The NSW sugar industry best practice guidelines for acid sulfate soils

2020
Introduction

The NSW Sugar Industry conducted an external review of the existing best practice guidelines in 2019/20 by an independent expert in the field of acid sulfate soil (ASS) management. The review was conducted by Bernie Powell a former Queensland Government soil scientist with more than 40 years’ experience. Bernie specializes in pedology and land suitability assessments and has undertaken soil surveys throughout Queensland. He has published more than 60 papers and reports, and for 15 years led the Land Resource Assessment section in the Queensland Government. In this role, Bernie also represented Queensland on two national soils committees and was chair for 3 years of the National Committee for Acid Sulfate Soil.

As a result of the external review these practices have been updated to ensure compliance with changed legislation, the Marine Estate Management Strategy, and revised guidelines regarding the management of acid sulfate soil (ASS).

Best practice and self-regulation

Best practice

Best practice is the application of currently recognised farming techniques capable of delivering environmentally and economically sustainable sugar cane production. Sugar Industry practices focus on measures that minimise the export of soil, acid, nutrients, agrichemicals and organic matter, to meet responsible environmental standards. Best practice in acid sulfate soil management is guided by the national acid sulfate soil guidelines.

Around 50% of NSW cane lands contain acid sulfate soils. The intended purpose of this document is to provide guidelines, based on the best available information, for cane farmers with these soils in order that they:

- Minimise the export of acidity and monosulfidic black ooze (MBO) from their farms;
- Minimise any downstream environmental impacts caused by acid and MBO export; and
- Maximise production from their land, and
- Comply with the relevant legislative provisions and statutory plans including Local Environment Plans.

The successful achievement of these goals may be affected by upstream and downstream actions by other parties, over which the industry has no control.

Self-regulation

The NSW Sugar Industry controls the on-farm management of acid sulfate soils through an industry-government self-regulation scheme. This allows farmers to disturb acid sulfate soils through normal farming and drain management practices without having to apply for regulatory approval. Following early pro-active efforts of the industry to manage acid sulfate soils on cane lands it was recognised that the sugar industry had the capacity to manage this issue via a self-regulation scheme provided the industry complied with a range of performance conditions. This includes every farm having an acid hazard and drain management plan, complying with best practice guidelines and an annual audit.
Commitment to best practice

The Sugar Industry is committed to minimising the production and outflow of acid from the acid sulfate soils which occur beneath much of the area planted to cane, to protect and improve the soil and water quality on farms, and to protect surrounding ecosystems for current and future generations. The industry’s objective is to ensure that activities of its members do not contribute to or exacerbate acid sulfate runoff. To this end, the Sugar Industry will continue to adopt current best management practices in its farming operations.

All farmers who supply sugarcane to Sunshine Sugar mills agree to the Standard Terms and Conditions for the Supply, Processing and Payment of Sugarcane, that individually confirms this commitment. Sunshine Sugar may refuse to accept or pay for cane produced from land where it concludes that the landholder continues to refuse to comply with the conditions of the farm acid hazard and drain management plan.

Extent of application

These guidelines apply to the existing cane lands with a Production Area Entitlement (PAE) belonging to farmers who supply cane to Sunshine Sugar. A grower supplying cane to Sunshine Sugar must have a Production Area Entitlement to grow and deliver cane to the Mill.

The intention is to give effect to clauses in Local Environmental Plans (LEPs) that exempt certain drainage works on sugar cane lands from the development assessment process providing the works are undertaken in accordance with an endorsed drainage management plan consistent with these guidelines.

It is understood that some drains may discharge poor quality water as a result of land uses or disturbances up and downstream of PAE areas. Some PAEs have been converted to other land uses e.g. macadamia orchards.

These guidelines do not apply to drainage union drains, new drains and earthworks in areas not subject to a PAE. Any works in these areas will be subject to the full development assessment process as outlined in the relevant Council’s LEP.

