Guide for use of environmental characteristics

Burnett - Mary priority catchments

Queensland Government

Prepared by

Soil and Land Resources, Landscape Sciences
Science and Technology Division
Department of Environment and Science
PO Box 2454
Brisbane QLD 4001

Disclaimer

Citation

Queensland Government (2019) Guide for use of environmental characteristic data sets: Burnett-Mary priority catchments, Soil and Land Resources, Department of Environment and Science, Brisbane.

Acknowledgements

This report has been prepared by staff of the Department of Environment and Science with the assistance of Department of Natural Resources Mines and Energy. Acknowledgement is made to the Department of Environment and Science Office of the Great Barrier Reef for funding this project.

May 2019

Contents

List of figures

List of tables

Introduction

In 2010, the Queensland Government introduced measures to assist in reducing the level of sediment, nutrients and herbicides (contaminants) reaching the Great Barrier Reef (GBR). The primary aim of this initiative is to encourage cane growers, graziers and other primary producers within the Wet Tropics, Burdekin and Mackay-Whitsunday (priority catchments) to manage their farms in a way that reduces the risks to the Reef from contaminant loss (sediment, nutrients and herbicides). It does this by providing a source of information on the natural landscape features that influence movement of contaminants off-property to assist decision-making by landholders and extension professionals. As part of the assistance measures, and research and development portfolio, a specific project was developed to identify landscape features (‘environmental characteristics’) that influence contaminant movement in cane growing areas. It should be noted that not all of the landscape features and biophysical factors that influence contaminant transport are discussed in this guide.

Environmental characteristic mapping for the Wet Tropics catchment was produced in 2011. As part of that process, a technical workshop reviewed the conceptual model and natural resource data used to produce the four environmental characteristic maps: *Erosion Potential; Flooding Potential; Water Pathway; and Soil Transport Potential*. Workshop attendees, including representatives from industry and NRM groups, accepted the information and concepts as technically sound and agreed the data sets are generally suitable for use at the strategic, regional and property level. It was also acknowledged that environmental characteristic maps can assist users to understand the variability and general features of soils found across cane farms (e.g. farms of 50 hectares or greater) to guide property planning. However, these maps do not precisely identify the location of soil boundaries well enough to support detailed property planning without additional on-farm investigations.

To support implementation of the package, the Department of Environment and Science (DES) is coordinating science projects focused on answering the following questions:

1. What and where are the natural features that predispose landscapes to contribute above natural levels of sediment and deliver nutrients and herbicides offsite through water movement?
2. What systems/practices are being used on cane and grazing properties to take into account the landscape features (environmental characteristics)?
3. Within the priority catchments, what and where are the main risks associated with cane and grazing activities?
4. What are the management systems that should be adopted to minimise risk?
5. What information on environmental characteristics could be provided to assist landholders in determining appropriate practices to minimise movement of contaminants off-site?

In 2012, Environmental Characteristics User Guides were completed for the priority catchment areas of the Wet Tropics, Burdekin Dry Tropics, and Mackay-Whitsunday. The products developed to date include spatial data, a technical report and user information for all priority catchments listed above.

In 2016 further funding was provided to develop an Environmental Characteristics User Guide for the Burnett-Mary catchment, in particular the intensively cropped areas of the coastal Burnett-Mary. This user guide adopts the approaches developed in 2011-2012 and provides advice on how to use the currently available environmental characteristic maps within the Burnett-Mary catchment for cane cropping areas.

The methods used to develop these maps and this guide are based on those already published for the Wet Tropics and the Burdekin and Mackay-Whitsunday. If users require further information about the process used to map environmental characteristics, they should refer to the technical report - '*Mapping environmental characteristics important for GBR water quality: Burdekin and Mackay-Whitsunday'* (Bryant *et al.* 2012)

The methodology used is available to download through the Publications Portal catalogue: https://www.publications.qld.gov.au/dataset/reef-water-quality-environmental-characteristics

The aim of this user guide

The aim of this guide is to assist users to understand and interpret environmental characteristic data (maps) currently available across most of the cane growing areas of the Burnett-Mary catchment.

This guide focuses on four environmental characteristics that influence the way soil and water moves across the landscape, including:

- Erosion potential (i.e. the inherent potential of soil to erode according to slope and soil features)
- Flooding potential (i.e. the landscape flooding that influences transport of contaminants to watercourses)
- Water pathway (i.e. the potential of soils to generate runoff and deep drainage which can mobilise and transport contaminants)
- Soil transport potential (i.e. the inherent potential for soil fractions to be transported long distances).

These characteristics are consistent with those used in the Wet Tropics, Burdekin and Mackay-Whitsunday.

Intended audience

Environmental characteristics maps are intended to assist extension professionals and other organisations (users) to:

- Understand the occurrence and implications of natural features that can influence soil and water movement across cane growing areas
- Support growers to adopt best management practices appropriate to their local conditions
- Prioritise education, extension and awareness activities across the Burnett-Mary catchment.

While these maps were primarily developed as a guide to assist in property planning for cane growing, a similar approach could be adopted for other cropping systems.

How to use this guide

This guide explains how to use the four available environmental characteristic maps, which include:

Erosion potential – indicates the susceptibility of landscapes to erode, which can contribute sediment and associated nutrients and herbicides to waterways.

Flooding potential – describes the potential of landscapes to experience inundation caused by flood events. Areas under cane that flood more frequently represent greater potential sources of contaminants.

Dominant water pathway – indicates the potential of landscapes to generate runoff, as inferred by the drainage and permeability characteristics of the soils.

Soil transport potential – indicates the potential for soil to be transported long distances, as inferred by the relative proportion of sand, silt and clay soil particles in the surface soil. Clay particles (<0.002 mm) are more easily transported over longer distances than larger silt and sand particles.

In addition to mapping the four characteristics listed above, this guide also provides information on:

- How the characteristic may affect water quality (background)
- A description of the data sets used and information products
- Information to support on-property interpretation of characteristics, including additional considerations such as rainfall, soil type and vegetation cover
- General implications for management (management)
- Other sources of information.

The study area is outlined in Figure 1. This area identifies where there is detailed land resource mapping which also corresponds to significant cropping areas along the Burnett-Mary coast. Sugarcane cropping is also illustrated on this map.

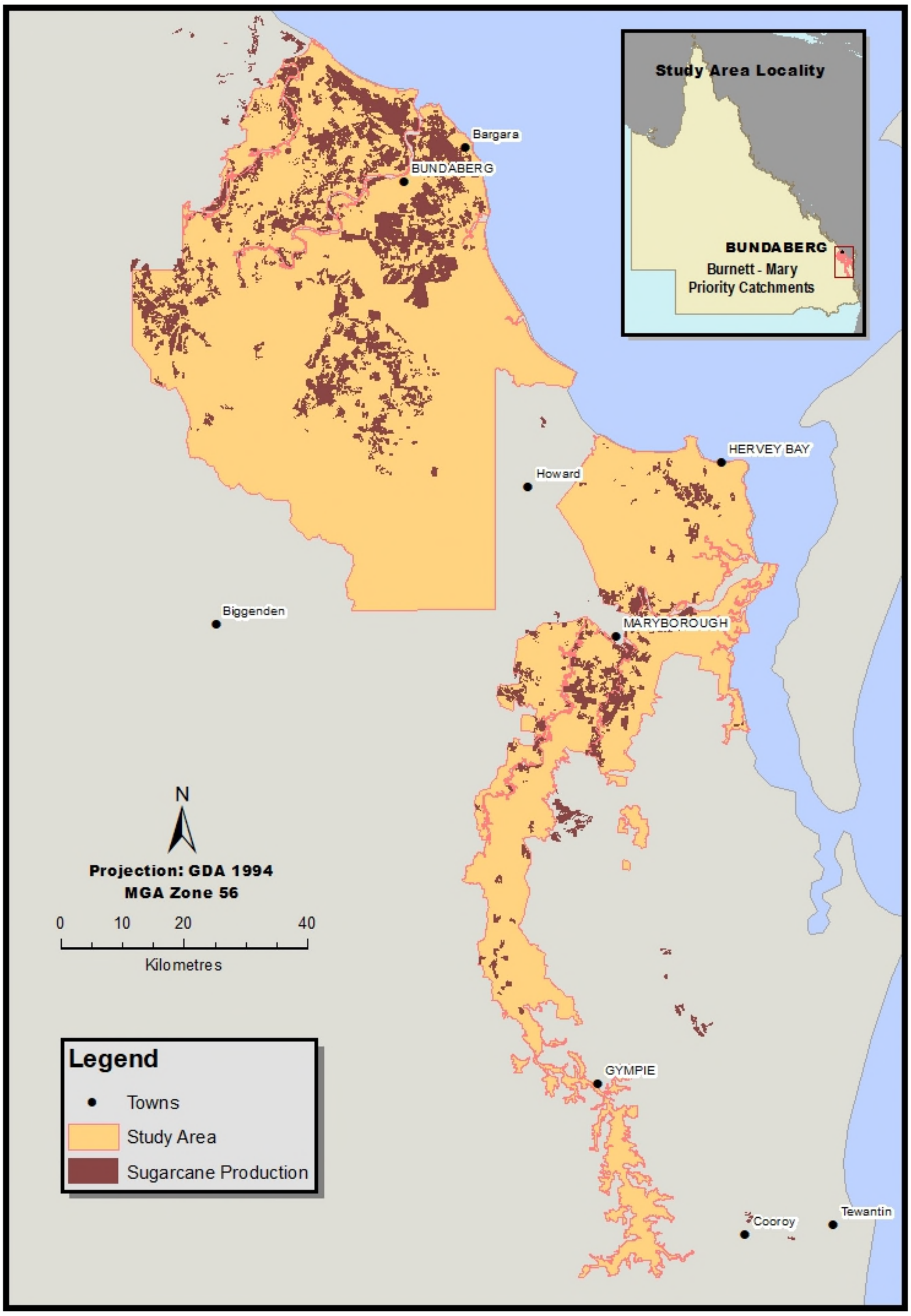


Figure 1. Burnett-Mary Catchment study area and extent of sugarcane production – 2009 land use data (DERM 2009)

Data used to assess environmental characteristics

The environmental characteristic maps are based on soil and landscape data collected during land resource surveys (refer to Appendix A for a list of surveys relevant to the area). The land resource surveys conducted in the Burnett-Mary were primarily undertaken in agricultural development areas to provide soil and landscape data and information for improved sustainable farming systems and to guide regional planning, catchment management and property management planning. Table 1 indicates the soil attributes used to assess environmental characteristics. For further information about the process used to assess the four characteristics, refer to the technical report produced Bryant *et al.* (2012).

Table 1. Summary of soil attributes used to assess environmental characteristics.

Environmental characteristic	Attributes assessed	Description of environmental characteristic
Erosion potential	Soil erodibility & slope	This data describes erosion potential from hillslope erosion processes (rill, sheet and scald) based on soil attributes and slope. This data also identifies known eroded land ('mapped eroded land'), including gully and streambank eroded areas, recorded at the time of surveys.
Flooding potential	Potential extent & frequency of inundation	These data describe the areas which are potentially subject to inundation as interpreted from two data sets • Land resource survey data captured at 1:100,000 scale or better is utilised to indicate annual flooded, and less than annual flooded, areas. These land resource surveys focused on areas suitable for intensive agricultural production and describe the extent and frequency of flood events. • Flood extent data from 2011 and 2013 flood events; highlighting the flooded area. Note: Areas not shown with flooding potential are either not flooded, or have insufficient data to determine flood extent or frequency.
Water pathway	Drainage class & permeability class	Water pathway is derived by combining drainage and permeability attributes of soils, as collected during land resource surveys. The decision matrix used to identify runoff and drainage landscapes is described in the Technical Report (Bryant *et al*. 2012).
Soil transport potential	Surface soil texture	This data describes the generalised texture of the soil surface. The classification of soil texture codes into four categories (sand, loam, clay) Appendix B.

