbrook. The district's ASS soil is a metre below ground level at the sites. The pasture growth rates will be evaluated in March, 1998. For more information, please telephone Dave McCoy on 065 527 299 or fax 065 512 253.

Yarrahapinni

The Yarrahapinni Wetland Reserve Trust (Crown Land Trust) has tendered for a consultant to prepare a Plan of Management. An environmental impact statement has been drafted for public display. The Trust has nine community representatives as well as Kempsey Shire Council, Department of Land and Water Conservation, NSW Fisheries and National Parks representatives. The Trust secretary is Craig Copeland, from NSW Fisheries on telephone 066 261 394

Rocky Mouth Creek

NSW Fisheries and Southern Cross University student, Greg Ryan, are preparing a draft Management Plan for the Rocky Mouth Creek floodplain. This plan has been sent to Richmond River Shire Council for possible inclusion in its broader Estuary Management Plan.

A University of NSW honours student, Brian Hughes, is also examining ASS in the catchment. He has found that, despite the creeks flood gates being open for two years, acid water (pH 3) is still being measured by an automatic data logger. For further information please telephone NSW Fisheries' Craig Copeland on 066 261 394.

National working party

The National Working Party and members of Queensland Acid Sulfate Management Advisory Committee joined in a field inspection of ASS pro-

ject in the Tweed Valley during March. At Tweed Heads, Griffith University's Associate Professor Paul Saffigna told the group about the ASS rehabilitation process used at the Chinderah bridge and bypass. Lime treatment of about 250,000 cubic metres of ASS silt produced a valuable top soil. (The construction company, Neumann Contractors, has a free video of the process - tel Annette Lee on 07 55892 746)

Don Buckley and Robert Quirk explained a proposed ASS restoration project in the upper Cudgen Creek catchment. Doug Smith and Justine Adams gave a demonstration of QUASSIT's new vibro-suction corer. The day continued with lunch at Tweed Shire Council, followed by ASS presentations by Don Buckley, Jes Sammut, Ian White, Mike Melville, Robert Quirk, Paul Saffigna and Kylie Hey.

Local cane farmer Robert Quirk displayed how laser-level cane fields increased production and reduced acid runoff. Filling acid-generating drains can provide an extra three rows of cane. The farmers have added lime to drain banks, increasing drain water pH levels from about pH 3 to pH 5. For more information please contact Ian White, ANU, telephone 06 249 0660, fax 06 249 0757 or email: ian.white@cres.anu.edu.au.

Potential tea-tree plantations concern fishers.

Local oyster growers organised a boat tour of the Hastings and Maria Rivers for the ASSMAC which met in Port Macquarie in February. Fishers and oyster growers say there is a potential threat to their livelihood from two big tea-tree plantations planned for ASS areas on the Maria River. ASSMAC's Fishing Industry Council representative, Phil March, says that several recent community information nights, which dealt with local ASS issues, each attracted more than 30 residents and landowners keen to find out more about the issue. For more information, please telephone Phil March on 065 666 879

Tuckean Swamp LandCare - Richmond River

Local landholders have formed a Tuckean Swamp LandCare Group to tackle one of the country's most difficult ASS problem areas.

The former Tuckean Swamp Management

Committee accepted a Land and Water Management Plan in March. The 70-page plan discusses land and water issues and proposes a Management Plan framework. The committee has now dissolved and the project coordinator has finished.

A National Fisheries Action Program Grant of \$10,000 will allow further investigation of the Tuckean's Bagotville Barrage operational policy. Richmond Catchment Management Committee Coordinator Gerry Ryan says this is necessary because landholders were cautious about the proposed actions.

Yellow creek update

NSW Agriculture Soil Chemist Roy Laurie's soil survey of the Tuckean's Yellow Creek area identifies the distribution and composition of the area's jarositic zone. Roy suggests the best way to reduce the acid leachate is to use drop boards at strategic locations to slow the fall of the water table.

Irrigation Officer Graeme Robertson (NSW Agriculture) has done a topographic survey of 5.3 kilometres of drain. It identifies changes in drain profile and plans the location of strategic drop board check structures.

A \$60,000 National Heritage Trust grant will enable the Tuckean Swamp Land Care Group to:

- build two drop board structures to manipulate the water table and prevent subsoil from aeration and oxidation,
- monitor water table and water quality at test wells across the flood plain and downstream of the works, and
- establish trial sites to evaluate pasture production using pond pasture species.

This funding will help evaluate sustainable farm activities.