Exemption for the sugar industry from the development assessment process as outlined in relevant local environment plans pertains to farm areas with an existing PAE and drainage management plan only.

Sunshine Sugar will only support expansion onto new land where new acidity will not be produced. All new PAEs will be assessed and approved by Sunshine Sugar using the procedure detailed in Appendix 2. Once the degree and extent of acid hazard is established, a drainage management plan for that PAE will be established in accordance with Sunshine Sugar procedures and the exemption will operate subject to compliance with the Standard Terms and Conditions for the Supply, Processing and Payment of Sugarcane.

Previous acid sulfate soil initiatives

The sugar industry has previously taken initiatives to manage acid sulfate soils including:

- Survey of all cane farms for acid sulfate soils
• Funding of external research
• Development of acid sulfate soils management protocols
• Subsidy of intensive soil sampling and analysis of cane lands for pH and nutrient monitoring
• Monitoring of water quality in drains
• Extensive use of lime to improve field pH
• Extensive laser grading and filling of existing open drains
• Managed opening of drain floodgates to provide tidal flushing
• Education of farmers and excavator contractors
• Establishment of Best Practice Guidelines
• On-going technical support for farmers to manage acid sulfate soils.

What are acid sulfate soils?

Acid sulfate soils (ASS) are the common name given to soils and soft sediments containing iron sulfides. In Australia, the acid sulfate soils of most concern are those which formed within the past 10,000 years, after the last major sea level rise. When the sea level rose and inundated land, sulfate in the sea water mixed with land sediments containing iron oxides and organic matter. The resulting chemical reaction produced large quantities of iron sulfides in the waterlogged sediments. These sediments are commonly buried beneath coastal floodplain alluvia. When exposed to air, these sulfides oxidise to produce sulfuric acid, hence the name acid sulfate soils.

The iron sulfides are contained in a layer of waterlogged soils. The water prevents oxygen in the air reacting with the iron sulfides. This layer is commonly known as potential acid sulfate soils (PASS) because it has the potential to oxidise to sulfuric acid (Fig 1.). When the iron sulfides are exposed to air and produce sulfuric acid they are known as actual acid sulfate soils (AASS). The soil itself can neutralise some of the sulfuric acid. The remaining acid moves through the soil, acidifying soil water, groundwater and eventually surface waters causing damage to drain and river ecosystems and reducing agricultural productivity.
Another consequence of ASS exposure can be the accumulation of monosulfidic black ooze (MBO), in flood-gated drains (Fig. 2). The factors that further promote the accumulation of MBO in drains include readily available organic matter, elevated temperatures, slow flow conditions and channel obstructions. Research has found the oxidation of MBO caused rapid deoxygenation and subsequent acidification of the overlying water when these materials were suspended in water (Sullivan et al., 2002). In addition to deoxygenation and acidification, MBO disturbance and oxidation can potentially result in the rapid release of toxic concentrations of associated metals and nutrients to surrounding surface waters.
Fig. 2 Monosulfidic Black ooze (MBO)

The propensity for MBO to accumulate, and then be mobilised by floodwaters in waterways such as drainage channels, has been identified as a contributing factor to deoxygenation in ASS areas (Sullivan and Bush, 2000, Sullivan et al., 2002).

Where do acid sulfate soils occur

ASS occur in low lying areas generally at, or just above, the mean tide level. They are associated with estuarine or marine sediments laid down in the past 10,000 years. Extensive tracts of low-lying coastal land in NSW and Queensland contain acid sulfate soils.

ASS occur below many cane growing floodplain areas in NSW. They are closest to the surface and are more likely to cause problems to the environment in low lying back swamp areas than on higher river levees. To help assess risk, the NSW Department of Planning, Industry & Environment has produced 1: 25,000 scale ASS risk maps. https://data.nsw.gov.au/data/dataset/acid-sulfate-soils-risk0196c

The NSW Sugar Industry has identified ASS risks for each farm in the industry through an acid sulfate soil farm sampling project. Around 50% of the NSW cane growing area is underlain with acid sulfate soil. This information forms the basis for drain management plans for each farm. Additional soil sampling will be undertaken at the discretion of the NSW Sugar Industry to improve individual drain management plans. Any new farms and PAEs in ASS risk areas will require a drain management plan (Appendix 1).

