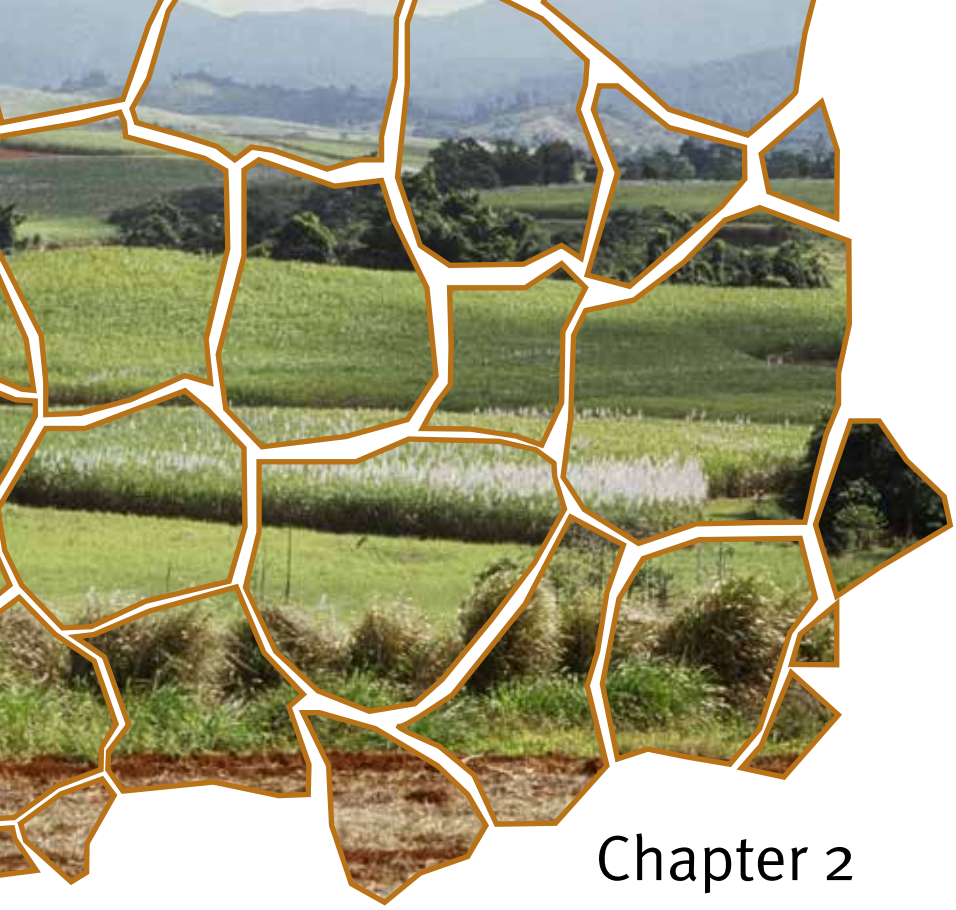


Chapter 2

Soil conservation planning

Key points

- 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.
- Soil conservation planning also involves identifying areas that are vulnerable to damage so that special precautions can be put in place to prevent erosion.
- Special precautions will depend on the land use and the nature and extent of the vulnerability. They may include actions such as establishing special groundcover vegetation, reforming the land surface or constructing contour banks.
- Soil conservation planning must be coordinated across the whole landscape. It is very rare that both the source and destination of run-off are wholly contained within a single property.

Contents

Glossary

Abney level: a surveying instrument consisting of a spirit level and a sighting tube, used to measure the angle of inclination of a line from the observer to another point

auto-steer technology: a navigation aid that utilises the global positioning system (GPS) connected to the steering mechanism to guide agricultural machinery.

broadacre cropping: large-scale growing of plants and/or production of bulk plant materials (such as cereal grains, oil seeds or pulses) for commercial purposes where plants live less than two years requiring cultivation of the soil and usually some nutrient, weed and moisture control.

contour bank: a constructed earth embankment, incorporating a channel on the upslope side, typically traversing a slope on or close to the contour to control and/or prevent the erosion of that slope.

erodibility: susceptibility (of a soil type, or part of the landscape) to erosion.

erosivity: potential ability (of an eroding agent such as rain, run-off or wind of a particular strength/ intensity and duration) to cause erosion.

gully erosion: a complex of processes whereby the removal of soil is characterised by large incised channels in the landscape. Such channels are generally greater than 30 cm deep.

land capability/suitability: the systematic arrangement of land into various categories according to its ability to support particular land uses/land management systems and the treatment required to sustain those uses/management systems without degrading the land.

regional ecosystems: vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil. Regional Ecosystems are the principal means of classifying native vegetation in Queensland for the purposes of establishing biodiversity conservation status.

rill erosion: the removal of soil by run-off from the land surface whereby numerous small channels, generally no more than 30 cm deep, are formed.

sheet erosion: the removal of a fairly uniform layer of soil from the land surface by raindrop splash and/ or run-off. No perceptible channels are formed.

sodosol: a soil defined in the Australian Soil Classification system as having a clear or abrupt textural B horizon and in which the major part of the upper 0.2 m of the B2 horizon (or the major part of the entire B2 horizon if it is less than 0.2 m thick) is sodic (i.e. has an exchangeable sodic percentage of 6 or greater) and not strongly acid (i.e. has a pH of greater than 5.5). Soils of this type are characteristically highly dispersive and are prone to gully erosion.

stereoscope: an optical instrument to fuse the pair of images of an overlapping scene in a stereo-pair of aerial photographs to obtain the appearance of a three-dimensional model.