Rules for using maps and supporting information

Environmental characteristics maps form part of a suite of spatial information that can assist extension professionals and other organisations to understand the natural features of farms across the Burnett-Mary. Through the use of spatial information, users can start to identify areas where land management practices could be managed to improve water quality. This can support a number of tasks, e.g. preparing for field assessments or having effective conversations with growers. It is important that users are aware of the following conditions when using maps and supporting information:

1. Each map should be considered separately. Combining data sets obscures the importance of each characteristic and does not adequately represent the natural features of farms.

   Information about the four environmental characteristics should be considered in conjunction with other property features that influence soil and water movement, for example, users may access other information sources to gain an understanding of characteristics such as rainfall, vegetation cover, location of watercourses and streambank stability. Satellite or aerial imagery can be useful to identify some of these features.
2. Environmental characteristic maps are a guide to the types of features present on farm and may not always reflect the on-ground environment for a range of reasons, such as scale limitations or influence of human activities. These maps were developed using natural resource data mostly at scale of 1:50,000. This scale of mapping can assist users to understand the variability and general features of soils across, or between cane farms. However, this scale does not precisely identify location of soil boundaries and should not be used to support detailed property planning, such as nutrient/herbicide use within a block.
3. Some areas in the Burnett-Mary catchment are mapped at a coarser scale (1:100 000), e.g. Childers district (Figure 2). Soil surveys at 1:100 000 scale are still considered to be appropriate for identifying possible landscape features as a guide only for property planning.
4. Users should check with growers if the maps represent the level of variation found on farm and if management has influenced the inherent environmental characteristics. For example, an area described as ‘poorly drained’ on the water pathway map may be improved with drainage works following the construction of farm drains. At times, growers will have access to more detailed soil information, which can better inform landscape assessment.

In light of the points described above, the environmental characteristic maps are not intended to support ranking of properties for any purpose.

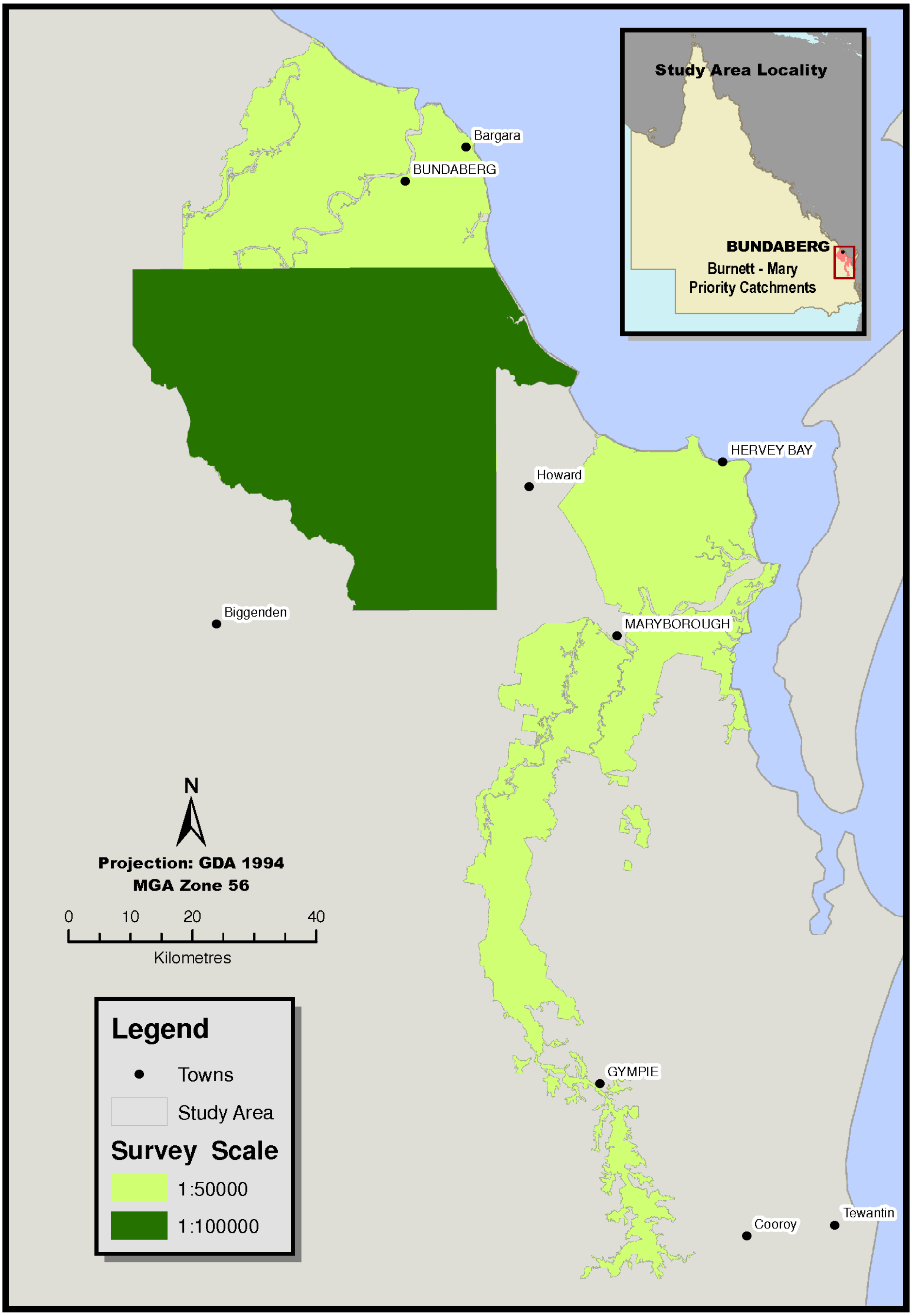


Figure 2. Land resource survey scales for the Burnett-Mary catchments.

Access to information

Spatial information

Users of the guide can obtain spatial layers for the four environmental characteristics as ArcGIS compliant files, e.g. shape-files. Environmental characteristics spatial information can be downloaded from the Queensland Government Information Service website http://qldspatial.information.qld.gov.au/catalogue/custom/index.page.

Technical report

The assessments for other priority GBR catchments produced both a methodology document and a Guide. A methodology document has not been produced for the Burnett-Mary, as the same methods were used as in the other priority catchments. Readers are referred to the technical report – *Mapping environmental characteristics important for GBR water quality: Burdekin and Mackay-Whitsunday* (Bryant *et al.* 2012) which provides further detail regarding the development of the four environmental characteristic maps. The data and rules used to assess the four environmental characteristics for the Burnett-Mary catchments are outlined within this report.

Environmental characteristics and their impact on water quality

The environmental characteristic maps that accompany this guide illustrate a range of inherent landscape features that remain relatively unchanged over time. These maps can help users gain an initial understanding of landscape features that could be managed to reduce the water-borne loss of soil, and movement of herbicides and nutrients. However, to fully understand the likelihood that these contaminants will be transported off-farm, the interaction between environmental characteristics and human activities (management factors) needs to be considered.

Environmental characteristics and management factors interact in complex ways resulting in the expression of the risk to water quality. On-farm management can have a neutral, positive or negative effect on the quality of water leaving the farm. For example, implementing green cane trash blanketing—instead of burning cane trash—on a farm with erodible soils could result in a rapid improvement to the quality of water leaving the farm. Some management changes may take longer to show an effect, i.e. there may be a lag period following the change. The interaction between environmental characteristics and management factors is illustrated in Figure 3.

To understand the risk that contaminants will be transported off-site, you need to consider the interaction between management factors and a range of environmental characteristics.

The four environmental characteristics in this guide are not the only landscape features that influence soil and water movement. Environmental characteristics such as rainfall, vegetation cover, proximity to watercourses and groundwater can also affect the quality of water leaving cane farms. Although these characteristics are not able to be mapped at this time, the influence of these characteristics should be considered as part of property planning.

Environmental characteristics

Remain relatively unchanged over time but can be influenced by management factors

e.g. rainfall, soil attributes, landscape position, geology

Management factors

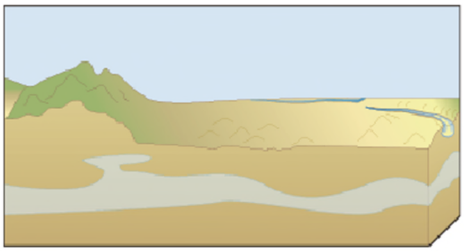
Are dynamic and the result of decisions made by land managers

e.g. tillage, nutrient, herbicide and drainage regimes

A response observed in the landscape may drive a change in management factors

Landscape response

The way the landscape behaves is a result of the interaction between environmental characteristics and management factors. The response may be positive (e.g. an increase in soil carbon levels), negative (e.g. surface soil is lost to erosion), or neutral.



Responses may be observed over the short or long term, for example:

A management practice change from burning cane trash to green cane trash blanket could cause a **short-term (rapid) response** in the quality of runoff leaving a property.

A change in water quality at the end of a catchment is a **long-term response** as this is a function of practice change from many properties, the lag periods involved in the delivery of dissolved and sediment bound nutrients and herbicides to the end of catchment and the in-stream transformations of nutrients and herbicides during transport.

Likelihood of negative response (i.e. risk to GBR water quality)
The Reef Protection Package aims to improve the nutrient and herbicide use efficiency and reduce the risk that sediment, nutrient and herbicides will be transported to surface water via runoff.

Figure 3. Overview of the interaction between environmental characteristics, management factors and landscape response.

Erosion potential

Background: types of erosion

Queensland's high-intensity summer rainfall means there is a significant risk of erosion by water, which may take any of the following forms: Rill, Sheet, Streambank, Tunnel and Gully (Figure 4).

The erosion potential from **hillslope erosion processes** (i.e. rill and sheet) is described during land resource surveys and assessed according to slope and the natural erodibility of the soil. The soils with the highest potential to contribute to sediment loss are those which are erodible on steep slopes.

The important factors to consider when managing land to minimise erosion are:

- Soil – some soil types are inherently more erodible than others.
- Slope – steeper slopes increase the velocity of runoff water, which can increase erosion. Longer slope lengths also increase the likelihood that soil particles will travel further from the point of origin.
- Rainfall – high intensity rainfall events can facilitate large erosion events on susceptible soils.
- Cover – vegetation cover protects the soil surface from raindrop impact and slows runoff water.

Appendix C outlines the soil types and their agricultural implications.

Rill erosion (a form of hillslope erosion)

Small channels are eroded in soil as runoff water concentrates down a slope.

Sheet erosion (a form of hillslope erosion)

A sheet of water running over the landscape carrying eroded sediments. This form of erosion may be less visible as it happens uniformly across a slope.

Streambank erosion

The direct removal of soil from banks by flowing water, exacerbated during periods of high streamflow or lack of vegetation cover.

Tunnel erosion

Dispersible subsoils with naturally high levels of sodium are removed through subsurface water movement. Surface soil initially remains intact, but may collapse and form gullies.

Gully erosion

Caused by the concentration of runoff water until flow velocity is sufficient to detatch soil particles along a drainage line. A waterfall may form over the gully head, and splashback causes the gully to migrate its way up the slope.

Figure 4. Erosion types

Description of erosion potential mapping

The erosion potential map indicates the natural susceptibility of landscapes to erode. However, the likelihood that soil will erode is largely dependent on land use and management practices. Hence soils that are naturally prone to erosion may not erode under good land management practices and conversely soils with low erosion potential may erode under poor management practice.

The soil and slope attributes that contribute to each category of erosion potential are detailed in Table 2 and the spatial extent of these categories is shown in Figure 5.