Gundurimba drain

A group of farmers at the Tuckean's Gundurimba drain found that drain cleaning has exposed ASS. NSW Agriculture Irrigation Officer, Graeme Robinson, says a survey shows the drain was enlarged over time. A drain flood gate contribute to flooding of lower farms. Local farmers will change the profile of the drain with the available spoil leaving a shallower drain with flatter batters to cover the exposed ASS. This will allow easier mow-

ing of grass.

A funding proposal for the project is with the Department of Land and Water Conservation's Rivercare Program.

For information on any of the above Tuckean issues, please telephone Richmond Catchment Management Committee Coordinator Gerry Ryan on 066 286 009.

Richmond River fish kill

Southern Cross University's Centre for Coastal Management has found that acid sulfate soil was not the only cause of a fish kill in the Richmond River in early March. Low dissolved oxygen levels and high sediment loads - caused by decaying vegetation from flooded pasture areas which have replaced permanent wetlands - killed the fish. Acid runoff from ASS land contributed to the problem. ASSMAC Chairperson John Williams says fish kills are a highly visible sign of the environmental damage caused by ASS runoff. 'Unfortunately, there is no quick fix - fish kills will only be solved over time by land owners, drainage unions, industry and local communities working together to manage ASS issues,' Mr Williams said.

\$110,00 for ASS works in Hastings Shire.

Hastings Shire Council has received a \$60,000 Environmental Trust (ETF) Fund grant to do ASS remedial work on Partridge Creek. It will cost about \$25,000 to open existing flood gates and build a weir to manage water levels. The liming of drains spoil areas will reduce creek pH levels. The funds will also pay for a Plan of Management. Council has also received a ETF grant of \$50,000 for similar Camden Haven River ASS works.

Council is developing a draft ASS Local Environment Plan (L.E.P) for the Shire. The L.E.P requires ASS consideration in all approval processes. Council has developed hybrid maps showing potential and existing ASS soils areas. For more information, please telephone the Council's Environmental Manager - David Pensini on 065 832 099.

Manning Local ASS Action Committee NSW Agriculture presented details about pasture management to control acid runoff at several recent public meetings. The meetings also covered Local Government Local Environmental Plans for acid

sulfate soils as well as how total catchment committees work. For information please telephone the Manning Catchment Coordinator, Carl Atchison on 065 522 788.

DLWC monitors Port Stephens ASS sites

The Department of Land and Water Conservation (DLWC) will sample water pH at numerous Port Stephens sites during the next six months. DLWC and Port Stephens Council, and Newcastle University, hope the tests will show the degree of ASS problems in Nelsons Bay as well as the Salt Ash, Bobs Farm, Williamstown and Anna Bay areas.

DLWC plans a number of local water catchment awareness days to explain the problem to landowners. NSW Fisheries has concerns about dredging and reclamation works in the Port Stephens area. Contacts: DLWC Catchment Manager for Lower Hunter 049 294 346;

Fisheries - John Holliday (049 821 232). A resident, Jim Finlay, wants to local people to contact him about this issue (049 821 870).

Drain approvals

Consent for drainage of coastal floodplains or earthworks in ASS areas in NSW is required by local government. As well, the Fisheries Act now requires the Minister's consent for dredging or reclamation works unless the works are authorised by a relevant public authority or under the Crown Lands Act 1989. Works include any work on drainage channels. Check with both your local council and local fisheries office before doing any drainage work. Any changes to farm drainage will affect your sub-catchment, so it is important that you consult other landholders before undertaking works. Whether you have existing drains which you maintain, or want to install a drain, the first thing to do is check your land on the ASS risk maps produced by the Dept of Land and Water Conservation (DLWC). For more information please contact your nearest DLWC office or local NSW Agriculture irrigation officer. A free information sheet on drainage in ASS areas is available from NSW ASS Information Officer, Jon Woodworth, tel 066 261 344, fax 066 281 744, or write c/o Wollongbar Agricultural Institute, Bruxner Highway, Wollongbar, NSW 2477.

Strategy to manage North Coast ASS

Stuart Naylor is the NSW Department of Land and Water Conservation's Resource Office on ASS. He is drafting a management strategy for North Coast ASS areas. This involves mapping the high-priority "hot" spots and suggesting practical ways to fix ASS problems. The Federal Government's National Heritage Trust pays for his position. For more information please telephone Stuart on 065 527 299, Fax 065 512 253

Reply to comments on adoption of reflooding

Jes Sammut (UNSW) writes that an article "Pitfalls of watertable management" (ASSAY Oct. 1996) appears to have been misunderstood by some readers.