2.1 Introduction

The preparation of a soil conservation plan requires consideration of many issues including soil types, topography, current and proposed land use and management, remnant vegetation, property infrastructure and run-off coordination with neighbouring properties and road and rail drainage. The planning process also provides opportunities to improve the overall property layout to achieve greater efficiencies in managing the property. This chapter relates mostly to situations that apply in broadacre cropping where contour banks and waterways are used. Chapter 12: *Soil conservation in horticulture* has information specific to horticultural crops.

A soil conservation plan can be a component of a farm management system where landholders consider personal, financial, natural resource and environmental management and other issues involved in farm business management. As these guidelines relate to the design of soil conservation measures this chapter concentrates on aspects related to the planning of these measures.

Historically, property development often occurred in a haphazard manner as different owners made their mark. Decisions on which land to clear and how to use it as well as location of infrastructure such as buildings, fences, tracks and watering points were often made 'on the fly' and for short-term goals. Once such decisions were made, they were not easy to correct and landholders learnt to live with past mistakes. The preparation and implementation of a soil conservation plan provides an opportunity to correct some past planning decisions that may have led to problems or inefficiencies.

With tree crops, it is especially important to implement adequate surface and subsurface drainage requirements before planting the trees. If not done properly, it is difficult and expensive to carry out remedial measures once soil losses start to occur after the trees have become established.

While the planning of some run-off control layouts can be straightforward, others can be more complex and require the consideration of a number of optional layouts. This is especially so when consultation is required with neighbours and authorities responsible for infrastructure such as roads and railway lines. A significant amount of time may be required to evaluate options on paper and it may be necessary to do some preliminary surveying in the field before deciding on the best option.

While farmers can acquire the skills to do their own planning, it is desirable to seek the expertise of someone with experience in this area. Such a person can play a similar role to that of an architect of a building, taking into account the needs of the property owner and preparing a plan that will be both practical and technically sound and which takes into account possible impacts on adjacent lands and other resources.

Other chapters of these Guidelines contain information about planning for soil conservation. These include:

- Chapter 7: *Contour banks*
- Chapter 8: *Diversion banks*
- Chapter 9: *Waterways*
- Chapter 10: *Land management on flood plains*
- Chapter 12: *Soil conservation in horticulture*
- Chapter 14: *Property infrastructure*.

2.2 Preparation of a soil conservation plan

This topic is discussed under various headings below. Additional supporting technical information is provided in the appendices.

2.2.1 Land capability assessment and land use

A basic principle in soil conservation planning is that land must be used within its capability. Using land beyond its capability leads to environmental instability and degradation, and ultimately to economic failure of the farmer and impoverishment of the community (Stone and Titmarsh 1997).

Different crops require different soil characteristics for optimum growth. When planning for soil conservation, each management unit on the property should be examined and an assessment made of its present productivity. Alternative uses for each should be considered, and estimates made of the cost of converting to that land use, the costs of production and the returns likely to be obtained.

A number of land capability/suitability assessment systems have been developed for describing land in Queensland. These systems are outlined in Appendix 2 and in various technical reports. This information has been made widely available to assist with the interpretation of many existing soil conservation plans that contain land capability/suitability information.

There have been many examples in the past of unsuitable land being used for cropping. Land slope, soil fertility and depth, moisture holding capacity and soil physical restrictions are the most common factors limiting cropping in Queensland. Eventually, economic limitations have reduced the viability of growing crops in such areas and in most cases this land has been returned to pastures and/or native vegetation. The presence of contour banks on much of this land provides evidence that it was once cultivated. If cropping was to become a more profitable enterprise, it is likely that there would be more pressure on marginal land to be cultivated.

2.2.2 Planning on a catchment basis

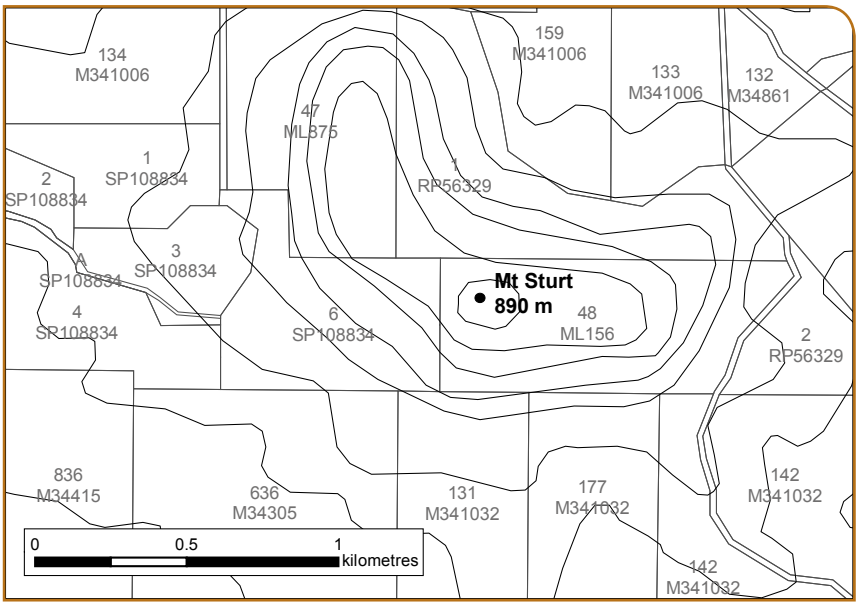
To address run-off control, planning must be carried out on a natural catchment basis and within bounds set by other features such as roads, railways and water supply channels. Every farm is part of one or more natural catchment areas. Even though it may be tempting to address erosion on a paddock level, the problems of inappropriate land use or uncontrolled run-off can seldom be separated from other areas of the property or adjoining land. In preparing a plan, it is important to get an appreciation of where a property fits within the local catchment. This involves getting a feel for the big picture before coming down to the farm level and finally to specific paddocks or problem areas. When looking at solutions, it is very important to check that the actions taken at a point in a paddock do not cause problems downstream—either within the farm or to neighbouring property including roads and railway lines.