Table 2. Description of erosion potential categories (adapted from Wide Bay-Burnett land resource assessment reports which used standard industry practices)

Category	Soil Type	Slope Class
Lower Potential	Very stable soils: Ferrosols	0% 0-2% 2-5% 5-8%
	Stable soils: Vertosols, clayey surfaced Dermosols, coarse surfaced well drained Dermosols, Chromosols, Rudosols and Kandosols	0% 0-2% 2-5%
	Unstable soils: Sodosols, Hydrosols, Podosols, Kurosols, loamy surfaced Dermosols and Tenosols	0% 0-1% 1-3%
Moderate Potential	Very stable soils: Ferrosols	8-12% 12-15% 15-20%
	Stable soils: Vertosols, clayey surfaced Dermosols, coarse surfaced well drained Dermosols, Chromosols, Rudosols and Kandosols	5-8% 5-12% 12-15%
	Unstable soils: Sodosols, Hydrosols, Podosols, Kurosols, loamy surfaced Dermosols and Tenosols	3-5% 5-8%
Higher Potential	Very stable soils: Ferrosols	20-30% >30%
	Stable soils: Vertosols, clayey surfaced Dermosols, coarse surfaced well drained Dermosols, Chromosols, Rudosols and Kandosols	15-20% >20%
	Unstable soils: Sodosols, Hydrosols, Podosols, Kurosols, loamy surfaced Dermosols and Tenosols	8-12% >12%

NB. Podosols in this instance are reported to have an ortstein pan within the top 1m of the soil profile.

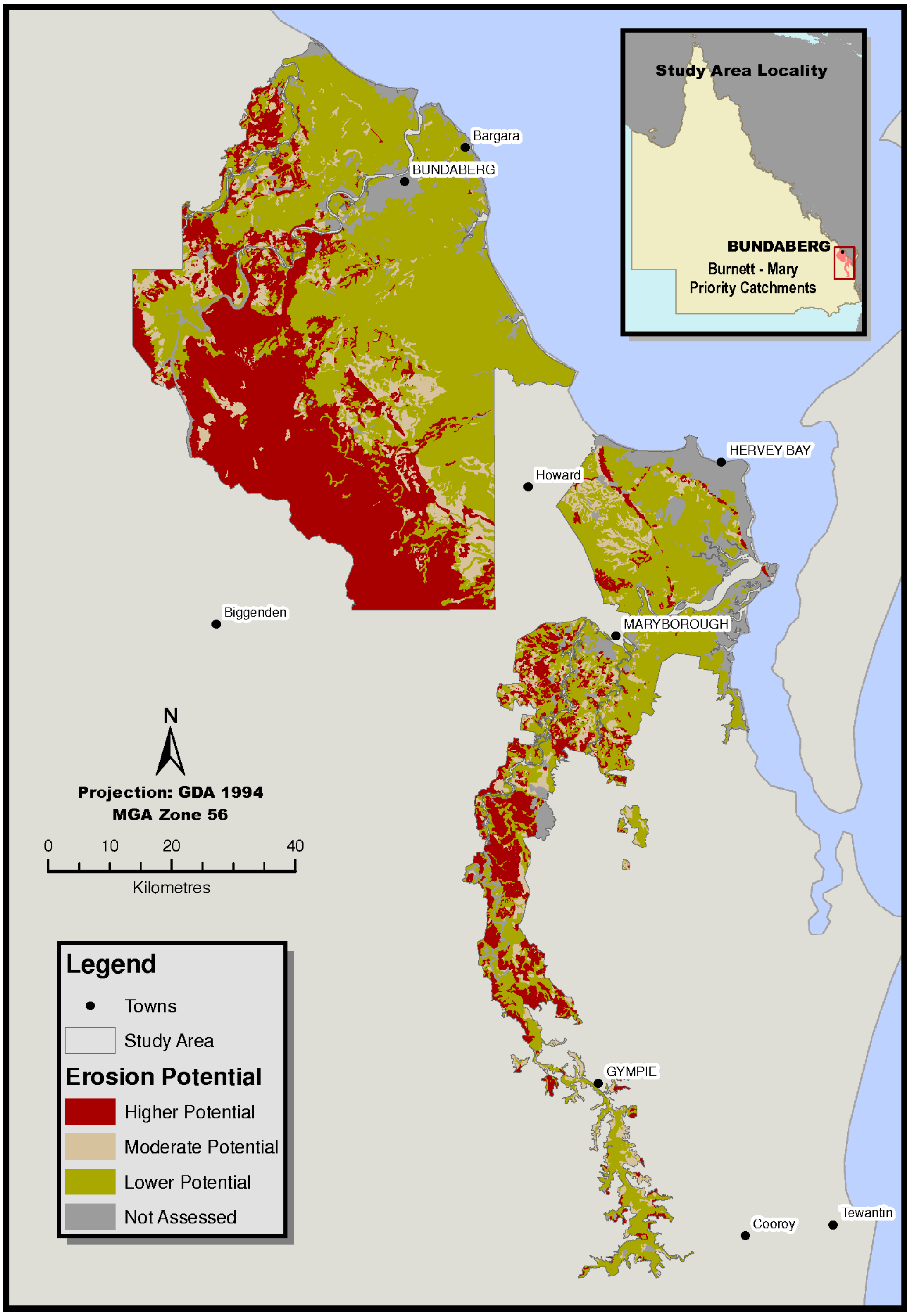


Figure 5. Erosion Potential - the Burnett-Mary catchments

The effects of rainfall and vegetation cover are not represented in the erosion potential map. However, these characteristics also influence the potential of landscapes to erode and it is important to consider these as part of property planning. Some contextual information about the effect of rainfall and vegetation cover is provided in the 'Additional considerations' section below.

Additional considerations

Rainfall

Patterns and intensity of rainfall can have a strong influence on rates of erosion, for example:

- Rainfall intensity, in addition to amount of rainfall, influences erosion. High intensity rainfall events increase the potential for erosion to occur.

  For example, 100mm of rain delivered in one hour is likely to cause greater erosion than the same amount delivered over one day.
- Rainfall intensity can be variable across small distances and is best discussed with property owners. When considering intensity, it may be sufficient to acknowledge that rainfall events are likely to be more intense during the wet season and in high rainfall areas. This will allow seasonal appropriate management practices to be discussed.
- Landscapes in different rainfall zones may experience different rates of erosion despite similar management practices.

The average rainfall for key areas (Bundaberg, Maryborough and Gympie) is outlined in Table 3. Information on daily, monthly and annual rainfall is also available from the Bureau of Meteorology website. Average annual rainfall is mapped across the study area in Figure 6.

Table 3. Average rainfall at Bundaberg, Maryborough and Gympie

Locality	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Bundaberg	171	156	113	56	68	51	39	34	36	78	85	127	1022
Maryborough	163	172	157	87	78	67	51	41	42	77	84	129	1138
Gympie	162	167	145	83	72	60	52	40	45	72	88	137	1124

Long-term average monthly rainfall statistics (BOM website accessed 15.12.2018)

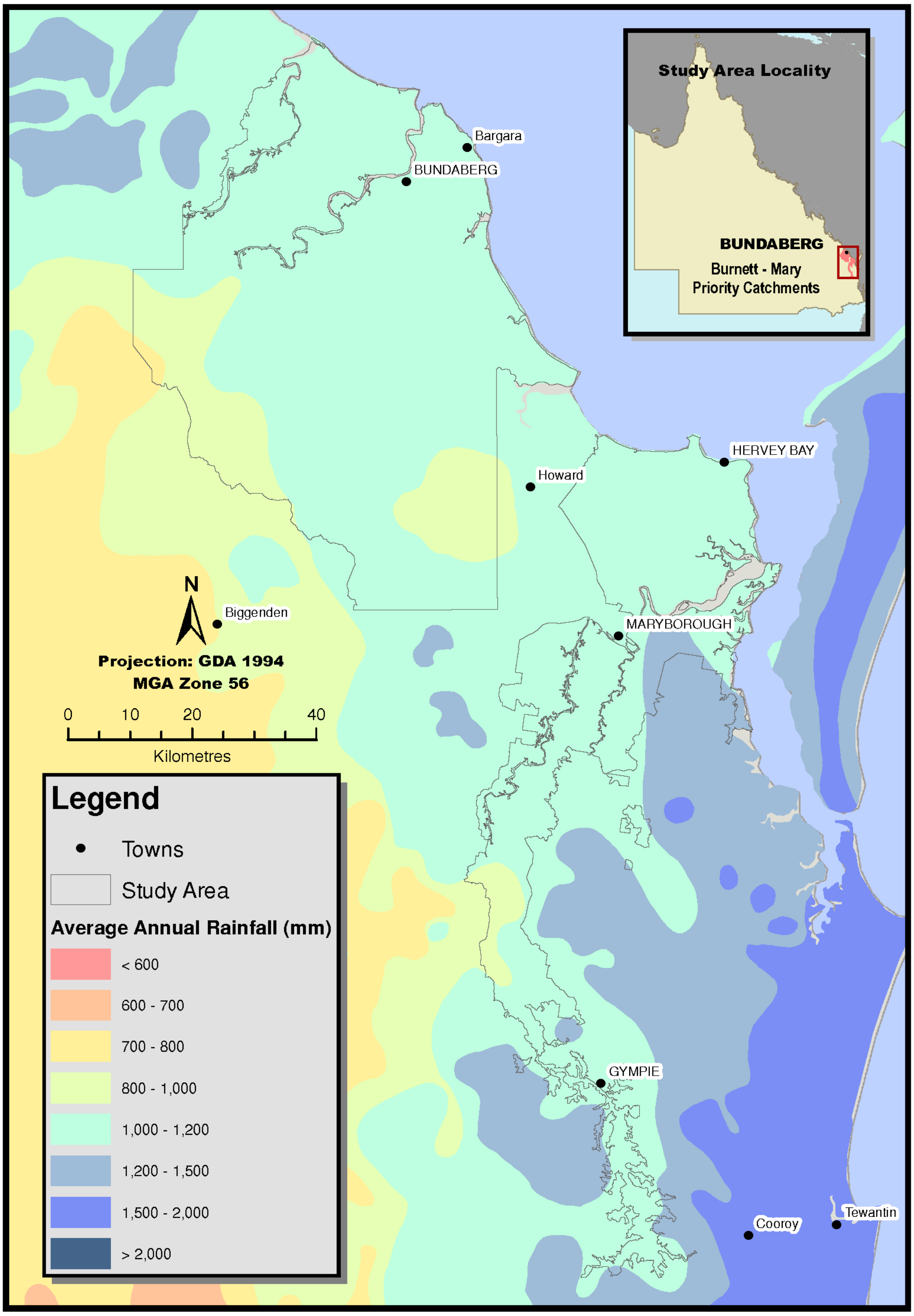


Figure 6. Average annual rainfall in the Burnett-Mary catchments (DNRM 2002)

Vegetation cover

Erosion is influenced by the level of vegetation cover present i.e. full crop, ratoon, break crop, fallow etc. Greater levels of cover reduce the chance of erosion exponentially. This means that cover as low as 40% can still significantly reduce erosion (Figure 7).

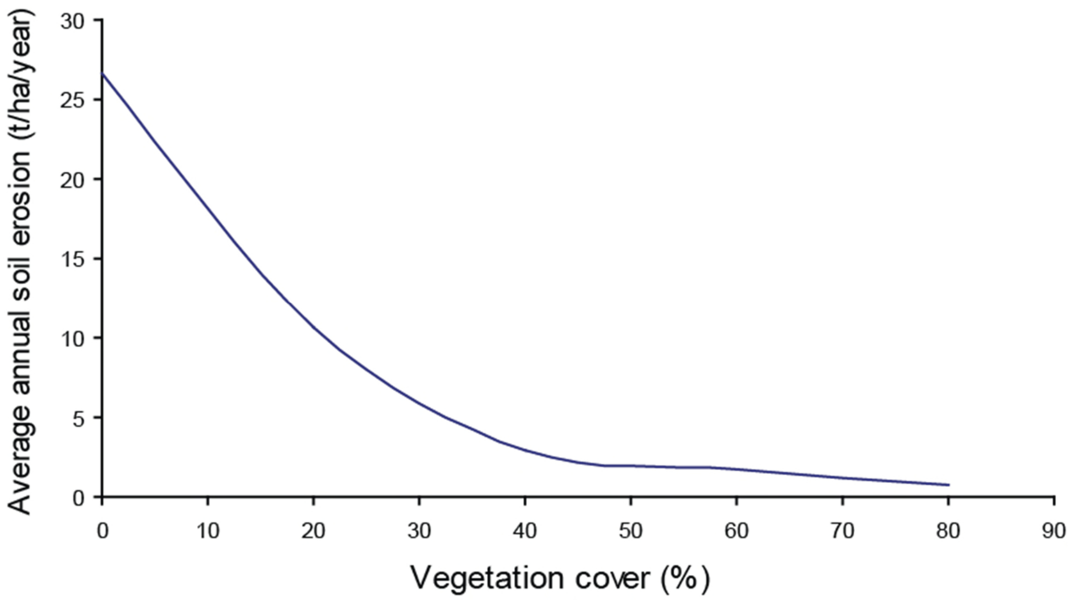


Figure 7. The influence of vegetation cover on soil erosion for a Dermosol. This relationship is similar for other soil types (graph produced using outputs from HowLeaky, McClymont *et al*. 2011).

