

# Soil conservation guidelines for Queensland

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## Foreword

Soil is a precious resource. Soil health and soil management, along with the availability of water, largely determines the level of food production. Healthier soils mean healthier food and more prosperous communities.

Soil is a non-renewable resource. It has taken a very long time for soils to develop—hundreds and thousands of years—and yet that soil can be lost forever as a result of intense rainfall when left unprotected or unsupported by appropriate land management practices.

Soil management guidelines have been produced by the Queensland Government since 1965 to provide support to farmers and land managers. This edition of the *Soil conservation guidelines for Queensland* is the result of an extensive review, and includes new chapters based on recent research and information from soil managers and experts. These guidelines provide information on soil degradation and practical tools for its prevention from water based erosion. They also provide tools and techniques to remediate degraded areas.

Over many years, and now driven by this government's commitment to conserve the Great Barrier Reef, the Queensland Government has been collecting and analysing crucial information related to soil and its management, including mapping the extent of groundcover and its seasonal changes, mapping of land use, mapping of erodible soils, identifying erosion processes and sources of sediment, and identifying active gullies contributing to soil erosion. The government has also developed decision support tools for farmers to reduce sediment and nutrient runoff, and modelled the effects of farming systems on soil loss.

The large body of knowledge has been combined with the shared knowledge and contribution of many academics and land management practitioners to produce this new edition of the *Soil conservation guidelines for Queensland*.

While the guidelines are based on Queensland experiences and conditions, the information has relevance across Australia. Land managers, Landcare Australia and other community-based groups, regional natural resource management groups and state and local government agencies will find this an invaluable resource informing their land management activities.

The guidelines are also a source of knowledge and practical science for universities and teaching institutions in the training of the next generation of soil conservation practitioners.

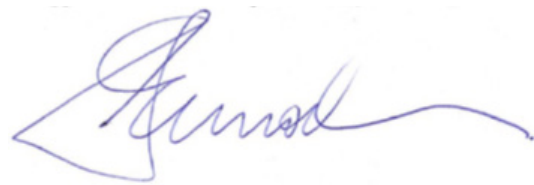
We would like to thank all the people who contributed their time and effort in updating the guidelines.

In particular, we acknowledge the principal authors, the late Bruce Carey and Barry Stone, who together brought to the guidelines the wisdom and experience of 90 years of public service to soil conservation.

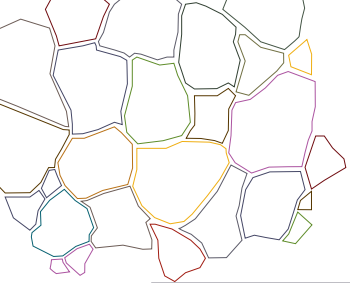
In conclusion, we strongly recommend the use of the *Soil conservation guidelines for Queensland* to all who value and work towards a sustainable approach to land management in Queensland, now and in the future.



**The Honourable Anthony Lynham MP**  
Minister for State Development and  
Minister for Natural Resources and Mines



**The Honourable Leeanne Enoch MP**  
Minister for Housing and Public Works and  
Minister for Science and Innovation



## Preface

This edition of *Soil conservation guidelines for Queensland* is dedicated to our dear friend and respected colleague Bruce Carey. Motivating and educating people about soil and the need to conserve it was more than a job for Bruce—it was his life-long passion. It was this passion that sustained Bruce over the challenging last few years of his life, and which inspired us and others to help him complete the significant task of rewriting these Guidelines. The result is a wonderful legacy that is certain to be appreciated by those responsible for managing Queensland's soils for generations to come.



This is the third edition of soil conservation guidelines for Queensland. The first, entitled the *Queensland Soil Conservation Handbook*, was published in 1966 by the Queensland Department of Agriculture and Stock. The second, entitled *Soil Conservation Measures—A design manual for Queensland*, was published in 2004 by the Queensland Department of Natural Resources and Mines. This, the third, is published by the Department of Science, Information Technology, and Innovation.

With each succeeding edition the information contained has become more extensive and comprehensive reflecting growth in our knowledge of soils and how to conserve them. This edition in particular represents a significant expansion from the previous, with new information about stream and gully erosion and on management of floodplains, infrastructure and horticulture. It is certain to be a very useful resource for soil conservation planners and practitioners across government, regional NRM bodies, Landcare, industries, the private sector and the community.

Early European settlers in Australia had little appreciation of the limitations particular to the soils and landscape they were developing for agriculture. They applied the farming practices with which they were familiar, those that worked in their homelands on the other side of the world, expecting the land to respond as it did there.