Some of the difficulties encountered when planning on a sub-catchment are due to the manner in which the land was originally surveyed. Early surveyors did not have the benefit of information that we have today about other resources or about the broader landscape. Also, the future use of the land had not been well established. Land was commonly subdivided in a rectangular pattern with little recognition of topography, natural catchments and drainage lines.

Figure 2.1 illustrates an example of where a mountain on a spur of the Great Dividing Range on the eastern Darling Downs was subdivided.

Town planners and land developers should be aware of the principles discussed in this chapter when considering subdivision proposals in rural areas. Ideally, property boundaries should conform to natural features and 'straight line' boundaries are usually not the best solution. Crothers (1991) addresses this issue in the booklet Rural subdivision planning—Guidelines for subdivision design.

Figure 2.1: Land subdivisions often had little regard for natural landscape features



A key element of a run-off control plan is to understand how run-off flows through a catchment. This may involve the coordination of flow from one property to another and across roads and railway lines, and tramlines in sugar cane areas. Utilities such as pipelines, power lines and underground cables also need to be taken into account.

Figure 2.2 illustrates some of the complexities involved in preparing a run-off control plan. It is part of a project plan covering six properties in the Warwick district. The codes A, B, C, D, U and W represent properties under different ownership when the plan was adopted in 1987.

Liaison with neighbours and agencies responsible for infrastructure such as roads, railway lines, cables and pipelines is necessary for run-off coordination. Failure to do this could cause damage to such infrastructure and landholders responsible for such damage may be liable for meeting the cost of repairs. Landholders have a 'duty of care' to not cause nuisance or harm to neighbours (refer to Section 179 of the *Property Law Act 1974*).

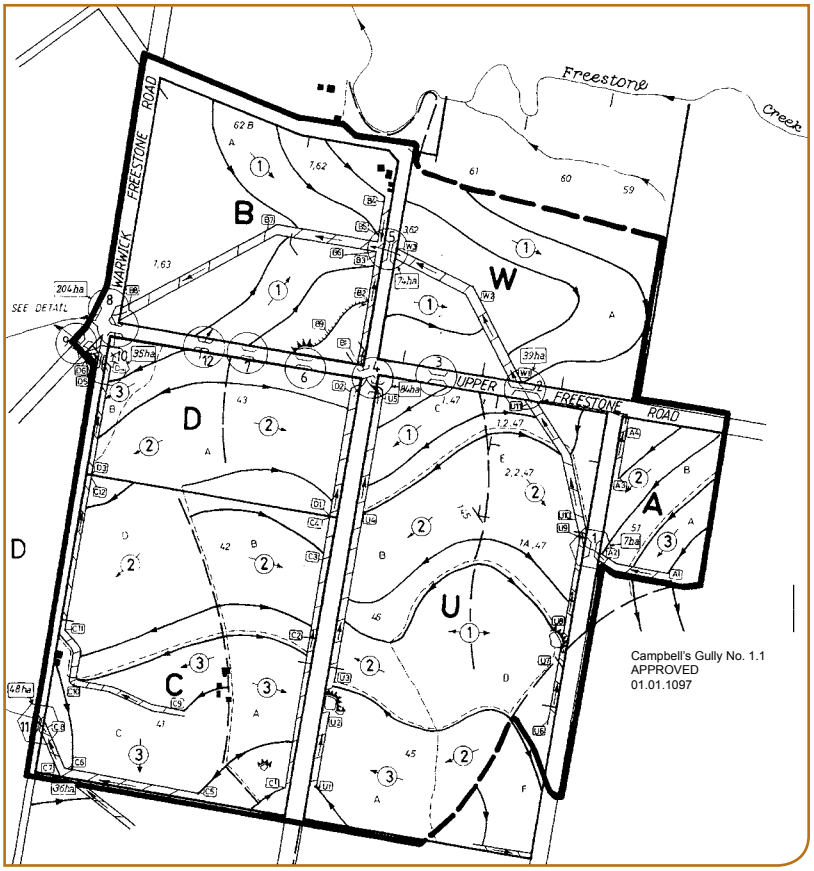
Run-off coordination issues tend to be most complex on combinations of topography and property size where overland flow passes through several properties before it meets a well-defined watercourse. This situation is most applicable to the Eastern Darling Downs, Atherton Tableland, Inland Burnett and some cane growing areas. In these districts, a drainage line may pass through as many as 10 properties as it flows from the most remote part of the catchment into a watercourse.

Planning is easier in more extensive cropping areas where one or two properties may cover a whole catchment. It can also be reasonably straightforward in many coastal areas with steep topography where drainage lines are normally well

defined and there is limited scope for the construction of artificial waterways that would flow from one property to another.

Figure 2.3 is an example of a soil conservation plan for a banana plantation illustrating how the run-off from the plantation is confined to natural watercourses. Such a plan would have minimal impact on the drainage patterns for neighbouring land.