At any point in time, approximately 15% of cane paddocks may be in fallow (Figure 8). Paddocks without appropriate cover have greater potential to erode, which increases if the soils are also prone to erosion

Trash blanketing has had a major impact on reducing erosion across cane farms (Figure 8), as it:

- reduces the effect of raindrop impact, which can dislodge soil particles
- slows the velocity of runoff, which reduces the likelihood of sediment being dislodged and also allows suspended sediment to settle out.

Figure 8. Cane paddock with no trash (left) and with trash blanket (right) near Bundaberg.

Soil type

The greatest potential for erosion occurs during the wet season (approximately December – April); however soil type also influences the degree to which soils will erode.

For example:

- sodic soils (e.g. Sodososls) can erode rapidly, if exposed, because of their highly dispersive nature when wet
- highly permeable basaltic soils (e.g. Ferrosols) are less susceptible to erosion because they are well structured
- sandy soils (e.g. deep sandy Tenosols) tend to erode less as they are very permeable and have large soil particles which are less susceptible to movement by water.

Constructed farm drains as a source of sediment

Many cane farms in the priority catchments are located in flat floodplain environments and improved drainage can be required to minimise water-logging of cane crops. In the high rainfall environments, even sloping country may require drains to facilitate water transport off farm in the wet season.

Management

The likelihood that soils will erode is largely dependent on management practices. Soils that are naturally prone to erosion may erode less under certain land management practices and conversely, soils which are naturally quite stable may erode under poor land management practices.

To reduce erosion potential, management practices must consider the implications of slope, soil type, rainfall, and cover. Table 4 outlines example management principles that could be employed to address these factors and minimise the risk of erosion.

Table 4. Management options for mitigating impacts of erosion

Erosion factor	Erosion principle	Examples of management principles to minimise erosion
Slope	Steeper slopes = increased chance of erosion	• Manage fallow to retain topsoil by providing cover, a well-managed legume crop during the fallow can help protect the soil when heavy rain occurs. • Wider row spacing allowing for controlled trafficking of machinery to aid infiltration and reduce runoff. • Reduce tillage operations, consider zonal or zero tillage. • Maintain green cane trash blanket throughout ratoons. • Installing berms or contour banks will help to reduce the velocity of the flow of run-off across the farm, thus will reduce erosion and allow sediments to be deposited before they leave farm. • Maintain well vegetated spoon drains, headlands and grassed treatment areas.
Soil type	Erodible soils = increased chance of erosion	• Minimum or zero till adopted. • Wider row spacing allowing for controlled trafficking of machinery. • Use double disc opener planters for reducing soil disturbance during planting. • Maintain green cane trash blanket throughout ratoons. • Ensure areas vulnerable to erosion or upstream from the erosion are well vegetated. • All drains are well vegetated. • Manage fallow effectively and maintain vegetative cover on soil. • Maintain well vegetated spoon drains, headlands and grassed treatment areas. • The timing of cultivation on erodible soils is specifically managed for high rainfall periods.
Rainfall	Higher rainfall intensity = increased chance of erosion	• Fallow managed to promote vegetative cover. • Consider rainfall forecasts prior to planting operations or tillage to reduce the risk of heavy rainfall coinciding with operations. • Adjust time of cultivation to avoid high rainfall periods. • Maintain green cane trash blanket throughout ratoons for avoiding direct exposure of soil to high intensity rainfall. • Maintain well vegetated spoon drains, headlands and grassed treatment areas.
Cover	Less cover = increased chance of erosion	• Fallow managed effectively to protect soil through crop cycle either by growing a legume cover crop or to promote other vegetative cover. • Prior to establishing plant crop, spray out cover crop with knockdown herbicides and leave as standing stubble or slash cover crop and leave on surface for minimising soil loss. • Maintain green cane trash blanket throughout ratoons. • Riparian vegetation is maintained.

Further information

Erosion fact sheets https://www.publications.qld.gov.au/dataset/science-notes-soils

- Soil conservation planning in cropping lands
- Runoff control measures for erosion control in cropping land
- Controlled traffic farming – soil conservation considerations
- Maintaining contour banks
- Contour bank specifications
- Soil conservation waterways – planning and design
- Soil conservation waterways – Construction and management
- Soil conservation waterways – Plants for stabilisation
- Erosion control in cropping lands
- How healthy is your watercourse?
- Streambank planting guidelines and hints
- Streambank vegetation is valuable
- What causes bank erosion
- What causes stream bed erosion
- Catchments and water quality.

Soil conservation measures—Design manual for Queensland

A web based publication – '*Soil conservation guidelines for Queensland*' is available. It provides current information on: planning, runoff estimation, channel design and special application. Refer to the Queensland Government publications website: https://publications.qld.gov.au/dataset/soil-conservation-guidelines

Land resource reports for the Burnett-Mary catchments.

Land resource reports provide information on the soils of the Burnett-Mary catchments. See Appendix A for a list of the soils surveys used to assess environmental characteristics.

Land resource reports can be viewed and downloaded through the publications portal: https://publications.qld.gov.au/

Alternatively, reports and fact sheets can be requested by emailing: soils@qld.gov.au

Flooding potential

Background

Wet season floods have a high capacity to transport contaminants, particularly those in dissolved forms, and are the major delivery mechanism of land-derived contaminants to the GBR (Brodie *et al.* 2008). Where cane farms are located in areas that flood relatively frequently, e.g. annually, there may be a higher potential for contaminants to be mobilised and delivered off-farm in floodwaters (Figure 9). Floods can also facilitate transport and spread of weeds.

Figure 9. Floodplain - Burnett River during 2013 flood showing inundation of property and crops in the Bundaberg district

Description of flooding potential mapping

Flooding potential is derived from two sources; land resource assessment and flood extent mapped from aerial imagery captured during the 2011 and 2013 floods.

Where detailed soils mapping is available the flooding potential layer indicates potential flood extent and frequency. Where detailed soils mapping is not available flood extent mapping captured during the 2013 and 2011 floods is used to indicate potential extent of inundation (the active floodplain) but **NOT** frequency.

The classification of flooding potential is outlined in Table 5 and mapped in Figure 10 for the Burnett-Mary catchments.

Table 5. Categories for flooding potential utilised for the Burnett-Mary catchments

Category	Description	Source
Annually flooded areas	Flooding frequency approaches annual occurrence - lower channel benches	Land resource assessment data (State of Queensland)
Less than annually flooded areas	Flooding frequency of approximately 1 in 2 to 1 in 10 years - levees and back swamps and some higher channel benches and flooding less than 1 in 10 years.	Land resource assessment data (State of Queensland)
Indicative flooded area (no frequency data)	Approximate inundation extent mapping, recorded from 2011 and 2013 flood events.	Flood extent mapping derived from high resolution aerial imagery captured at flood peak 2013 and flood water inundation mapping from State wide aerial imagery 2011 (State of Queensland)
No Flooding or insufficient data to determine flooding extent or frequency.	Area outside indicative flooded extent for the Burnett and Mary Rivers and or regarded as no flooding by soil mapping.	Exclusion from areas described above.

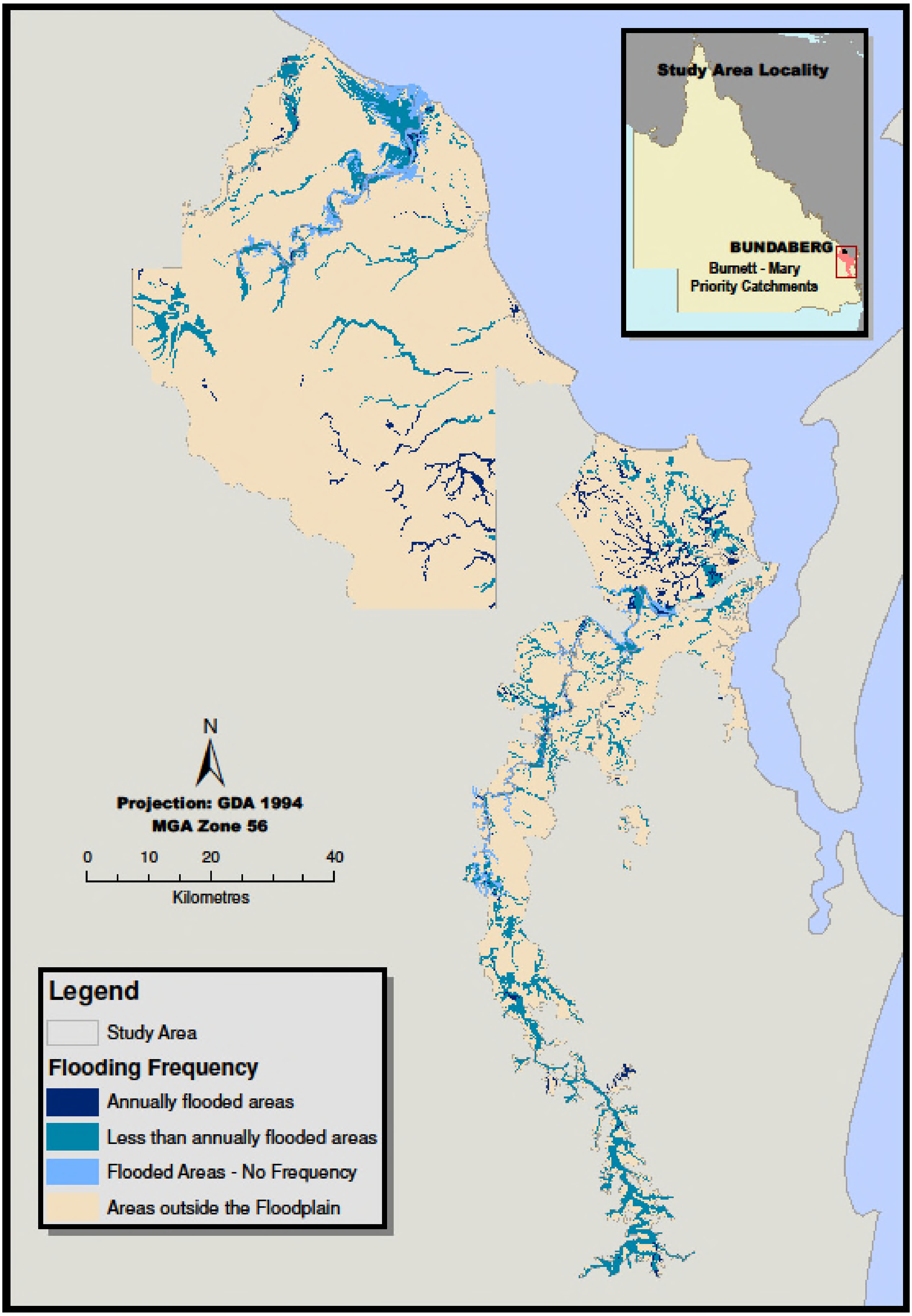


Figure 10. Flooding potential – Burnett-Mary catchments.