Much cropping was undertaken without recognising the importance of retaining vegetation to conserve the soil and protect biodiversity, land subdivision was usually based on the simplest geometric, rectangular layout with little consideration of natural drainage systems, topography and soil types—even mountains were subdivided—and, as if it were needed, additional incentive for wholesale clearing and cultivation was provided by governments requiring that land be developed immediately upon selection.

Soil erosion was the first land degradation problem to become readily apparent in Queensland. Our state's intense and episodic rainfall and the inherent instability of many of our soils mean that Queensland will always be prone to a high risk of erosion.

By 1950, large areas of cropping land in Queensland had become so badly eroded that they had to be withdrawn from cultivation. The government of the day (and those of the following decades) responded with a raft of investments, in particular, research to understand the issues and develop solutions, and extension programs to support farmers and graziers change to more sustainable practices.

Thanks to those efforts, considerable progress has been made. Conservation tillage is now widely practised throughout the cropping lands, steep land is now generally not cultivated or is protected with conservation works such as contour banks and constructed waterways, and graziers are much more diligent about maintaining groundcover. However it is important that we continue to be vigilant. Soil erosion represents a greater risk to Queensland than any other land degradation problem, and the cycles of long periods of reduced erosion under low rainfall and limited runoff which are typically experienced in Queensland can encourage complacency about the risk and lead to neglect of important soil conservation measures.

The process by which public investment in managing natural resources (including soils) is directed and coordinated has become much more decentralized throughout Australia in recent decades. In the past, the government's investment in technical advice and soil conservation planning and design was delivered directly by government agencies. This encouraged a close relationship between landholders and their local government soil conservation extension specialist.

Under the new arrangements, communities through local and catchment-based non-government organisations, play a much greater role in planning and delivering publicly-funded extension advice and on-ground works. Whilst this process of planning through partnerships undoubtedly increases stakeholder engagement and ownership, the need for technical knowledge and proficiency is not reduced. In fact, at a time when experienced people are retiring and regional representation is declining due to the ongoing drive for cost-efficiencies across all sectors of government, the need for a consolidated ‘point of truth’ such as provided by these guidelines has never been greater.

## Acknowledgments

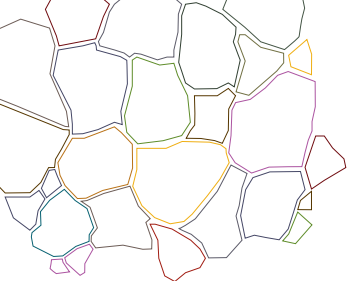
The people listed below are thanked for their valuable contributions to this and previous editions.

- for technical input and editorial assistance:
  - employees of the former Soil Conservation Branch of the Queensland Department of Primary Industries and its successors including: George Bourne, Dave Carey, John Chapman, Vic Cummins, Ken Dixon, Daryl Evans, Shane Flint, David Freebairn, Mark Genrich, Trevor Glanville, Ernst Heijnen, Dominic Henderson, Clive Knowles-Jackson, Jerry Lovatt, John McLatchey, Lew Markey, Doug Muller, Simon Newett, Paul O’Hare, Peter Pearce, Bob Shepherd, Bill Steentsma, Geoff Titmarsh, Phillip Trendell, Carla Wegscheidl, and Peter Wilson, amongst others
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- for editorial and publishing, assistance was provided by: Stephanie Butcher, Colin Campbell, Daryl Green, Fiona Hamilton, Linda Skopp, and Murray Willson.



The authors: (from left) Peter Shilton (Principal Policy Officer, Department of Natural Resources and Mines), Phil Norman (Principal Scientist, Department of Science, Information Technology and Innovation), and Barry Stone (Senior District Advisor, Department of Natural Resources and Mines). *Bruce Carey passed away on 10 July 2015.*





## Chapter summaries

### Chapter 1: Introduction to the guidelines

Soil erosion remains a major concern for Queensland. The state's climate, soils, and how the land is used make it particularly vulnerable to soil erosion. The impacts of soil erosion are felt by the whole community, it reduces agricultural productivity, pollutes water supplies, damages infrastructure and threatens biodiversity. Past successes and ongoing research have taught us a lot about how to prevent erosion. Above all, we must remain vigilant. Because most erosion occurs in occasional severe episodes it is easy to become complacent.



### Chapter 2: Soil conservation planning

The fundamental principle when planning for soil conservation is that land should not be used in ways that exceed its capabilities. Using land in ways that exceed its capabilities will damage the land and cause adverse impacts off-site such as polluting water resources and degrading aquatic habitats. Characteristics inherent to land, such as its slope, fertility, drainage, or rockiness determine its capability for different uses.



Soil conservation planning involves mapping characteristics of land to identify the capability of different areas and to determine which uses the land can safely be put to. It also involves identifying areas that are vulnerable to damage so that special precautions can be put in place to prevent erosion.