Figure 2.2: Part of the Campbell's Gully No. 1.1 Project Plan

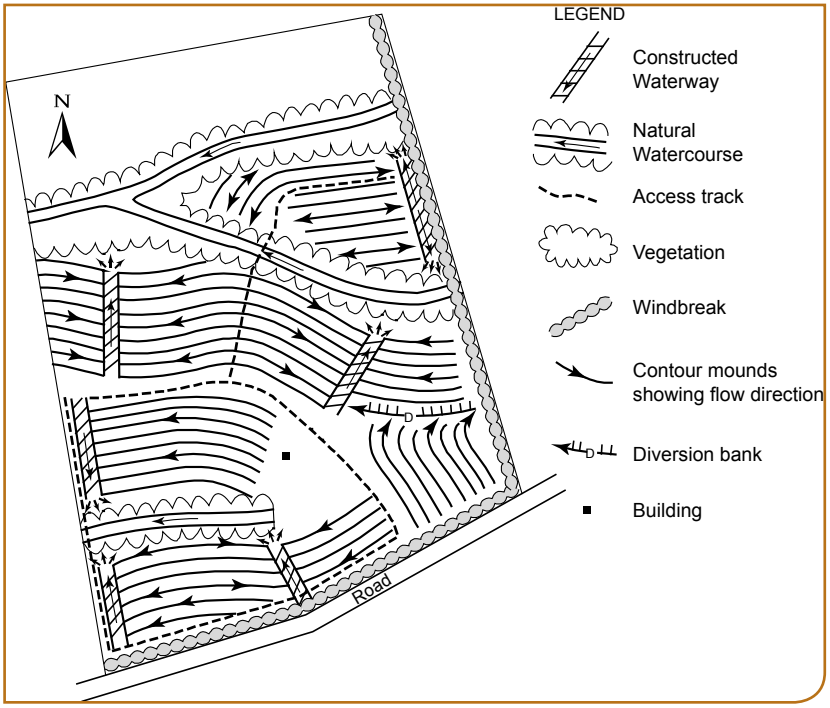


Coordinated run-off control planning is based on the principle that a property should accept the run-off from higher land, which it would receive under natural conditions.

It is preferable that run-off is allowed to remain in its natural catchment. However to achieve a practical soil conservation layout, it is often necessary to move run-off from one sub-catchment to another. There are occasions when the manner in which the land was originally subdivided may lead to some debate as to how run-off should be routed. Past siltation may also have modified run-off patterns making the location of the 'original' drainage pattern unclear. Historical aerial photography may need to be used, or topographic data collected in the field, to provide clues as to the location of such patterns.

The situations described above are easily resolved when neighbours are cooperative. However uncooperative neighbours may result in a lack of consensus as to how run-off should be coordinated. Resolution of such issues requires careful negotiation between all parties including representatives of agencies responsible for the various utilities that may be involved, such as roads, railways, telecommunications, and electrical infrastructure.

Figure 2.3: Soil conservation plan for a banana plantation



2.2.3 Legislative and regulatory requirements

When preparing a plan for soil conservation purposes, planners and landholders should take into account any legislative and regulatory requirements that may affect the property. Relevant controls may exist as part of planning schemes approved by local governments, or by legislation related to catchment development, natural resource management, soil conservation, water allocation and management, vegetation management, environmental protection, or protection and management of government-owned lands (including leasehold land) and utilities.

2.2.4 Coordination with road and rail drainage

When planning a soil conservation layout, every attempt should be made to make use of existing road and rail cross-drainage structures such as culverts, inverts and floodways. However, in some cases it will be necessary to modify an existing structure or to build a new one. Negotiations with the relevant agency responsible for the structure (referred to as the 'road controller') will then be necessary to determine planning options, required specifications, options for funding the works and construction schedule. In canegrowing areas, it may be necessary to negotiate with the sugar mill responsible for maintaining tramlines for transporting cane to local mills.

Roads should not be used as a site to locate waterways. Roads were seldom surveyed with the intention of them being a corridor for managing concentrated flows from surrounding catchments. There is generally insufficient width in the road corridor to construct a waterway of adequate width. The use of such an area will often result in run-off being diverted out of its natural location. This can have an adverse impact on downstream areas when the run-off must eventually return to its natural location. If it is considered that there is no alternative to the use of

the road corridor in which to locate a waterway the proposal must be discussed with the relevant road controller.

Where an unused road is to be used as a location for run-off disposal or even if it is proposed to be crossed with contour banks (if the same person owns the land on either side of the road or leases it from the state), an application can be submitted for the road to be permanently closed. However, it is recommended that before this is done that the planner contact the 'road controller' to raise the issue of what will be requested in the formal application. Once there has been an informal endorsement, it would then be practicable to make an application to the relevant authority. If the application for permanent closure is successful, the road can be closed and included in the tenure of the person who submitted the application and the soil conservation works can proceed.

If it is not possible for the road to be closed, the 'road controller' should be approached to determine if there are any other options such as the temporary closure of a road. In such circumstances it is important to bear in mind that a temporarily closed road can at any time be reopened if it is required for use as a road. Any works constructed on a temporarily closed road would need to be able to be easily removed or modified if the road is to be reopened. It is recommended that the following notation be included on the plan where unused roads have been used for water dispersal:

> *Approval has been obtained for unused roads to be utilised for soil conservation purposes on this plan. Amendment of this plan may be necessary if the road is to be opened for public use or for any other reason put forward by the agency responsible for the road.*

Where a road has been temporarily closed or where approval has been obtained to construct soil conservation works on an unused road, there may be a requirement to also obtain development approvals under the town planning scheme from the local government where the land is located.

The impact of roads and rail lines on run-off flow patterns may be particularly significant on extensive cultivated flood plains such as those of the Condamine and Macintyre Rivers. For this reason, this topic is also dealt with in detail in Chapter 10.