Management

Nutrients and herbicides applied on the floodplain can be mobilised in their dissolved forms and transported by floodwaters. Dissolved contaminants are the most likely to reach the GBR because there is no potential for them to settle out of suspension. Sediment and associated nutrients and herbicides may also be mobilised and transported. It is therefore critical to consider timing of land management practices to reduce the movement of contaminants in floodwaters, either via sediment or in dissolved forms. Table 6 outlines example management principles that can assist to minimise the movement of sediment, nutrients and herbicides in floodwaters.

Table 6. Management options for mitigating impacts of flooding.

Transport process	Principle to reduce movement in floodwaters	Example of management principles to mitigate impacts of flooding
Nutrients and herbicides transported attached to sediment	Reduce offsite movement of sediment	• Fallow areas managed to promote vegetative cover, so that bare soil is not exposed during wet season. • Maintain well-vegetated spoon drains, headlands and grassed treatment areas. • Incorporate sediment traps, retention ponds or constructed wetlands to collect first flush and prevent discharge of contaminated runoff. • Promote growth of native deep-rooted vegetation and control weeds in riparian zone.
Nutrients and herbicides transported in dissolved form	Minimise soil concentrations during times of likely flooding	• Consider rainfall forecasts prior to herbicide spraying and placement of fertiliser, particularly surface banded fertilisers. • Where possible, spot spray small weed infestations and avoid applying during high risk periods (wet season). • Incorporating fertiliser applications through irrigation (overhead vs flood irrigation) improves the likelihood that nutrients and herbicides will be incorporated before wet season arrives. • Use soil, leaf testing to inform fertiliser application rates. • Manage fallow effectively so that bare soil is not exposed to rain and subsequent floods. • Schedule fertiliser application to coincide with crop demand • Consider sub-surface application of fertiliser in plant and ratoon • Consider weed type and pressure prior to spraying of residual herbicide application. • Use trash blanketing to suppress weeds. • Use of water treatment infrastructure to collect first flush and prevent discharge of contaminated runoff.

Dominant water pathway

Background

Water pathway indicates whether soils are more likely to drain or generate runoff, based on the drainage and permeability characteristics of the soil. Impermeable or poorly drained soils are more likely to generate runoff, which can transport sediment, nutrients and herbicides to nearby watercourses. Figure 11 displays the difference in appearance between a well drained soil and a poorly drained soil. The bright red colours of the basaltic soils (Ferrosol) on the left are an indicator of good drainage. The pale colours and mottling in the soil on the right (Hydrosol) indicates that this soil is poorly drained.

Figure 11. Example of a well-drained soil (left) and a poorly drained soil (right).

Description of water pathway mapping

To generate water pathway data, soil permeability and drainage classes were combined to identify the dominant pathway of water when it contacts the soil surface (Moody and Cong 2008).

The classification of water pathway categories are summarised in Table 7. Where Tables 8 and 9 provide additional information. The dominant water pathway for the Burnett-Mary priority catchment is mapped in Figure 12.

Table 7. Pathway Description

Dominant water pathway	Description	Implications*
Drainage	Highly permeable and well or rapidly drained soils with low potential to generate runoff	Nutrients such as nitrate may leach - resulting in accelerated soil acidification and groundwater (see glossary) contamination
Drainage/runoff	Permeable and imperfectly drained soils with moderate potential to generate runoff	
Runoff/ponding	Poorly drained and slowly permeable soils with high potential to generate runoff.	Runoff can lead to accelerated soil erosion, which can impact on surface water quality

* Source: Moody and Cong (2008)

Table 8. Description of Water Pathway Requirements

Permeability Class	Drainage Class					
	1	*2*	*3*	*4*	*5*	*6*
1	R/P	R/P	R/P	R/P	R/P	D + R/P
2	R/P	R/P	R/P	D + R/P	D + R/P	D + R/P
3	R/P	R/P	R/P	D + R/P	D	D
4	R/P	R/P	D + R/P	D + R/P	D	D

R= Runoff, P=Ponding, D= Drainage

Table 9. Drainage and Permeability

Drainage Class	Description
1 Very poorly drained	Water is removed from the soil so slowly that the water remains at or near the surface for most of the year.
2 Poorly drained	Water is removed very slowly from the soil in relation to supply which may result in seasonal ponding. A perched water table may also be present.
3 Imperfectly drained	Water is removed slowly from the soil. Intermittent waterlogging throughout the soil results in many profiles having gleyed, mottled colours or rusty root channel linings.
4 Moderately well drained	Water is removed relatively slowly after supply. Some horizons may remain wet for as long as one week after water addition.
5 Well drained	Water is removed readily but not rapidly from the soil. Some horizons may remain wet for several days after water addition.
6 Rapidly drained	Water is removed from the soil rapidly. The soil is not normally wet for more than several hours after water addition.

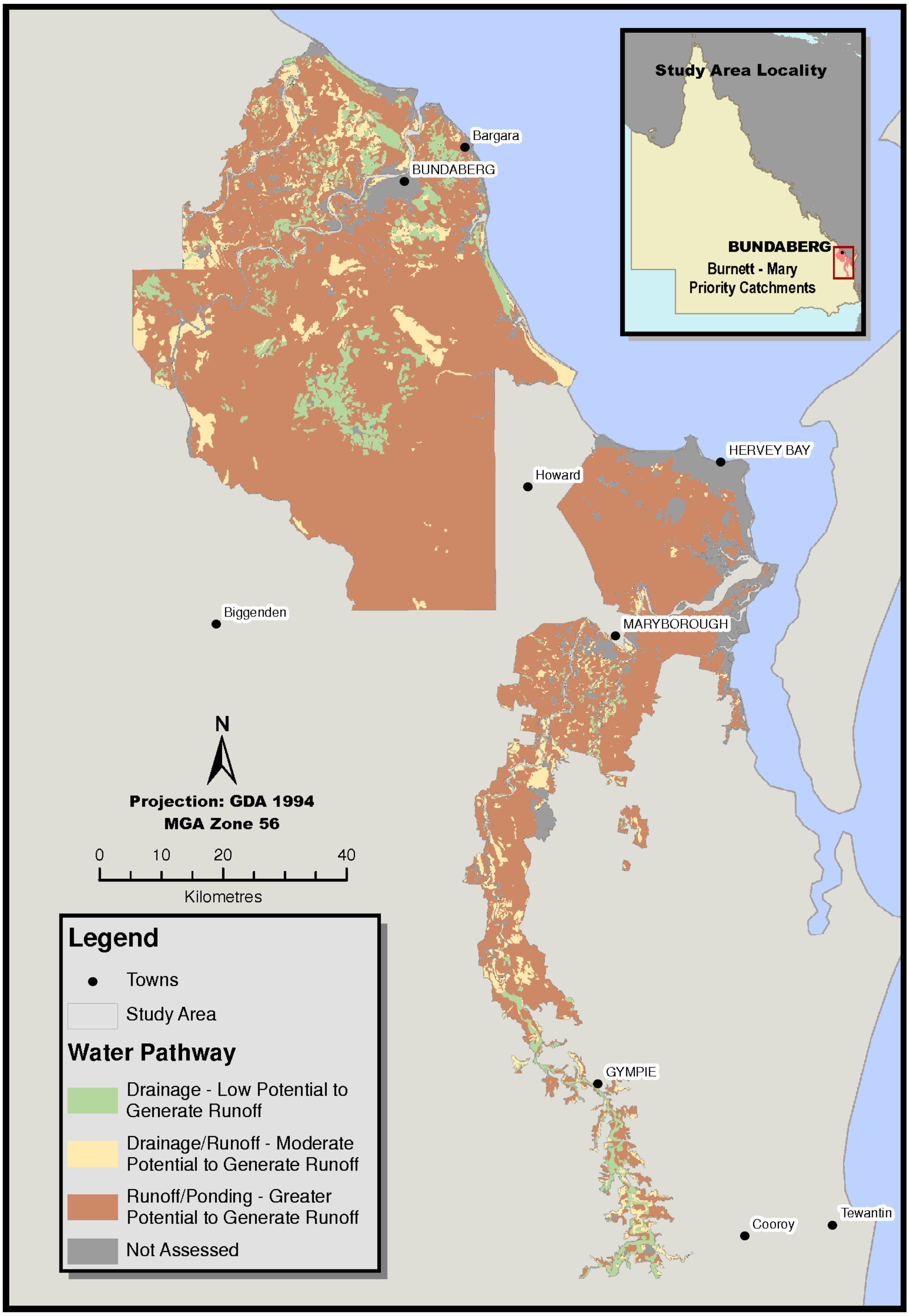


Figure 12. Dominant water pathway-Burnett-Mary Catchments.

Note: The scale of mapping precludes the identification and mapping of actual water pathways. Rather, the mapping provides an indication of the location of soils likely to be subject to different predicted categories of water pathways based on soil characteristics.

Additional considerations

Rainfall

The quantity of rainfall during the wet season, and therefore the time taken for soils to reach saturation, varies significantly. This may impact on when soils become saturated and become more likely to generate runoff, regardless of whether they are naturally well drained or not. If farms are irrigated, this will also influence the time taken to reach saturation.

Farm drains

Soil drainage and permeability characteristics are described in their natural state during a land resource survey. However, properties with farm drains can alter the drainage characteristics of soils, i.e. poorly drained soils can become well drained following the construction of cane drains.

Surface *vs* subsurface drainage constraints

Surface drainage issues are usually those which can be easily addressed i.e. low lying areas which can get water logged and can be remediated by laser levelling. Subsurface constraints that may have an impact on cane yields are more difficult to identify and remediate i.e. sub surface compacted clays layers.

The water pathway layer does not describe drainage in terms of surface or subsurface separately. It is an assessment of the entire soil profile.

Management

Management principles should be adapted depending on whether landscapes are likely to drain (e.g. deep sandy soils) or generate runoff (e.g. heavy clays). In all instances, it is important to optimise inputs (nutrients and herbicides) to reduce the volume of contaminants available for transport – whether via surface water run-off or leaching past the root zone. Table 10 outlines example management principles for mitigating impacts of water pathway.

Other environmental characteristics: groundwater contamination

Environmental characteristic maps focus on the potential for contaminants to be transported off farm via surface water. However, nutrients and herbicides can also be transported to the GBR via groundwater pathways.

Users can start to identify areas vulnerable to groundwater contamination by considering parts of the landscape that facilitate drainage (as shown on the water pathway map). The focus in these areas should be to minimise leaching of nutrients and herbicides past the root zone.

The likelihood that contaminants will actually be transported to groundwater is influenced by a range of features, e.g. rainfall, soil and regolith properties, and proximity to aquifers. Some of these features are not well understood at this time, however work is ongoing to improve understanding of groundwater transport processes across the GBR catchments.

Table 10. Management principles for mitigating impacts of water pathway.

Dominant Water Pathway	Principle to minimise runoff and leaching	Examples of management principles that mitigate the impact of water pathway
Drainage	Minimise leaching of excess water and nutrients /herbicides	• Consider weather predictions of rainfall prior to the placement of fertiliser, particularly surface banded fertiliser. • Fertiliser application should take place when the crop is actively growing to promote more rapid uptake of nutrients by the crop. • Optimise timing and rates of nutrient/herbicide application, e.g. accounting for inputs from legumes and mill mud, timing application of nutrient/herbicide with irrigation application, sub-surface fertiliser application. • Irrigate optimally based on soil types in blocks. • Avoid fertiliser application when soil profile is very wet.
Drainage/runoff	Maintain water balance	
Runoff/ponding	Minimise erosion and contaminant transport associated with runoff	• Match irrigation application rate and volume to the infiltration rate and capacity of the soil type. • Manage fallow effectively so that soil is not exposed during the wet season when flooding potential is greatest. • Include spoon drains, sediment traps, filter strips and headlands for effective treatment of water leaving the farm by to collecting first flush and prevent discharge of contaminated runoff. • Install sediment traps at appropriate locations, i.e., in the lowest part of the blocks, prior to drainage into riparian areas or adjoining waterways. • Using irrigation recycle pit to capture irrigation runoff will help to detain first flush surface run-off, thus assisting in nutrient retention and sediment trapping. Structures need to suit farm specifics including soil type, runoff rate and volume. • Optimise timing and rates of nutrient/herbicide application to reduce the volume of contaminants available for transport.