*Jes writes: The article does not state that reflooding is not a viable option. It simply suggests that caution should be exercised when reflooding is used and that negative impacts should be evaluated. To date, many proponents of reflooding have not accounted for potential negative impacts, or even recognised that post-oxidation, acid sulfate soils are markedly different chemically and physically. Trials should be considered before reflooding is adopted widely. Freshwater and saltwater flooding may produce different responses in different soil types, and these need to be assessed. Clearly, the article does not rule out reflooding but draws attention to issues that must be considered. I fully support Andrew Porter's * findings and hope that proponents of reflooding use the method with the caution that is required for any treatment of acid sulfate soil.*
* The article was based on Andrew Porter's honours thesis.

For further information, contact Jes Sammut. on 02 993854386 or email at J.Sammut@unsw.edu.au\

ASSAY - It pays to advertise

Starting next issue, space will be allocated for advertisements in ASSAY. With more than 1400 people on its mailing list, ASSAY gives you a cost effective means of reaching a specific audience with your product, message or service. Ads will cost \$200 for a half page or \$100 per quarter page. (NB ASSAY's editor reserves the right to reject unsuitable copy)

Next Issue

The next issue of ASSAY will be published in early July.

Gold Coast about to adopt ASS policy.

Gold Coast City Council will soon ratify a "Policy for Management of Activities to be located within Gold Coast ASS". Gold Coast covers 1400 sq kilometres with large areas of low-lying coastal land. ASS maps for the Gold Coast are being drafted by Australian Geological Survey Organisation. For information about the policy please telephone John Carleton on 07 5581 6140 or fax 07 5581 6346.

Two-day technical workshop at Cairns

Department of Natural Resources QASSIT members Bernie Powell, Col Ahern and Errol Best conducted a two-day technical workshop on ASS at Cairns, on 17-18 February, 1997.

A total of 85 people attended the workshop and field trips to development areas such as Earl Hill. Other presenters were Mary Power and Ron Anderson (DoE) Anne Clarke and John Russel (DPI), David Finney (C & B Consultants) and Paul Scells (Golders).

Apart from DNR, sponsors included: DoE, DPI, Cairns City Council, the Cairns Port Authority, LandCare, and BSES.

While in the north, the QASSIT team also conducted public seminars on ASS in Cairns and Townsville and spoke with locals about management of disturbed ASS sites.

The next QASSIT technical workshop is at the Gold Coast on 16-17 June, 1997.

Technical workshop to be held on the Gold Coast - June 16th to 17th

QASSIT and Gold Coast City Council will hold a two-day technical workshop on ASS on June 16th & 17th.

Visiting speakers are Jes Sammut of NSW University and Trevor Graham of the Coastal Management Group, Australian Geological Survey Organisation (AGSO).

The workshop will focus on ASS identification, environmental impacts, management and regulatory issues surrounding ASS in Queensland. It will target industry, consultants, developers, as well as



Workshop participants examine ASS indicators at Earl Hill, Cairns during a recent workshop organised by the Qld Department of Natural Resources' Queensland Acid Sulfate Soil Investigation Team members Bernie Powell, Col Ahern and Errol Best. (see previous page for more details)

landholders and community groups.

The workshop costs about \$200, including lunch and bus field trips. Numbers will be limited to 100 people so be quick to register.

To register contact Kylie Hey, Qld ASS Information Officer ("QASSIO") and workshop organiser on Email: HeyK@dpi.qld.gov.au, or Fax: 07 3896 9782. (Give your email address to get electronic updates.)

New ASS publications and papers

Hedlund, Anna. Aluminium in an acid sulphate soil in Vietnam: concentration & speciation in relation to period of drainage of raised beds in the Mekong Delta, Vietnam: a minor field study.

Source: Uppsala: Swedish University of Agricultural Sciences, International Rural Development Centre, 1996. 30, iv p. : ill., map

Minh, Le-Quang: Integrated soil and water management in acid sulphate soils - Balancing agricultural production & environmental requirements in the Mekong Delta, Vietnam.

Source: [Wageningen : s.n., 1996] 134 p. : ill

Tri, Le-Quang. Developing management packages for acid sulphate soils based on farmer and expert knowledge: field study in the Mekong Delta - Viet Nam.

Source: [Wageningen : s.n., 1996] 200 p. : ill., map

Mensvoort, M.-E.-F. van. Soil knowledge for farmers, farmer knowledge for soil scientists: the case of acid sulphate soils in the Mekong Delt, Viet Nam.

Source: [Wageningen : s.n., 1996] 135 p. : ill., maps

To-Van-Truong; Nguyen-Tat-Dac.; Huynh-Ngoc-Phien. Simulation of acid water movement in canals. Source: J-hydrol. Amsterdam : Elsevier Science B.V. May 15, 1996. v. 180 (1/4) p. 361-377.

Source: Mekong River Commission Secretariat, Bangkok, Thailand.

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