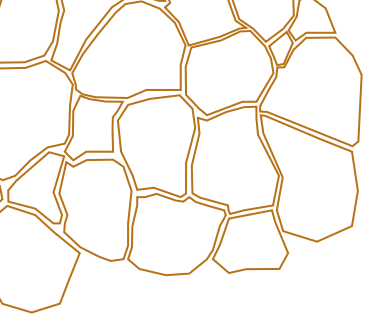
2.2.5 Locating property infrastructure

The location of infrastructure such as access tracks and fences can have a significant effect on run-off patterns. Inappropriate location can result in damage to infrastructure and cause erosion of adjacent areas. Well-sited and well-constructed property improvements will provide many years of low maintenance service with minimal adverse impacts.

The direction in which a track or fence is orientated to the contour has significant implications for run-off management. The options for preparing a property plan illustrated in Figures 2.7 to 2.13 are relevant to this issue. More information on this topic is provided in Chapter 14.

2.2.6 Taking cadastral boundaries into account

Many properties are made up of a number of individual lots of land. In some intensively subdivided areas such as the Eastern Darling Downs, a single property may include 10 or more individual lots. If it is likely that some of the lots could be sold as a separate entity in the foreseeable future, this needs to be taken into account in the planning process. If there is potential for this to occur then this issue needs to be addressed with the landholder during the preliminary planning stages.



In most cases it is impractical to prepare a 'self-contained' plan for all individual lots. Such planning would lead to small paddocks and inefficient layouts with short contour banks and numerous waterways. However, it is desirable to consider the presence of individual lots during the planning process when there should be opportunities to, for instance, align some structures with lot boundaries. Where fences on lot boundaries are removed, original survey pegs should be retained for future reference.

Where a soil conservation layout is prepared that combines a number of lots, it is recommended that the following endorsement be printed on the face of the plan:

In order to achieve more efficient soil conservation layouts, some lot boundaries have been disregarded in the preparation of this plan. Amendment of this plan may be necessary if the sale of any lot makes the plan unworkable.

2.2.7 The mapping base

When preparing a run-off control plan, a base map of the area first needs to be prepared. This needs to be at an appropriate scale. A scale of 1:10,000 is generally suitable for most run-off control planning in Queensland. However, on small, intensively cropped horticulture properties a scale of 1:5000 or larger is preferable whilst on extensive properties with very large paddocks, a scale of 1:20,000 may be acceptable. A map based on aerial photography or high-resolution satellite imagery is a useful aid to the planning process as it provides a better appreciation of the location of proposed works.

Current information about property boundaries, survey control information, survey plan history, land tenure, and actions on land parcels is available from the Queensland Department of Natural Resources and Mines. A selection of this information can be integrated into one map—called a SmartMap—based on a property, locality or any geographical area. SmartMaps are available from DNRM service centres and can be ordered online. For more information, check the DNRM website. Cadastral mapping and a range of other natural resource mapping, including soils, is now also available via the Queensland Globe.

Aerial photography and satellite imagery

Aerial photography and satellite imagery are both valuable aids to soil conservation planning.

The Department of Natural Resources and Mines has a large collection of current and historical aerial photography for most parts of Queensland. Older photography is generally at a scale of 1:25,000 in more closely settled areas and 1:40,000 in less closely settled areas. More recent photography (since 2009) is captured digitally generally at a scale of 1:30,000 or 1:15,000 in closer coastal areas and 1:80,000 in remote areas (generally west of 144 degrees longitude). In the more closely settled areas, aerial photographs are taken about every 10 years whilst other areas are photographed less frequently. Aerial photography can be rectified—by use of a Geographic Information Systems (GIS) computer program—to produce true-to-scale property maps with a cadastral overlay.

Satellite imagery is generally captured more frequently that aerial photographs. Recent imagery is available at a range of scales some of which are suitable for property mapping.

2.2.8 Collecting data and information

Topics covered in this section include:

- existing soil conservation plans
- topographic information
- vegetation
- soils and land use.

Existing soil conservation plans

It is especially important to obtain any plans that may exist on neighbouring properties to ensure that any future planning will be compatible with existing plans. It is most likely that existing works had been previously implemented under approved schemes. Many of these plans had been previously approved under the *Soil Conservation Act 1986*, particularly for properties on the eastern Darling Downs, reflecting the necessity to coordinate the flow of run-off between many properties in this region. Such planning had also been carried out in other cropping districts in Queensland, including Bundaberg, South Burnett, Central Highlands and the Atherton Tablelands. Copies of such plans may be available through the local natural resource management body.

Topographic information

Some form of topographic (land slope and aspect) information is essential for planning and designing soil conservation structures. Topographic maps are available from the Department of Natural Resources and Mines and Geoscience Australia. Scales range from 1:2500 to 1:1,000,000. Broadscale maps (1:100,000 and greater) are available for the whole state, while more detailed maps are generally available only for more closely settled areas.

Topographic image maps (orthophoto maps) produced by DNRM are available for some areas. They have contour lines over an aerial photograph background with an accurate scale ranging from 1:2500 to 1:25,000.

For most run-off control planning, topographic information is required at a scale of 1:5000 to 1:10,000 with a contour interval of no more than 2.5–5 m. Information of this quality is normally available for more closely settled areas but not for extensively cropped areas such as the Central Highlands and areas to the west of the Darling Downs.