What farming activities may cause a problem?

Any activity that disturbs or has disturbed ASS or lowers the water table below the upper level of the ASS layer will potentially create an acid sulfate management problem.

Common activities that can disturb acid sulfate soil or can excessively lower the water table on cane farms include:

1. constructing drains
2. land grading.
3. floodgate management activities.
4. cleaning drains
5. constructing dams and water holes
6. stockpiling of spoil
7. pump drawdown of water table below the sulfidic layer
8. farm access works

In most cases, best practice with ASS requires land and drain management that maximises the retention of existing acidity under the cane crop and minimises its export from the site. Earlier editions of these guidelines have resulted in considerable change to the floodplain landscape, particularly through best practice land grading and a reduction in the density and depth of paddock drains.
The keys to the success of ASS management are:

A drain management plan, developed by extension staff and supported by research.

Using the knowledge and experience of the landholder of the site to implement the plan.

What tidal floodgate activities may cause a problem?

Proper operation of floodgates is critical to the success of both flood mitigation and managing water quality in and discharging from drains. The level of risk to water quality management depends on circumstances specific to a floodgate (Table 8). The hydraulic forces associated with tidal and flood flows can be large, and unless taken into consideration, can impact on headwork and drain stability, maintenance and longevity.

Flooding can result in erosion or sedimentation in the vicinity of structures. In addition, logs, litter and other debris can be deposited and consequently damage or impair the operation of any works. Inspection should be undertaken as soon as possible after storm and flood events to note and repair any such defects.

The introduction of tidal flows into drains should incorporate a staged approach. Stage 1 of the project may be the partial opening of a single floodgate and the subsequent monitoring of its impacts on issues including the area of wetland and surrounding country likely to be affected by re-inundation, the existing native vegetation and wildlife habitat, the existing fishing and oyster growing activities in receiving waters, the groundwater, and the social and economic well-being of the local community.

If there is risk of lateral salt seepage, monitoring of salinity and acidity both downstream and upstream will help decide whether, and for what period, to open floodgates. If saline water begins to enter areas where it is not desired, changes to the operation of floodgate should be implemented.
### Table 2. Risk assessment relevant to floodgate management/modifications (Tulau, 2007)

<table>
<thead>
<tr>
<th>Factors in deciding the level of risk</th>
<th>Level of environmental risk</th>
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<tr>
<td><strong>Nil to low</strong></td>
<td><strong>Medium</strong></td>
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<tr>
<td>Saline incursion (Lateral salt seepage)</td>
<td>Soil Hydraulic conductivity ($K_{sat}$) &lt;1.5m/day</td>
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<tr>
<td>Enhanced acid discharge</td>
<td></td>
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<tr>
<td>Large catchment flows</td>
<td>Medium catchment flows</td>
</tr>
<tr>
<td>Higher elevation ASS, &gt; 2m AHD</td>
<td>Medium elevation ASS, 1 - 2m AHD</td>
</tr>
<tr>
<td>No in-drain MBO’s</td>
<td>High buffering / neutralising capacity receiving waters</td>
</tr>
<tr>
<td>High degree of tidal exchange</td>
<td>Moderate in-drain MBO’s</td>
</tr>
<tr>
<td><strong>Dieback of freshwater vegetation</strong></td>
<td>Drain not connected to freshwater wetland</td>
</tr>
<tr>
<td>Overtopping and water levels</td>
<td>Maximum drain water level lower than land surface</td>
</tr>
<tr>
<td>Structural failure</td>
<td>Small catchment, structure designed for maximum expected flows</td>
</tr>
<tr>
<td>Maintenance schedule adhered to</td>
<td>Maintenance when defects noted</td>
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### Other disturbances of acid sulfate soil

These guidelines apply to all ASS disturbances associated with cane farming such as the maintenance of cane pads and farm tracks. All disturbances of ASS require liming at rates specified in the drain plan.