Further information

Soil Constraints and Management Package (SCAMP)

This publication provides a decision-support framework that bridges the gap between taxonomic soil surveys and informed management strategies for sustainable production on upland soils in the tropics. Available to download at: https://aciar.gov.au/node/9401

Fact sheets https://www.publications.qld.gov.au/dataset/science-notes-soils

- Soil limitations to water entry

Material safety data sheets (MSDS): Material safety data sheet may provide a source of information on different soil types and times to avoid application

Soil transport potential

Background

Soils vary in their potential to be eroded (see section on erosion potential) and their potential to be transported over long distances (soil transport potential). Smaller soil particles such as clays are transported more easily and over longer distances than larger silt and sand sized particles, which are more likely to fall out of suspension. Soils with high clay content therefore have a greater potential to reach the GBR (Figures 13 and 14). Furthermore, generally soils with high clay content are more likely to bind nutrient cations and electro-positively charged pesticide compounds, due to the negative charge of the clay particles.

Figure 13. Sediment plume into the GBR. Smaller soil particles will be transported further and are more likely to reach the GBR.

Figure 14. Clays particles may remain suspended in rivers giving them a turbid appearance. These soil particles can be transported long distances in suspension

Description of soil transport potential mapping

The amount of sand, silt and clay particles in the surface soil is determined by soil texture tests in the field (see further information section). Table 11 divides surface soil texture into sand, loam and clay classes with the equivalent field textures. The soil transport potential map for the Burnett-Mary catchments is shown in Figure 16, recognising that soils over 35% clay have a higher potential to be transported over long distances. All field textures and their equivalent categories are listed in Appendix B.

Table 11. Description of surface soil texture classification.

Category	Surface soil texture	Clay Percentage
Sands *(lower transport potential)*	Sand (general equivalent field texture: sand, loamy sands, clayey sands).	<10%
Loams *(moderate transport potential)*	Loam (general equivalent field texture: sandy loams, loam, clay loams, silty loams).	11-34%
Clays *(higher transport potential)*	Clay (general equivalent field texture: light clays, medium clays, heavy clays)	>34%
Not recorded	No surface soil texture category is recorded	

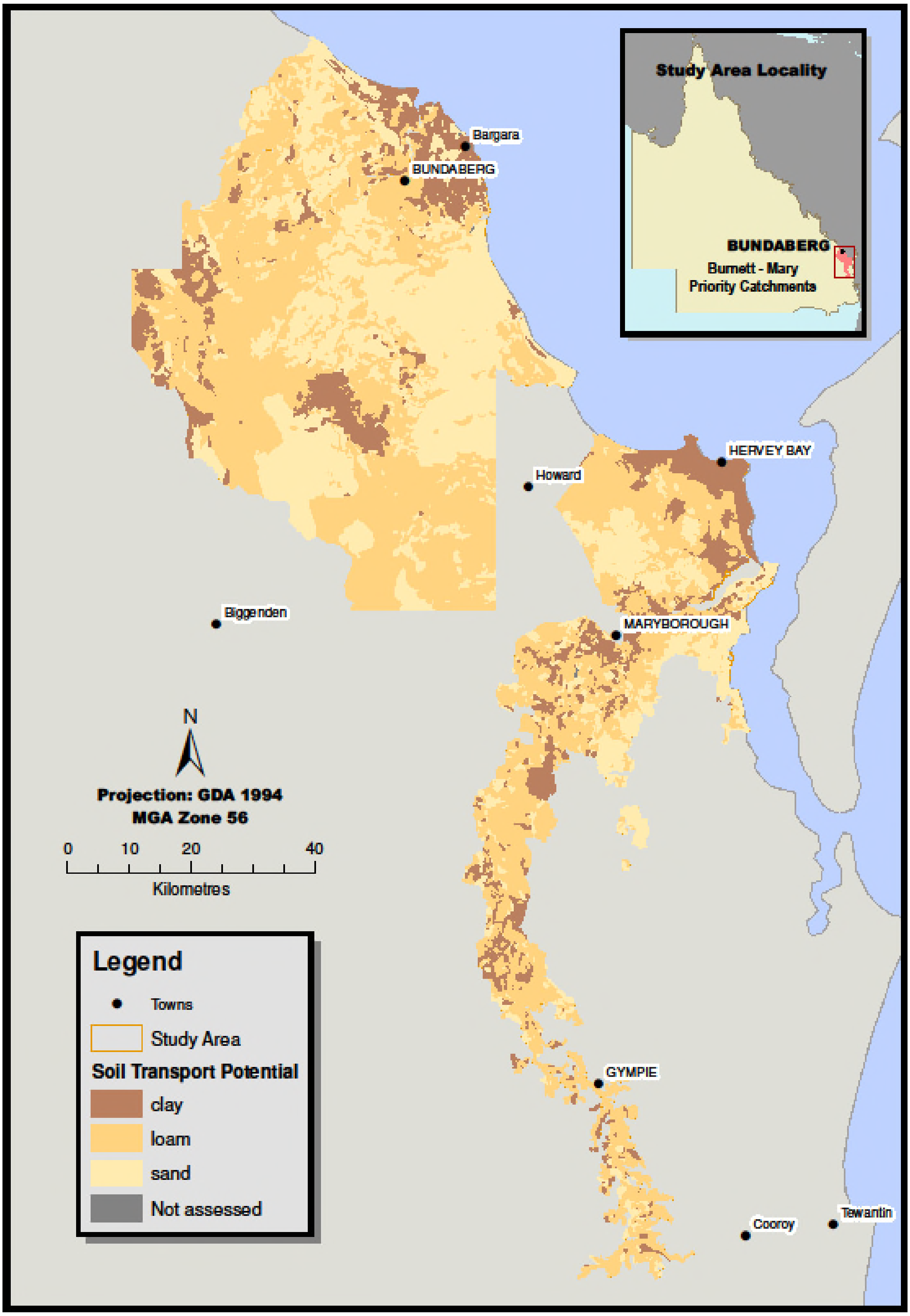


Figure 15. Soil transport potential – Burnett-Mary catchments. (derived from Australian Soil Resource Information System – ASRIS)

Note: The scale of map does not precisely identify surface soil texture boundaries, it indicates the likely soil transport potential based on soil texture.

Additional considerations

Soil structure

Soil structure influences the soil stability when affected by rainfall and runoff. For example, a well-structured soil allows water to infiltrate and excess water to drain. This increases the time it takes for the soil profile to become saturated, reducing the occurrences of contaminants in runoff water. Environmental characteristic maps do not currently consider soil structure, as this characteristic is not accurately mapped for cane growing areas. Although soil structure is described during land resource surveys, it is easily influenced by land management practices and therefore the soil structure present in cultivated situations is likely to be different to that described by surveys.

The Soil Constraints and Management Package (SCAMP) (see further information section below) describes a range of simple field tests that can assist growers and field officers to gain an understanding of the soil structure of a farm.

Clay types

The mineral composition (or mineralogy) of clays influences their ability to attach to contaminants. Clays can be divided into two broad groups based on their mineral composition – 1:1 clays (e.g. kaolinite) and 2:1 clays (e.g. illite and smectite). Mineralogy affects the capacity of clays to hold water and positively charged ions (e.g. Na+) between layers and therefore the capacity to absorb water and bind nutrients. Generally, 2:1 clays have a higher capacity to bind nutrients and herbicides. However, this process is highly complex and influenced by other features such as organic matter content and chemical characteristics of nutrients and herbicides.

Management

To minimise soil transport potential it is important to ensure that soils with high clay content are not exposed to erosive processes. Options for managing different soil textures are broadly outlined in Table 12.

Table 12. Management options for mitigating impacts of soil transport potential.

Surface soil texture	Principle to minimise erosion and leaching	Examples of management principles to mitigate impact of surface soil texture
Sands	Minimise leaching of excess water and nutrients /herbicides	Fertiliser application should take place when the crop is actively growing to promote more rapid uptake of nutrients by the crop. Optimise timing and rates of nutrient/herbicide application, Check product label with regard to efficacy of different product for different soil types and weed species. Include spoon drains, sediment traps, filter strips and headlands for effective treatment of water leaving the farm.
Loams	Maintain water balance	
Clays	Minimise erosion	Manage fallow effectively by inclusion of well managed legume crop in break year at the end of cropping cycle, so soil remains covered during entire cropping cycle. Include spoon drains, sediment traps, filter strips and headlands for effective treatment of water leaving the farm. Adoption of controlled traffic has been found to reduce run-off and the amount of sediment (clays) in run-off. This leads to minimum tillage – eventually to zero till. Grass headlands maintained

Further information

Soil Constraints and Management Package (SCAMP)

This publication provides a decision-support framework that bridges the gap between taxonomic soil surveys and informed management strategies for sustainable production on upland soils in the tropics. Available to download at: https://aciar.gov.au/node/9401

Material safety data sheets

Material safety data sheet may provide a source of information on different soils types and times to avoid application.

Glossary

Alluvial

Alluvial refers to soils formed by the deposition of sediment in riverine landscapes.

Australian Soil Classification (ASC)

Australia's official system for classifying and identifying Australian soils. The system is based around 14 soil orders: Anthroposols, Organosols, Podosols, Vertosols, Hydrosols, Kurosols, Sodosols, Chromosols, Calcarosols, Ferrosols, Dermosols, Kandosols, Rudosols, Tenosols. Information regarding the ASC is available at:
https://www.clw.csiro.au/aclep/asc_re_on_line_V2/soilhome.htm

Deep drainage

The volume of water that moves below the root zone which may or may not enter the saturated zone and become recharge to the groundwater system.

Drainage

It is the rate of removal of water from the soil profile. It describes the 'local soils wetness conditions' and is determined by soil properties, and the position of the soil within the landscape (e.g. topography, slope etc.).

The following terms are descriptions of drainage attributes (adapted NCST, 2009):

- Very poorly drained – water is removed from the soil so slowly that the water remains at or near the surface for most of the year.
- Poorly drained – water is removed very slowly from the soil in relation to supply which may result in seasonal ponding. A perched water table may also be present.
- Imperfectly drained – water is removed slowly from the soil. Intermittent waterlogging throughout the soil results in many profiles having a gleyed, mottled colour or rusty root channel linings.
- Moderately well drained – water is removed relatively slowly after supply. Some horizons may remain wet for as long as one week after water addition.
- Well drained – water is removed readily but not rapidly from the soil. Some horizons may remain wet for several days after water addition.
- Rapidly drained – water is removed from the soil rapidly. The soil is not normally wet for more than several hours after water addition.

Groundwater

Water beneath the surface contained in saturated soil or porous rock. Groundwater systems are connected to surface water and the marine environment, but further research is required to quantify this connectivity. Groundwater is not considered in this assessment, but may be incorporated in future work.

HowLeaky (McClymont et al. 2011)

Is a daily simulation model based on a crop cycle of: plant cane, ratoon cane, soybean fallow crop

Landscape response

The combination of environmental characteristics and management factors will drive a response in the landscape. For example, burning trash (management factor) on an erodible soil (environmental characteristic) can lead to erosion and sediment movement (landscape response).

Management factors

Management factors are land management practices which are dynamic, require input, and are influenced by decision making (e.g. green trash blanket, controlled traffic farming, timing and rate of fertiliser or herbicide application).

Mottles

Mottles are spots, blotches or streaks of subdominant colours which are different to the matrix colour. Mottles are an indication of water fluctuation throughout a soil profile.