Soil conservation planning must be coordinated across the whole landscape as it is very rare that both the source and destination of run-off are wholly contained within a single property.

### Chapter 3: Peak discharge estimation

Soil conservation structures are designed to accommodate runoff up to a maximum amount (or peak discharge). The peak discharge is determined by the catchment area above the structure and the rate of runoff expected from that catchment under the conditions for which the structure is designed. Runoff is a sporadic occurrence, most is the result of occasional intense storm events.



For any particular locality rainfall events of high intensity occur less frequently than those of low intensity. The frequency with which rainfall events of a particular intensity are predicted to occur (the average recurrence interval or ARI) can be determined for different localities in Queensland from intensity-frequency-duration (IFD) charts available from the Bureau of Meteorology. Soil conservation structures are generally designed for a 1 in 10 year ARI event. The rate of runoff is also affected by physical characteristics of the catchment including its shape, landform, soils, and land management. Modelling approaches have been developed to calculate peak discharge using values for these characteristics as inputs.

### Chapter 4: The empirical version of the rational method

The rational method is a set of formulae used to determine the peak discharge expected from a particular soil conservation structure, such as a contour bank design. The empirical version is a simplification of the full rational method which uses parameter values that are based on experience or observation (rather than calculated using comprehensive models).



The size and timing of flows (the hydrograph) at a design point in a soil conservation plan (e.g. at the entry to a structure) resulting from a rainfall event falling in a catchment depend on the characteristics of both the event itself (intensity, duration, and location) and the catchment (area, shape, slope, and land surface condition) above the design point.

The peak discharge from a rainfall event can be calculated manually using charts (available in various publications, including in the Appendix to these guidelines) or an Excel workbook (RAMWADE) developed for use with these guidelines.

### Chapter 5: Darling Downs flood frequency (DDFF) version of the rational method

The DDFF version of the rational method has been customised for use in soil conservation design for small non-contoured bank catchments in an area of southern Queensland. The application of the DDFF in soil conservation design is limited because it does not allow for different forms of land management and because it is restricted to a comparatively small area.



## Chapter 6: Channel design principles

The faster water flows in a channel the greater the likelihood that it will erode. Soil conservation structures need to be planned to transport water safely under the design conditions without eroding. The velocity of flows within a channel can be calculated from the slope, cross-sectional shape and size, and the roughness of the channel surface.



The major influence on channel roughness in planning soil conservation structures is the amount and type of vegetation lining the channel. The extent to which vegetation retards flows depends on its density, height, and physical characteristics (such as flexibility). The flow in a channel is also affected by the inherent tendency of water to become turbulent as the cross-sectional area decreases and flow rate increases. Turbulent water is more likely to erode the bed and banks of a channel.

## Chapter 7: Contour banks

Contour banks intercept run-off before it concentrates and starts to cause erosion and safely channel it into stable grassed waterways, natural depressions or grassed areas adjacent to a paddock.



When designing contour banks the key objective is to ensure that under the design conditions the velocity of flow remains low enough to avoid erosion. The velocity of flow depends on the gradient, length, spacing and cross-section (or depth of flow) as well as the vegetation cover between, in, and on the banks.

The major considerations when designing contour banks are the land slope, land use/cover, soil type and rainfall of the catchment. It is also important to consider practical farm management requirements such as trafficability especially in choosing the spacing and alignment of the banks.

Contour banks are usually designed to a standard that will safely carry runoff resulting from a rainfall event with a 10 year average recurrence interval.

## Chapter 8: Diversion banks

Diversion banks are used to direct runoff around and away from areas where it could cause problems (such as cultivated paddocks) to areas where it can safely be disposed of (such as stable waterways or water storages). Diversion banks are usually designed for an average recurrence interval (ARI) of 20 years.



When designing diversion banks the same formula is used as for other waterways (incorporating channel slope and dimensions, rainfall and catchment conditions) with the objective being to keep the average maximum velocity under the design conditions below a level that would cause erosion.

## Chapter 9: Waterways

Soil conservation waterways collect runoff from contour bank systems and safely convey it to a drainage line or creek system where it can disperse without causing erosion.

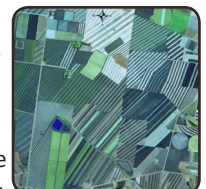


When designing waterways the objective is to determine the cross-section, slope and alignment that ensures a velocity that will not cause erosion at the design average recurrence interval (ARI), usually 20 years, taking into account the catchment characteristics, vegetation cover, and soil erodibility.

Waterways are especially vulnerable to erosion so it is essential that they be well stabilised, with vegetation (preferably uniform sod forming grasses) or artificial (e.g. concrete) lining before use. Waterways that follow natural drainage lines are less likely to erode.