Construction of farm dams, buildings, stockyards, bridges and other works that disturb ASS but are not directly associated with the production of sugar cane are not covered by these guidelines and may require development consent from Council.

### Managing acid sulfate soils

Inappropriate management of ASS may decrease farm productivity. Management procedures are available for ASS. It is important to minimise the constraints that ASS soils pose to agricultural activities and to incorporate their management into the overall management of the farm. An objective of the sugar industry with respect to ASS is to minimize historical broadacre disturbances and mitigate any impact of contemporary disturbance. The highest risk period is when an extended hot and dry period is immediately followed by a heavy rainfall and discharge event.

ASS Management is based on:

- Retaining existing acidity in the landscape.
- Minimising the conduits that deliver acidity to waterways
- Minimising the volume of acid drainage
- Avoiding the creation of new acidity
- The use of lime on existing cane lands and in freshly disturbed areas
- Minimising the build-up of trash in drains
- Maintenance and control of floodgates

To do this it is necessary to know:
- where the ASS occurs (location and depth)
- the intensity of the acid hazard
- the size, location and number of drains
- the level of accumulation of MBO in drains.

The drain management plans produced for each farm contain information on location, depth and intensity of acid hazard and the size, location and number of drains. Growers need to be aware of the topography and surface runoff characteristics of the property and drainage characteristics due to the permeability of the farm soils. Management decisions based on these principles will minimise production and discharge of acid from cane lands.

**Drainage management plans**

The majority of drainage systems in cane land remove surface water. These drains can be categorised as (i) Primary, (ii) Secondary or (iii) Tertiary (Fig. 3). Sub surface or mole drains are also used on some farms.

Government owned primary drains, and all drain outlets to the river are controlled by a number of state government departments. A special type of large Primary drain is privately owned and operated by Drainage Unions or Drainage Trusts. Secondary and Tertiary drains are the cane farmers’ responsibility.

![Diagram of drainage layout](attachment:fig3.png)

*Fig 3. Representative drainage layout for sugar farms adjacent to a coastal river*
All cane farms on flood plains have a drainage management plan prepared by Sunshine Sugar. These plans provide information on depth, location and nature of acid sulfate soils. They also provide information on the location and dimensions of existing, new or redesigned drains (on existing PAE’s) that will provide efficient drainage without creating an acid hazard. They indicate liming rates for drain spoil. They detail drain maintenance programs on individual properties. They will be reviewed and revised periodically to ensure they remain current.

Any disturbance of soil below 300mm in ASS areas should be consistent with a drainage management plan.

It is important to note that whilst drainage management is the primary tool to manage acid and MBO from cane farms, there are other farm activities which may cause acid and MBO formation, and discharge, which are to be managed under the requirements of the LEP exemptions.

Appendix 2 provides a summary of the best practice guidelines for drain assessment and maintenance, and floodgate management.

**Floodgate and drain management**

Cane farmers will co-operate with government agencies to manage floodgates. They must be trained to safely adjust the gates as part of ‘Active Floodgate Management’ programs aimed at keeping subsoils hydrated, and any ASS layers submerged. Tidal saltwater entry is the preferred method of drain cleaning though it is acknowledged that this option is not available for all drains. The drains in these landscapes are cleaned by farmers to preserve their hydraulic functioning.

Floodgate management will vary, depending on the extent of tidal exchange available. Receiving waters that have considerable acid buffering capacity, such as those with considerable inputs of seawater from estuaries, will generally be able to resist acidification. These waters are also more effective for drain cleaning but floodgates need to be managed carefully to avoid saltwater intrusion affecting the adjacent cane crop. Receiving waters further away from estuaries with a greater freshwater input will generally have lower pH buffering capacity due to lower bicarbonate (HCO$_3^-$) contents.