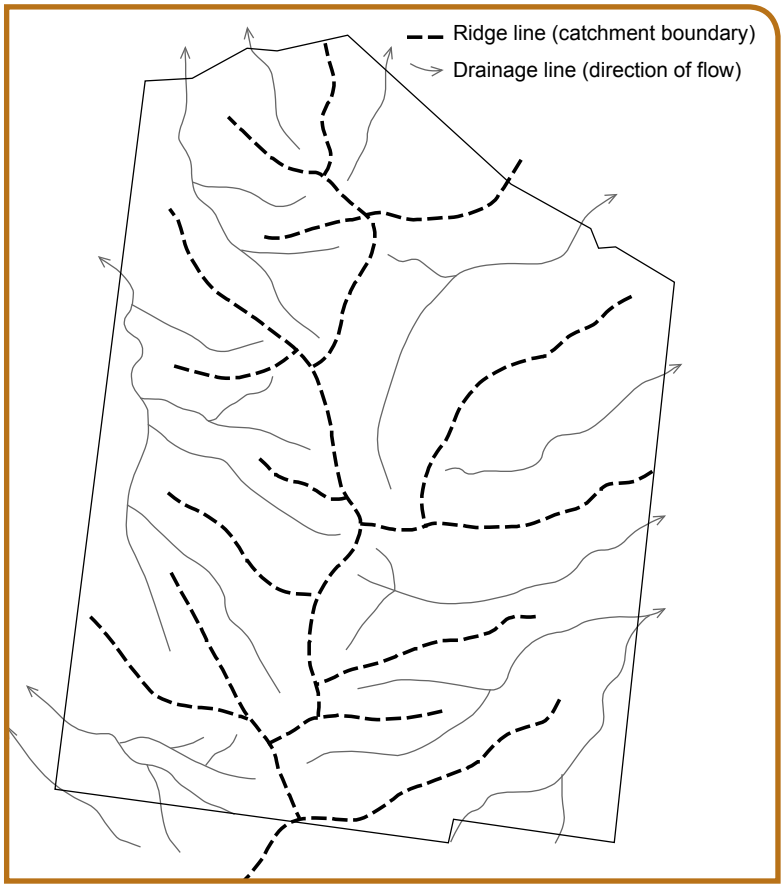
Topographic information can be obtained in the field by using surveying equipment. Prior to the mid-1990s the Queensland Government carried out detailed topographic surveys on the flood plains of the Darling Downs to collect data to assist in planning of strip cropping layouts to aid in flood plain management. On individual properties, conventional surveying equipment can be used to establish trial contour lines (i.e. 'formlines') or sightings can be made onto fence posts, trees etc. If detailed topographic information is required in order to prepare a soil conservation plan, it may be necessary to employ a business that specialises in the acquisition of such data.

The auto-steer technology now used by many farmers has the capacity to collect topographic information (Neale 2009). Elevation/height data can be collected using an RTK GPS system which is a variation of the system used by surveyors to collect spatial data. The data can be obtained at the same time as the auto-steer is functioning and it can be used to produce contour, elevation, slope and aspect maps. Alternatively, the data can be collected by using an RTK GPS mounted in a 4WD vehicle and programmed to log data points every few metres.

A more traditional option for obtaining basic topographic information is by studying paired aerial photographs through a stereoscope. An example of information obtained from such a study is shown in Figure 2.4. With stereoscopic aerial photography it is possible to accurately map the location of major drainage lines and the catchment boundaries (ridge lines) between them. On land with limited slope (e.g. below 2%), this approach is more difficult to use. If some parts of the property are difficult to interpret for this reason, the locations should be noted for later confirmation during a property inspection. Once catchments and drainage lines have been identified, it is possible to roughly 'estimate' the location of contour lines on paper maps, for use in determining layout options for contour banks and waterways. The accuracy of this estimation will depend on the skills and experience of the person doing the planning. For this reason the actual position of such structures will need to be confirmed by field survey prior to commencing earthworks.

Where possible, it is recommended to 'split' contour banks on ridge lines to allow run-off to remain in its natural catchment. Such a split also provides an excellent location for an access track. However, the exact location of broad ridges and broad depressions cannot be pinpointed on most topographic maps. If contour banks are to be split on a broad ridge, it will not be possible to determine the exact location of the split until the contour banks are surveyed in the field. When marking out contour banks the location of splits may need to be temporarily identified with a marker such as a steel peg on each survey line. Their location can then be sighted and modified if necessary to provide a well-aligned access track.

Figure 2.4: Example of topographic information obtained from a stereoscopic survey of aerial photographs



Vegetation

In Queensland different vegetation types are mapped as regional ecosystems. Regional ecosystems are vegetation communities that are consistently associated with a particular combination of geology, landform and soil. Maps showing regional ecosystems have been produced covering all of Queensland. These maps are at a scale of 1:100,000 in coastal areas and at coarser scales for the inland. Regional ecosystem maps identify where for instance clearing may be restricted.

Soils and land use

A series of land resource bulletins and land management field manuals produced by DNRM contain useful information about land resources, climate, vegetation and land use and management at scales from 1:25,000 to 1:500,000. Broadscale maps (>100,000) will not accurately identify the soils at a specific location but provide an indication of the soil types likely to occur in a specific area and information about their characteristics. If necessary, additional soils information can be obtained by taking soil samples or by employing a soil surveyor.

2.2.9 Property inspection

Planners can more readily gain the confidence of landholders if they are familiar with the property before setting foot on it. Before inspecting a property, any relevant information previously described in this chapter should be collected.

A useful way of becoming familiar with a property before making a visit is to study paired aerial photographs under a stereoscope. Another option is to study satellite imagery, although this may give a misleading impression of the landform. Oblique views are useful as they provide an indication of the topography of a property. It can be useful to take another look at the aerial photographs soon after the property visit to help resolve any questions or doubts about interpretations remaining from the initial stereo survey.