Permeability

Refers to the potential of a soil to transmit water internally. Permeability is related to the saturated hydraulic conductivity of the soil profile and is independent of the soils' position in the landscape. The following terms are a description of permeability attributes:

- Very slowly permeable – transmission through the soil profile is very slow. It would take at least a month for the profile to reach field capacity after wetting.
- Slowly permeable – transmission through the soil is slow. It would take at least a week or more after wetting for the soil to reach field capacity.
- Moderately permeable – transmission through the soil profile is relatively fast, field capacity is reached between 1–5 days after wetting.
- Highly permeable – transmission through the soil profile is very fast, field capacity is reached within 1–12 hours after wetting.

Pre-clear vegetation mapping

Pre-clearing vegetation is simply the vegetation present before clearing. The term equates to what is generally mapped as 'pre-1750' or 'pre-European' vegetation.

Sodic

A soil is considered sodic when the sodium ions present reach a concentration where the soil structure is degraded and dispersion in apparent when wetted. The sodium weakens the bonds between clay sheets when wetted resulting in the clay particles swelling and detaching and dispersing into the water making it cloudy.

Soil erodibility

It is the susceptibility of soil particles to detach and be transported by rainfall, runoff and flooding. Generally, soils with faster infiltration rates, higher levels of organic matter have a greater resistance to erosion.

Soil structure

Refers to the way soil particles group together to form aggregates (or peds). These aggregates vary in size and shape from small crumbs through to large blocks. Where there are no peds present, the soil is described as 'structure-less' and may be either loose (single grain) or hard (massive). Soil structure has a major influence on water and air movement, biological activity, root growth and seedling emergence.

Soil texture

Refers to the proportion of sand, silt and clay sized particles that make up the mineral fraction of a soil. For example, a light textured soil refers to a soil with a high proportion of sand relative to clay, whereas heavy soils have a higher proportion of clay particles.

Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, such as muddiness (soil) in water or smoke in air.

Water pathway

Describes the dominant pathway or movement of water, when it comes into contact with the soil surface. This is inferred from the drainage and permeability characteristics of soils.

References

BOM (2018) Bureau of Meteorology: Climate data online, accessed [15/12/18], available at <www.bom.gov.au/climate>

Brodie J, Binney J, Fabricius K, Gordon I, Hoegh-Guldberg O, Hunter H, O'Reagain P, Pearson R, Quirk M, Thorburn P, Waterhouse J, Webster I and Wilkinson S (2008) 'Synthesis of evidence to support the Scientific Consensus Statement on Water Quality in the Great Barrier Reef', Reef Water Quality Protection Plan Secretariat, Brisbane, Queensland. Available at www.reefplan.qld.gov.au/publications/scientific_consensus_statement.shtm

Bryant K, Philip S, Hughes K and Willis, R (2012) Mapping of environmental characteristics important for Reef water quality Burdekin and Mackay-Whitsunday priority catchment: Assessment methodology, Land Resource Assessment, Department of Science, Information Technology, Innovation and the Arts, Brisbane.

DERM (2009) Queensland Landuse Mapping Program, Department of Environment and Resource Management, Brisbane.

DNRM (2002) 'Queensland Isohyet Lines', Available from Departmental SIRQRY database, Department of Natural Resources and Mines, Brisbane.

McClymont D, Freebairn DM, Rattray DJ, Robinson JB and White S. (2011) Howleaky V 5.40.10 : Exploring water balance and water quality implication of different land uses. http://www.howleaky.net/ .

Moody PW & Cong PT (2008) 'Soil Constraints and Management Package (SCAMP): guidelines for sustainable management of tropical upland soils', ACIAR Monograph No. 130, 86pp.

Appendix A: Land resource publications relevant to the Burnett-Mary cane area

Land resource reports provide information on the soils of the Burnett-Mary catchment.

Land resource reports can be viewed and downloaded through:

- Queensland Government Spatial Catalogue – Qspatial at:
  - http://qldspatial.information.qld.gov.au/catalogue/custom/index.page
- the publications portal: https://publications.qld.gov.au/

Alternatively, reports can be requested by emailing: <soils@qld.gov.au>.

SALI[1] project code	Title
BURNETT-MARY PUBLICATIONS	
BAB	Soils and Irrigated Land Suitability of the Bundaberg Area
CBW	Soils and Agricultural Suitability of the Childers Area
GCL	Soils and Agricultural Suitability of the Gundiah – Curra Area
MHB	Soils and Agricultural Suitability of the Maryborough – Hervey Bay Area
MRC	Land Resource Assessment lowlands – Curra to Imbil – Mary River Catchment
MTL	Soils and Agricultural Suitability of the Maryborough – Tiaro Area
NON-REGIONAL PUBLICATIONS	
	Atlas of Australian Soils - Queensland Coverage

[1] Soil and Land Information system (SALI) –corporate database which stores all soil and land resource information

Appendix B: Surface soil texture categories

Soil texture codes were generalised into four categories (sand, loam, clay and other) as described in the table below. The category 'other' incorporates non-soils (e.g. gravel) and non-mineral soils (e.g. peats).

Texture Code	Texture Description	Notes	Category
CFS	clayey fine sand	clay content <10%	sand
CKS	clayey coarse sand	clay content <10%	sand
CL	clay loam	30-35% clay	loam
CLFS	clay loam, fine sandy	30-35% clay	loam
CLS	clay loam, sandy	30-35% clay	loam
CLZ	clay loam, silty	30-35% clay, with silt 25% or more	loam
CS	clayey sand	clay content <10%	sand
FS	fine sand	clay content <10%	sand
FSC	fine sandy; clay	assume 35% clay	clay
FSCL	fine sandy clay loam	20-30% clay	loam
FSHC	fine sandy heavy clay	>40% clay	clay
FSL	fine sandy loam	10-20% clay	loam
FSLC	fine sandy light clay	35-40% clay	clay
FSLMC	fine sandy light medium clay	>40% clay light medium clay	clay
FSMHC	fine sandy medium heavy clay	>40% clay	clay
HC	heavy clay	>40% clay	clay
IP	fibric peat	non-mineral soil	other
KS	coarse sand	clay content <10%	sand
KSC	coarse sand, clay	5-10% clay	sand
KSCL	coarse sandy clay loam	20-30% clay	loam
KSL	coarse sandy loam	10-20% clay	loam
KSLC	coarse sandy light clay	35-40% clay	clay
KSLMC	coarse sandy light medium clay	>40% clay	clay
KSMC	coarse sandy medium clay	>40% clay	clay
KSMHC	coarse sandy medium heavy clay	>40% clay	clay
L	loam	25% clay	clay
LC	light clay	35-40% clay	clay
LCFS	light clay; fine sandy	35-40% clay	clay

Texture Code	Texture Description	Notes	Category
LCKS	light clay; coarse sandy	35-40% clay	clay
LCZ	light clay; silty	35-40% clay	clay
LFS	loamy fine sand	25% clay	sand
LFSY	loam; fine sandy	25% clay	loam
LKS	loamy coarse sand	clay content <10%	sand
LMC	light medium clay	>40% clay light medium clay	clay
LMCFS	light medium clay; fine sandy	>40% clay light medium clay	clay
LMCS	light medium clay, sandy	40-45% clay	clay
LS	loamy sand	clay content <10%	sand
LSY	loam, sandy	25% clay	loam
MC	medium clay	>40% clay	clay
MCFS	medium clay; fine sandy	>40% clay	clay
MHC	medium heavy clay	>40% clay	clay
S	sand	clay content <10%	sand
SC	sandy clay	assume 35% clay	clay
SCL	sandy clay loam	20-30% clay	loam
SCLFS	sandy clay loam, fine sandy	20-30% clay	loam
SL	sandy loam	10-20% clay	loam
SLC	sandy light clay	35-40% clay	clay
SLMC	sandy light medium clay	>40% clay light medium clay	clay
SMC	sandy medium clay	>40% clay	clay
SMHC	sandy medium heavy clay	>40% clay	clay
ZC	silty clay	assume 35% clay	clay
ZCL	silty clay loam	30-35% clay	loam
ZL	silty loam	25% clay	loam
ZLC	silty light clay	35-40% clay	clay
ZLMC	silty light medium clay	>40% clay light medium clay	clay
ZMC	silty medium clay	>40% clay	clay
ZMHC	silty medium heavy clay	>40% clay	clay

Appendix C: Common soils of the Burnett-Mary cane growing area

(described using dominant Orders of the Australian Soil Classification)

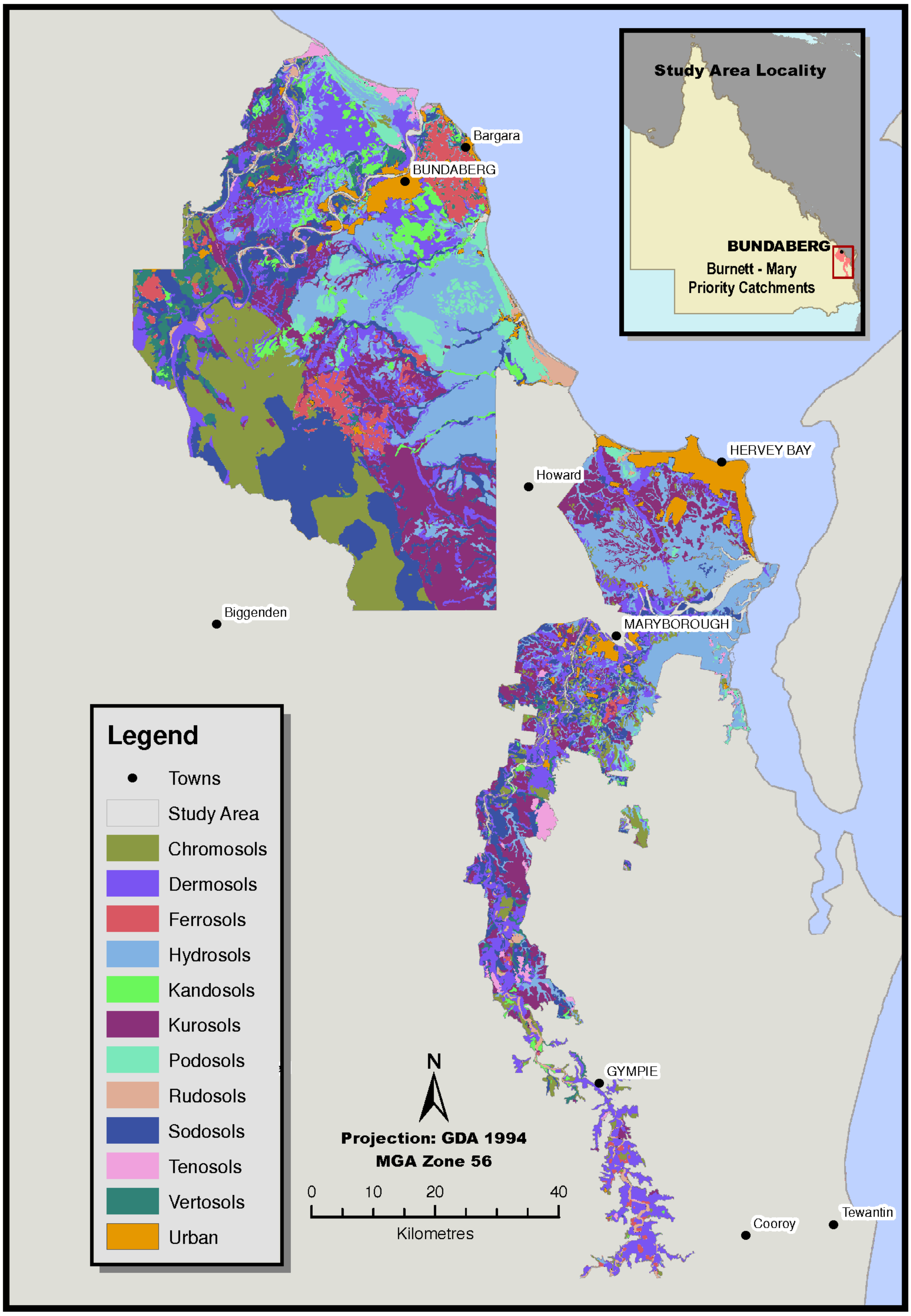
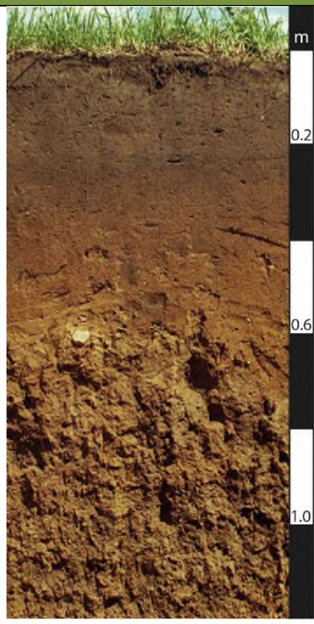


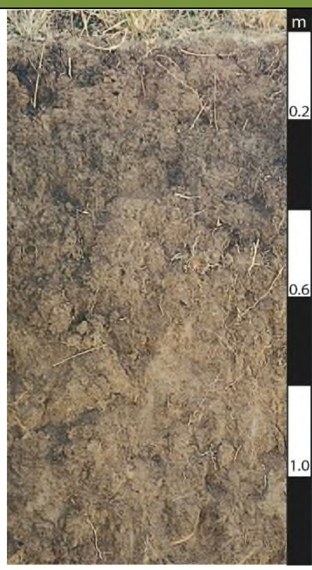
Figure 17 Australian Soil Classification Orders across the Burnett-Mary catchments (QLD Soil and Land Information database).