When conditions are suitable, floodgates should be opened to allow flushing with saline tidal waters within the confines of the drain. Gates should be opened when drains are relatively dry to prevent the discharge of acid water. Responsibility for floodgate maintenance lies with various government agencies. All primary drain outlets to the river are government owned. Once water crosses the farm boundary, it enters a complex ownership and cross jurisdictional area, with ownership sectioned between local government and Crown Lands, and jurisdiction exercised by NSW Planning, NSW Lands, Local Shire Councils, NSW Water, NSW Fisheries and Roads and Maritime Services (Fig. 4).
The accumulation of MBOs in drains can be minimised by following one or more of four potential management strategies:

1) Maintain flow rates that remove MBO as it forms (floodgate control, channel design).
2) Minimise organic matter accumulation.
3) Maintain regular wetting and drying cycles
4) Minimise the source of sulfate from acidic runoff and leachate

Herbicide control of weeds without soil disturbance is the preferred option in ASS. The rate and direction of the spray should be managed to avoid complete destruction of vegetation that may result in collapse of the drain sidewall or erosion of the drain bank. The herbicides must be registered for use in drains.

It is recognised that the death of weeds in drains will initially enhance MBO formation and accumulation. Timely floodgate control of flow rates will help minimise this build up.

The extent and means of drain cleaning should be identified in the drain management plan. Drains that have an acid and MBO hazard and are mechanically cleaned, should be limed so as to neutralise any acidity that might be created as a result of the operation.

In laser levelled paddocks with very shallow spinner drains (Fig. 5 and Fig. 6), trash debris may be
blown in and accumulate. Cleaning out the organic debris with a spinner involves minimal soil removal (a few mm) at the most and would only require follow up liming if an acid hazard was identified.

*Fig 5. Rotary drain spinner (left) and drain plough, shallow drain cleaning implements*

*Fig 6. Shallow drain constructed with a drain spinner in green fallow*

Any mechanical clearing should not increase the depth of the drain. Mechanical weed removal should be by excavators equipped with slotted and raked buckets that minimise soil disturbance (Fig. 7).

*Fig. 7. Slotted excavator bucket*
Mechanical maintenance in ASS areas may create an acid hazard in the freshly exposed sides and base of the drain and in the spoil from the drains. Lime should be applied to neutralise the acidity in both instances (Fig. 8).

![Image](image_url)

*Fig 8. Liming of secondary drains pre- and post-cleaning with a weed bucket*

Spoil should be placed so that any drainage from spoil will not carry acid into the drain. Spoil should be neutralised by application and incorporation of lime, or it can be spread in fields and neutralised there. Apply the required rate of lime to the drain spoil and incorporate, or apply half the required lime as a base layer where the spoil will be placed upon then place the remainder on top of the spoil.

The lime should be applied before or within 2 days of drain maintenance.

All exposed surfaces (batters) must be limed to ensure neutral drain water after cleaning. Mix the lime into spoil as soon as the material is dry enough to be cultivated.

The rate of lime is determined by the degree of hazard indicated in the drainage management plan and liming rates are specified in the plan.

**Re-design of drains on existing PAE’s**

The depth and intensity of the acid sulfate layers has been assessed in key areas of each farm and is shown on a drain management plan. Using currently appropriate soil testing, the same will be required on any new PAEs on ASS prone floodplains.

When farm drainage systems are being redesigned, new drains or remodeled drains will need to be clearly outlined in the drainage management plan. Construction details and timing are critical. Drain design should be properly engineered and the alignment and depth should be as per the plan.

Any disturbance of acid sulfate soils or lowering of the water table will require an assessment of the
hazard produced, and the application of lime to neutralise the acid that may be generated. In some instances, it may not be possible to construct any drains due to the acidity hazard.

**Land grading**

Appropriate land grading will result in a landform that can prevent excess surface water displacing acidic groundwater into the drainage system (Fig. 9).