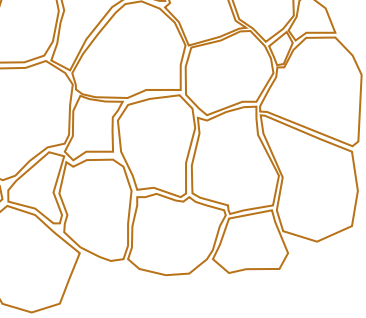
Historical aerial photography should also be checked if possible. This is a good source of information about the past development and land use of the property. Since the location of drainage lines and watercourses may have changed over the years, historical photography can provide some clues as to the location of past run-off and land-use patterns.

On large properties, where the homestead may be several kilometres from the road, it is advisable for planners to become orientated as soon as they arrive at the entrance to the property and to check the map and make observations as they drive to the homestead. Sometimes a person's sense of direction can let them down, particularly on cloudy days when there is no sun to help with orientation. Landholders will also appreciate the fact that you have been observant and that you are taking a keen interest in their property.

It is most important that the landholder accompanies the planner on the initial inspection at least. The planner should closely observe infrastructure such as gateways, tracks, electric fences, and other things that will impact on ease of movement around the property during subsequent inspections.

Initial discussions with the landholder should include the following issues:

- Overall goals and priorities for the property
- Areas needing the most urgent attention
- Any proposed changes in the future use of the land. This has a significant impact on optimal paddock size with significant differences between a property used for broadacre cereal growing (large paddocks and long contour banks) compared to one used for horticultural crops or dairy farming (smaller paddocks and shorter contour banks).



- The need to consider individual lots of land when developing the plan. For instance, what are the chances that some of the lots are likely to be sold separately in the future and what impact would this have on the chosen run-off control plan? Is there scope to, at a later date, amalgamate existing lots or subdivide them in a manner that would better complement the soil conservation layout?
- Attitude in relation to making modifications to the existing fencing. During the planning process, it is useful to think about natural catchments and land resource boundaries rather than being restricted by the existing fence layout.
- Where waterways need to be constructed. Is the landholder aware that, depending on seasonal conditions, it may take several years before a waterway becomes adequately stabilised with suitable grasses?
- Information about neighbouring landholders and possible impacts on, or from, adjacent lands. It is important to know about the willingness of neighbours to participate in the planning process and whether or not there is already a soil conservation plan for their property, any progress made in the implementation of the plan, and the maintenance of existing works. It is also worth finding out if the neighbours have any future plans such as expanding their area of cultivation or implementing new soil conservation measures.

Finalising a plan on the first visit to a property should be avoided, as first impressions can be deceiving. An open mind is necessary, and it is best to avoid getting a quick 'fix' on a solution until the whole property has been inspected, the views of neighbours sought, and discussions held with relevant road authorities if necessary. In some cases, subsequent review of detailed topographic information, that may not have been available during the property visit, can reveal a different viewpoint from that gained at the initial inspection. If the planner is getting 'bogged down' in a particular area or issue, it is probably best to move on to another part of the property. Difficult planning issues are usually less complicated and more easily resolved when viewed from a different direction or perspective.

It is essential to follow the property tour on the base map. Preferably the base map will have an aerial photograph or satellite image as a background to make it easier to recognise features. The landholder should be encouraged to assist in interpretation. GPS equipment and vehicle odometers are useful to accurately plot the information on the plan and for checking the accuracy of the scale on the plan.

Any public roads adjoining a property, as well as internal property roads and fencelines are good places from which to collect useful information such as road cross-drainage points, ridges and drainage lines. Pay particular attention to the following during property inspections:

Land issues

- Land types
- Extent of existing erosion and other forms of land degradation (salinity, seepage areas, scalded areas, declining pasture/crop growth)
- Land slopes at key locations (including potential sites for waterways where designs will be required). A clinometer or an Abney level can be used for quick checks if no suitable topographic information is available. Slopes are normally expressed as a percentage. In some low sloping situations, the eye can often be deceived by the lie of the land—what appears up may in fact be down and vice versa. Slope can be particularly difficult to judge on broad flood plains. A useful tip for flood plains is that the general slope of land in a particular location will usually be away from the closest mountains.

- Well defined changes in land slopes
- Catchment boundaries (ridge lines)
- Key locations such as rocky outcrops or areas of protected vegetation that may restrict construction of soil conservation measures.

Water issues

- Points where run-off enters and leaves the property and the presence of cross-drainage structures in adjacent roads and railway lines
- Location and condition of drainage lines and other areas where it may be necessary to construct waterways to receive run-off from contour banks and any suitably grassed areas that can be used for safe disposal of run-off
- The suitability of locations in watercourses where it may be necessary to discharge run-off from a constructed waterway, diversion bank or contour bank
- Existing dams and possible locations for future storages
- Location of watering points and pipelines if the property is used for grazing
- The presence of any structures on flood plains that may impact on flood flows.

Vegetation issues

- Areas of native vegetation that are covered by tree clearing permits. This may apply to any part of the property
- Areas where revegetation would be beneficial, such as wildlife corridors, shelter belts, or degraded areas requiring rehabilitation
- Condition of riparian vegetation
- Remnant vegetation clumps and corridors and their impact on proposed soil conservation structures
- The occurrence of pest plants and of soil types that are at risk of invasion by weeds
- Suitability of existing pasture species for stabilising waterways, run-off disposal areas, or degraded areas.