Brief description and agricultural limitations of Australian Soil Classification Orders

CHROMOSOL	
Brief description	Chromosols have a distinct texture-contrast between the surface and subsoil. Chromosols have sandy or loamy surface soils overlying a yellow, brown, red-brown or sometimes black clay subsoil, which is generally neutral to alkaline. In contrast to Sodosols, the subsoil is not sodic (see glossary), at least in the upper section.
Agricultural implications	Where there is adequate rainfall these soils constitute important grain producing areas, particularly on lower slopes. They are generally used for sown pastures on moderate slopes and native pastures on drier or steeper slopes. Chromosols have a reasonable agricultural potential with moderate fertility and water-holding capacity. They can be susceptible to soil acidification and soil structure decline and may experience poor local drainage.
Percentage of cane soils in Burnett-Mary	32%
Local soil types	Isis, Kepnock, Watalgan, Gooburrum, Farnsfield, Isis Rocky Phase, Aldershot, Boyne



DERMOSOL	
Brief description	Dermosols are a diverse group of soils with loam to clay textures that may be of varied red, brown, yellow, grey or black coloured. They have structured subsoils. This soil order mainly occurs throughout the higher rainfall coastal and sub-coastal regions of Queensland.
Agricultural implications	Dermosols are commonly quite fertile and, in the drier sub-coastal areas, used for intensive horticulture. Dermosols generally have high agricultural potential with good structure and moderate to high fertility and water-holding capacity, and are generally well drained.
Percentage of cane soils in Burnett-Mary	20%
Local soil types	Meadowvale, Woolmer, Clayton, Granville, Mary, Flagstone, Woco, Walla, Tiaro, Otoo, Bucca, Tandora, Mungar, Doolbi, Walker, Timbrell, Gahan Netherby



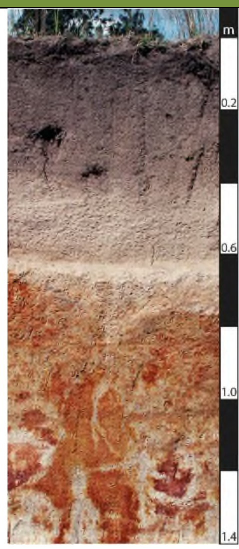
FERROSOL

Brief description	Ferrosols do not have a strong texture-contrast between the surface and subsoil. They are well drained soils with clay-loam to clay textures throughout the surface and subsoil. They are high in iron and can be red or yellow coloured and are generally well structured.
Agricultural implications	Good structure with moderate to high fertility and water-holding capacity. Prone to compaction and nutrient leaching and in high rainfall areas they may suffer from acidification. Ferrosols also have a high phosphorus fixing capacity which affects the application of fertilisers.
Percentage of cane soils in Burnett-Mary	4%
Local soil types	Childers, Telegraph, Woongarra, Windermere, Bidwell, Teddington

HYDROSOL

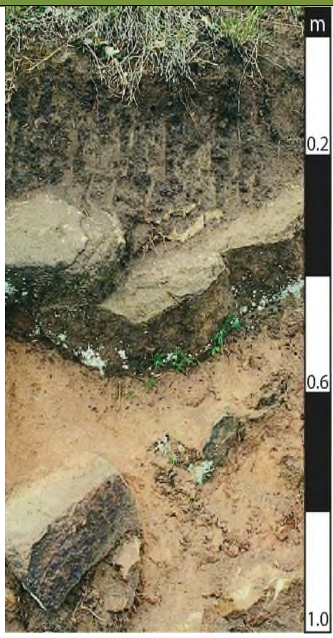
Brief description	Hydrosols are soils that are saturated with water for long periods of time (for at least 2-3 months). They are typically grey (or greenish-grey) in colour with strong yellow, brown, orange or red mottling. Hydrosols can vary in texture.
Agricultural implications	This soil type is mainly found in coastal areas however, many inland wetlands are dominated by Hydrosols even though these areas may only be intermittently inundated. Saturation by a water table may not necessarily be caused by low soil permeability. Often site drainage will be the most important factor, while in other cases tidal influence is dominant.
Percentage of cane soils in Burnett-Mary	19%
Local soil types	Robur, Woober, Mahogany, Kalah, Quart, Kolbore, Wallum, Theodilite, Jaro, Ashgrove, Fairydale, Winfield, Fairymead,

KANDOSOL		
Brief description	Kandosols are porous sand to loamy soils that may be red, yellow or grey. They have unstructured subsoils, (and are also known as massive earths) and usually have a gradational increase in clay content with depth.	
Agricultural implications	They generally have low fertility and low water-holding capacity, however physical properties are favourable for plant growth. A wide range of crops can be grown on these soils where rainfall is higher or where irrigation is available. Generally, Kandosols have a low to moderate agricultural potential and land use is more suited to the grazing of native pastures.	
Percentage of cane soils in Burnett-Mary	2%	
Local soil types	Oakwood, Littabella, Rothchild, Eerwah, Gillen	

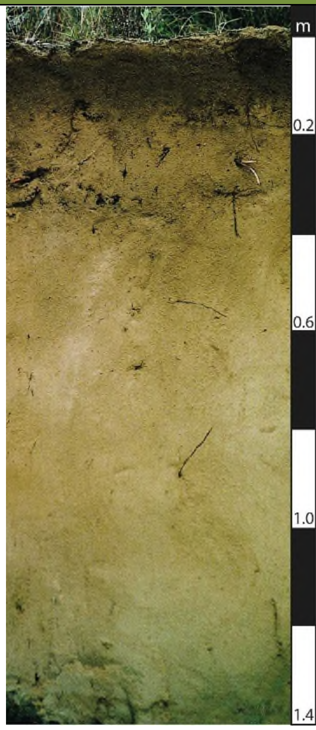
KUROSOLS		
Brief description	Kurosols are texture-contrast soils with a strongly acidic subsoil. The sub-soil is generally moderately permeable and may vary in colour from red, in well-drained situations, to yellow and mottled-grey in poorly drained areas.	
Agricultural implications	They generally have lower agricultural potential because of their acidic sub-soil (pH < 5.5) and lower fertility and reduced water-holding capacity. However the physical characteristics of a Kurosol are often satisfactory for plant growth. Primary uses are grazing, in steeper drier areas, and cane, horticulture and softwood forests elsewhere.	
Percentage of cane soils in Burnett-Mary	9%	
Local soil types	Avondale, Turpin, Kolan	

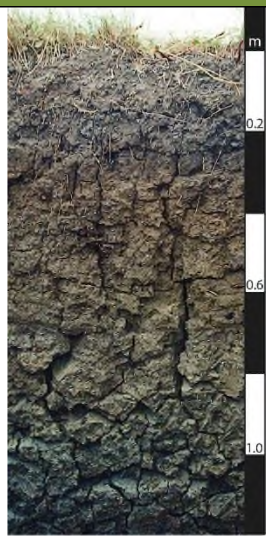
ORGANOSOL		
Brief description	Organosols occur in wetland areas along the coast in high-rainfall zones. Organosols are rich in peat and other humus rich layers. Areas of these soils are quite small.	**NO PHOTO AVAILABLE**
Agricultural implications	Often site drainage will be the most important factor.	
Percentage of cane soils in Burnett-Mary	NA	
Local soil types	NA	

PODOSOL		
Brief description	Podosols occur in the more humid coastal regions where annual rainfall is greater than about 700 mm. The subsoil of a Podosol is dominated by compounds of organic materials, aluminium and/or iron and may contain an irregular dark pan called ‘coffee rock’. Podosols are uniform textured soils of loamy sand to sand, which are usually very permeable unless continuous hard setting pans are present in the subsoil.	
Agricultural implications	Generally, Podosols have little agricultural potential with very low fertility and water-holding capacity. They are also susceptible to wind erosion if vegetation is removed. Groundwater contamination may be a problem due to the high permeability of these soils.	
Percentage of cane soils in Burnett-Mary	<1%	
Local soil types	Colvin, Moore Park, Kinkuna	

RUDOSOL		
Brief description	Rudosols have virtually no soil profile development apart from the slight accumulation of organic matter at the surface. They are usually young soils in the sense that soil forming factors have had very little time to modify the parent materials. They are commonly found adjacent to watercourses where flooding is frequent.	
Agricultural implications	Rudosols are usually sandy and may also be shallow and stony.	
Percentage of cane soils in Burnett-Mary	<1%	
Local soil types	Burnett, Baddow, Johnson	

SODOSOL		
Brief description	Sodosols are texture-contrast soils (also known as duplex soils) with sodic (see glossary), low permeability subsoils. The sodic subsoil is dispersible and prone to gully erosion if exposed to the surface or tunnel erosion if drainage conditions are altered. Most Sodosols have hardsetting surfaces that reduce infiltration. Seasonal perched water tables are common.	
Agricultural implications	Sodosols generally have low fertility and are susceptible to erosion and dryland salinity if vegetation is removed. The key to managing these soils is reducing disturbance and being aware of how thick the protective surface soil is. These soils are more suited to grazing of native or improved pastures but are used for both dryland and irrigated agriculture, though they commonly experience poor drainage.	
Percentage of cane soils in Burnett-Mary	11%	
Local soil types	Auburn, Peep, Givelda, Owanyilla, Gigoon, Crossing, Butcher	

TENOSOL		
Brief description	Tenosols have weakly developed soil profiles (that show very little change with depth). The group includes deep sands and shallow stony soils.	
Agricultural implications	Tenosols generally have lower agricultural potential due to very low fertility, poor structure and low water-holding capacity. Hence these soils are more suited to grazing of native pastures. Ground-water contamination can be a potential problem due to the high permeability of these soils. Some of the deep sands have agricultural potential if groundwater is at a depth that crop roots can access without being waterlogged.	
Percentage of cane soils in Burnett-Mary	<1%	
Local soil types	Tinana, Takoko, Diamond	

VERTOSOL		
Brief description	Vertosols are cracking clay soils. By definition they must have a clay content of at least 35% throughout the whole profile. Vertosols are divided into subgroups based on colour (e.g. black, grey, brown) and/or wetness. They sometimes have a hummocky microrelief called gilgai, and many have a loose crumb like surface (known as a 'self-mulch'). They are the most common soil type in Queensland.	
Agricultural implications	A moderate to high fertility and high water-holding capacity. Heavy clays can be difficult to cultivate especially when they are wet. Vertosols are extensively used for dryland agriculture but are also irrigated for a variety of crops such as cane and cotton. Vertosols feature significantly in the grazing areas of Queensland	
Percentage of cane soils in Burnett-Mary	1%	
Local soil types	Maroondan, Pelion, Walla	