![Fig 9. Laser levelling machinery used to ensure efficient drainage of surface water.](image)

Land grading has the potential to reduce the export of acid by reducing the number of drains in fields. However, deep cuts may expose larger areas of acid sulfate soils where they occur close to the surface. Fields in which acid sulfate soils occur within 500mm of the soil surface should not be graded without first assessing and then treating the acid hazard that may be created. In areas where the ASS layer is within 500mm of the soil surface Drain Management Plans will specify the lime requirement for the cut areas in the laser graded block.

**Monitoring acid management**

Farmers are required to keep records of land forming (laser grading), earthworks including drain construction and maintenance and any applications of lime to their farms. These records will be available for inspection by sugar industry or local government personnel.

By 30th June each year farmers shall record:

1. length of drains that have been modified in the previous 12 months to a shallower design
2. area laser graded in the past 12 months
3. total area limed and amount of lime applied
4. details of drain maintenance during the previous 12 months including:
   a) location and length of drains cleaned
   b) date last cleaned
   c) method of cleaning e.g. weed bucket; laser bucket; herbicides, spinner
   d) amount of lime applied to works
5. observations of any fish kill incidents in the drains during the previous 12 months
6. how any property or authorized floodgates have been managed during the previous 12 months including any changes in practices.
7. any other works which potentially result in acid discharge

Auditing sugar industry performance

An Audit Committee will make an assessment of compliance with these best practice guidelines. The audit committee shall as a minimum consist of a member of Sunshine Sugar Agricultural Services and a representative from the local Council.

Council LEP sugar industry exemption clauses for the management of acid sulfate soils require that an annual review of drainage management plans and works is to be carried out to a standard satisfactory to the Council and to Sunshine Sugar. Council is to be issued with a copy of the results after it has been carried out. Council may reserve the right to issue a notice relating to any one or more of the works if either of those requirements are not complied with.

To ensure transparency of the process and as a review of the compliance with self-regulation, 10 Production Area Entitlements (PAE’s) from each of the three NSW milling areas will be selected by the relevant Council (s) for an audit of acid management practices each year (30 in total). The PAE’s will be selected from high, medium and low risk areas.

In the event of a breach of these Guidelines and the Agreement being observed during the annual audit, the Co-operative must inform the Local Council of the procedures taken to remediate the breach. Any works carried out without a management plan or not covered by the existing drainage plan will be notified to Council. Actions recommended to redress issues raised by the audit will be detailed as well as the timeframe for compliance. The circumstances of any breach and actions proposed will be fully detailed in the audit report.

In addition to any monitoring by the audit team of actions taken to remediate the breach, the farm involved should be inspected again the following year as part of the annual audit (in addition to the requisite 30 random inspections). Additional audit inspections of farms will be carried out at the discretion of the local Council.
Additional information

Sunshine Sugar Agricultural Services can provide farmers with further information.

Condong Mill 02 6670 1700
Broadwater Mill 02 6620 8200
Harwood Mill 02 6640 0400

Information is also available through NSW DPI
Appendix 1. Sunshine Sugar acid sulfate soil assessment and approval procedure for new PAEs

1. Identify if the new PAE is in a mapped ASS risk area.

2. If in an ASS risk area, undertake soil survey of area to determine depth and degree of ASS hazard
   a. Sampling locations determined in consultation with grower
   b. Soil cores to include sites in the lowest part of the proposed area
   c. Have grower present at time of sampling to provide awareness of presence of any ASS found
   d. Take samples at 30cm intervals to a sampling depth of 1.5m
   e. Record detailed description of soil profile
   f. Samples will be sent for laboratory analysis
   g. Prepare an ASS hazard map.

3. Calculate lime requirement using a look-up table or through laboratory calculation.

4. Develop a Drain Management Plan based on the ASS hazard map and using drainage guidelines in the ASS Manual (Stone et al., 1998) and council LEP documents.
   a. Avoid strongly acidic areas
   b. Utilise best practice in drainage design
   c. Implement laser land grading to improve cross paddock drainage
   d. Document drain maintenance procedures in the plan
   e. Inform new growers of the obligations of self-regulation.