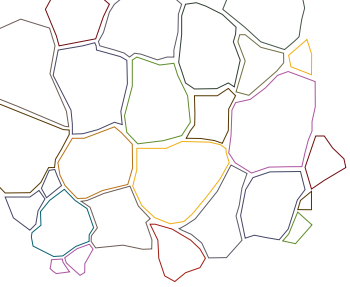
## Chapter 10: Land management on flood plains

Agriculture is by far the most extensive land use on floodplains in Queensland. Much of the state's most productive agricultural land lies on flood plains.



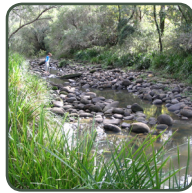
Floods are a mixed blessing. On the one hand floods can threaten lives, damage infrastructure, destroy crops and pastures, spread weeds, reduce water quality and cause serious erosion. On the other hand floods replenish groundwater, deposit fertile silt, and restore wetlands and other habitats.

Flood plain erosion can be minimised by maintaining groundcover and by protecting streambanks and channels.



## Chapter 11: Stabilising streams

It is natural for the bed and banks of streams to erode, for sediment to be transported by streams, and for stream channels to move. However excessive stream bank erosion can damage land and infrastructure and pollute water-supplies.



Natural variability is important for stream stability—simplifying, straightening and/or de-snagging streams can lead to problem erosion. Most streambank erosion occurs in occasional severe flood events. Both the streambank and/or streambed can be affected by erosion.

Engineered structures, such as rock-walls, can be useful in protecting against erosion however the long-term stability of streams requires establishing and maintaining appropriate vegetation in the stream, on the banks, in the riparian strip and throughout the catchment.

## Chapter 12: Soil conservation in horticulture

Horticulture is a significant part of agriculture in Queensland. Horticultural land is valuable and can be vulnerable to erosion. It is important to carefully plan before laying a property out for horticulture to avoid creating erosion or increasing existing erosion problems.



Horticulture is intensive. It generally involves frequent cultivation and reforming of the soil surface (e.g. mounding or terracing). Most horticultural properties are irrigated, many are in high rainfall areas, and some are on steep slopes. Because of this they have the potential to generate runoff that can be damaging to soil on the property and to the environment downstream.

It is critical that groundcover be maintained to prevent erosion occurring. The best way of maintaining groundcover will depend on the crop type, the crop management system, and the land surface modification.

It is best to manage runoff on site to ensure that any water leaving the property is suitable for reintroduction to the environment. Runoff from horticultural properties is commonly managed with earthworks such as mounding and/or construction of drains and artificial wetlands.

## Chapter 13: Gully erosion and its control

Gullying occurs in many parts of Queensland. Under natural conditions gullying is an important process of landscape evolution. However, man-made gullying is a serious form of land degradation reducing soil fertility, inhibiting access, damaging infrastructure, reducing water quality and degrading habitat.



Remediating gullies and preventing them from forming requires an understanding of the processes of gully formation and of the characteristics that make particular parts of a landscape prone to gullying. Gully control works are expensive, have a high risk of failure, and are only financially justifiable where the gully threatens valuable assets (such as infrastructure or highly fertile land).

Controlling a gully once it has started generally requires a combination of engineering structures, earthworks and revegetation.

Maintaining ground cover throughout the catchment, protecting drainage lines, dispersing runoff, and avoiding exposure of dispersive subsoils are all potentially important strategies to prevent gullies from forming.

## Chapter 14: Property infrastructure

Infrastructure is critical for property management. Roads and tracks provide access; fences, laneways, stockyards and holding paddocks are required to manage livestock; firebreaks protect important assets; and watering points and irrigation structures provide access to an essential resource.



Infrastructure that is well planned and constructed will provide many years of satisfactory service and require limited maintenance and repair whilst infrastructure that has been poorly designed and constructed will require constant attention.

Farm infrastructure can exacerbate existing erosion and/or initiate new erosion. For this reason, when planning and installing new farm infrastructure it is worth investing time and effort to get it right the first time.

Retrofitting erosion mitigation elements to existing infrastructure is usually less effective and more expensive than designing and constructing the infrastructure to mitigate, or prevent erosion in the first place.



**Appendices:** information on air photo interpretation, land capability/suitability classification, and recommended plants for stabilising runoff management structures, as well as tables and charts commonly used for designing soil conservation works.

**RAMWADE:** a Microsoft Excel template file that uses the Empirical version of the Rational Method (as described in Chapter 4) to calculate a peak discharge and channel dimensions for an Average Recurrence Interval of 10, 20, or 30 years and for high (such as heavy vegetation) and low (such as bare soil) retardences. RAMWADE already contains Intensity/Frequency/Duration data for 12 centres throughout Queensland but also provides for IFD data for any other centre to be added.