5. Following approval, undertake prescribed auditing of acid management practices.
Appendix 2. Best practice guidelines for drain assessment, maintenance, and floodgate management.

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<th>ITEM</th>
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<th>EXPLANATION</th>
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| Timing of Works | • Drain cleaning works should not be carried out during runoff events  
• Drain cleaning in the lower estuary should be scheduled for late winter/early spring period  
• Plan to coincide with land preparation of fallow paddocks | • There is a high risk of discharges of acid products and silt when drains are flowing  
• Cooler months (July-September) are when flowering/fruiting cycle of marine plants is least and there is minimal fish migration  
• Drain spoil can be spread across fallow paddocks |
| Deepening or Widening Drains | • Original drain profiles should not be enlarged  
• Where drain design is inadequate, seek an engineering assessment prior to redesign  
• Maintain drains no deeper than the pipe or culvert  
• Dish drains should be installed in laser levelled fields rather than deep drains | • Deep drainage lowers groundwater levels and increases the export of acid products  
• Some drains which need to be redesigned may require Development Approval  
• Laser levelling removes the need for the maintenance of deep drainage |
| Excavator Operators | • Operators must be provided with information on acid risk as described in the ‘Drain Management Plan’ specific to each farm  
• Operators must have received approved training in recognising and handling ASS material  
• The use of a Laser guided bucket is a good way to ensure constant depth | • Written instructions are an important means of risk management as well as assisting in improving operators’ understanding of the issues  
• On-the-ground training is also essential so operators can recognise ASS and understand why particular practices are important. |
| Liming Drain | • Apply the required rate of lime to the drain spoil and incorporate, or apply half the required lime to the drain before use of the weed bucket then apply the remainder as a bed of lime for the spoil to be placed upon.  
• All exposed surfaces (batters) must be limed to ensure neutral drain water after cleaning  
• Mix the lime into spoil as soon as the material is dry enough to be cultivated  
• Where spoil heaps have not naturally revegetated within a few months, rehabilitation (cultivation, liming, seeding) must be carried out | • Liming drains prior to cleaning assists in mixing lime and sludge giving better neutralisation and stabilisation of acid products  
• Intercepts and neutralises acid seepage from drain sides  
• Thorough mixing of lime is required to ensure efficient neutralisation  
• Bare spoil heaps can continue to leach acid products as well as being a source of erodible material  
• If regrowth is not occurring within a “normal” period after seeding, then additional lime should be cultivated into bare areas and subsequently reseeded. |
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| Handling Monosulfidic black ooze (MBO or Black drain sludge) | • Spread drain sludge (MBO) as a thin layer in cultivated paddocks, lime and incorporate into top soil when dry enough at an appropriate rate to neutralise acidity  
• In pasture areas, if black drain sludge is not being spread, ensure that the sludge is placed so as not to be flushed back into drains; bund and lime as required. | • Concentrated MBO in drain sediments need to be handled very carefully as they can begin to oxidise and generate acidic products within minutes of exposure to air  
• Drain sludge is easily washed back into drains |
| Controlling Discharge of Polluted Water | • Clean drains in stages, beginning furthest from the floodgates to minimise the risk of sediment transport to the estuary  
• Install where necessary a temporary weir or silt curtain in drains to contain water/sediment prior to commencing works  
• Monitor drain water pH  
• Treat drain with lime to raise pH of drain water | • Drain cleaning can disturb toxic sediments (monosulfides) which can impact adversely on the estuary  
• Reliance on sea water to buffer acid caused by drain cleaning, strips the water of carbonate which is deleterious to aquatic life |
| Weed Removal | • Where practical, salt water flushing should have been practiced prior to chemical or mechanical weed removal  
• A reed bucket should be used wherever possible in preference to silt bucket  
• Once removed, plant material and spoil should be placed as far away as practicable from the drain | • Weed control with salt water is less environmentally damaging  
• Reed bucket removes minimal sediments from drain  
• Vegetation will release phosphate and nitrogen which is best absorbed in the paddock, rather than running back into the drain to promote further weed growth |
| Spraying Aquatic Weeds | • Ensure that the proposed use of a pesticide is fully compliant with label directions  
• Apply herbicides only in dry periods to avoid adverse impacts from both the pesticide and the export of decaying organic material  
• Timely spot spraying is preferred to blanket spraying of drains  
• Only spray the bottom of the drains, not the batters | • Pesticide use in aquatic situations is strictly controlled because of the risk of environmental damage  
• Pesticide use can lead to low dissolved oxygen levels through vegetation rotting in drains  
• Spot spraying can effectively control invasive water weeds  
• Erosion of batters is minimised if they are well vegetated |
| Salt Water Flushing | • Accept minor leakage of floodgates as an alternative method of weed control. Repair minor leaking floodgates only if they are causing damage to agricultural production or are in danger of structural failure. (Note: Repair of long term leaky gates requires NSW Fisheries approval)  
• Accept partial opening of floodgates as an alternative method of weed control  
• Investigate whether floodgates could be seasonally opened  
• Investigate whether floodgate redesign is required (e.g. mini-sluice gate, sluice gate)  
• Introduce salt water gradually to drains to minimise damage; | • Leaking floodgates can have environmental benefits by flushing drains thus improving water quality, controlling water weeds, maintaining elevated groundwater and allowing fish passage  
• Gradual opening avoids fish kills, rapid death of plants and deoxygenation of water and rapid sediment removal by tidal flushing  
• Gradual opening allows the extent of salt water intrusion to be gauged  
• Salt damage to crops and pasture can occur from surface inundation and through lateral intrusion in sandy soils and through mole drains  
• Expert advice will be necessary to assess these risks in some situations |
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| Native Vegetation | - Local Land Services approval is required to trim, lop or destroy any native vegetation on protected lands including slopes over 18 degrees and riverbanks  
- Place spoil on previously disturbed areas rather than in areas of native vegetation  
- Where possible examine the use of shade trees along weed infested drains as a means of weed control;  
- Encourage permanent vegetation on at least one drain batter which may be alternated in different parts of the drain; Where continuous trees cannot be tolerated, encourage isolated trees with grass understorey;  
- Vegetation and drain clearing to allow for floodgate operation and maintenance in front of floodgates should be limited to a radius no more than the width of the floodgate headworks structure. Additional vegetation clearing should be limited to one side of the drain as it passes into the estuary, by agreement with NSW Fisheries as required | - Vegetation growing on drain banks helps prevent soil erosion  
- Shade is also important in maintaining high dissolved oxygen levels in drains  
- Permanent vegetation along drain banks encourages diverse aquatic ecology to establish.  
- Where machinery access is required for drain clearing only one side of drains should be allowed to revegetate with permanent tall vegetation |
| Aquatic Fauna & Flora | - Where eels are observed in drain spoil, defer spreading of spoil heaps for 24 hours  
- Removal of marine vegetation (e.g. mangroves or seagrass) requires written authority from NSW Fisheries  
- Encourage permanent aquatic habitat along the edge of major drains, including overhanging trees; | - Drain cleaning can result in substantial number of eels being placed on land. The fate of these eels is not known but it is likely that they will find their way back into the drain if they are in good physical condition  
- Continuous vegetation provides important sheltered habitat for juvenile migrating fish |
| Monitoring results of drain maintenance | - Keep a record of the timing of drain works and methods used  
- Record the outcomes (quarterly/annually as relevant) regarding issues such as regrowth of weeds, water quality and sedimentation issues, flooding related issues, and any aquatic life in the drains  
- Record any fish kills in the drains  
- Follow trends in water quality in the drain and record any significant changes | - Keeping a record of what was done and the outcome can lead to improved environmental outcomes and more effective and cheaper methods of drain management. |
References