Infrastructure (public and on-farm)

- The location and condition of existing fences. Are there any options for modifying the layout through the proposed soil conservation works to improve general workability?
- Location and standard of existing soil conservation works, both on the property and on adjacent lands
- Levee banks
- Irrigation infrastructure (private or public)
- Gas and water pipelines, power cables and telephone lines
- Access tracks
  - Are they well positioned?
  - What is their condition/standard?
  - Are there opportunities to relocate them?
- Stock yards and buildings
- Road/rail cross-drainage structures.

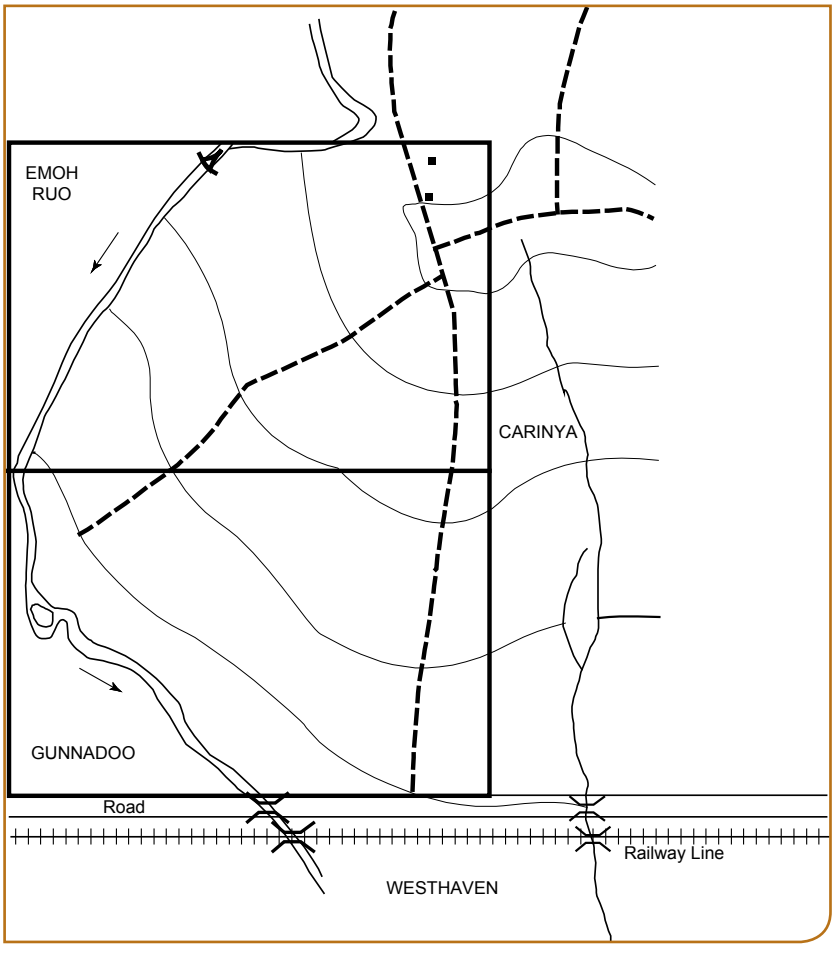
2.3 Evaluating layout options—case studies

Figure 2.5 shows an area of land for which a soil conservation plan is to be prepared. The blocks Emoh Ruo, Gunnadoo, Carinya and Westhaven have different land titles. However they could be separate properties under different ownership or they could be individual paddocks on the one property. The intention is to prepare a run-off control plan for Emoh Ruo and Gunnadoo featuring contour banks and waterways. The land use can be assumed to be dryland cereal or forage cropping.

The aim of this example is to prepare a number of options that may be considered in developing a suitable soil conservation layout. The following information is deliberately not provided in order to consider a broader range of options:

- the map scale
- land slope
- land capability
- proposed land use
- the extent of clearing, and
- existing internal fencing.

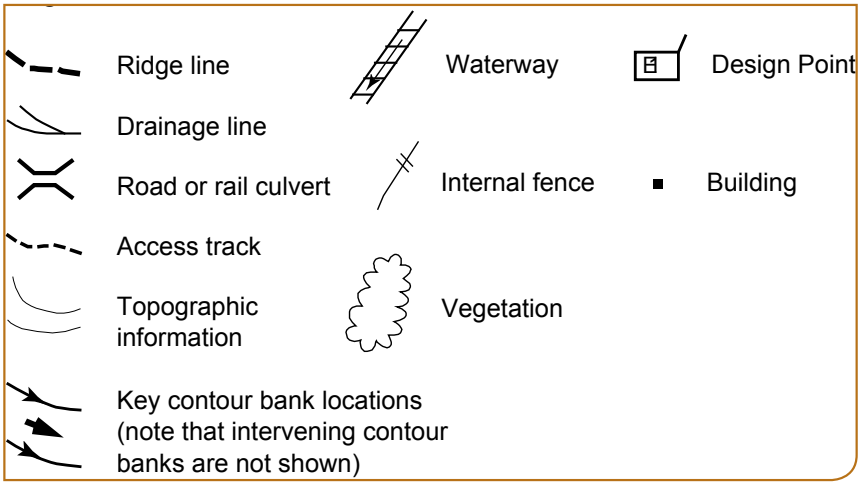
Figure 2.5 Map of an area for which a soil conservation plan is to be prepared



The following information should be shown on each plan using the legend provided in Figure 2.6:

- key contour banks including flow directions
- waterways and run-off disposal areas
- diversion banks
- design points
- catchment boundaries (ridge lines)
- vegetation
- fences
- access tracks
- road and rail cross-drainage points.

Figure 2.6: Legend used in planning options



The topographic information in Figure 2.5 provides a firm indication as to the general position and orientation of the contour banks to be constructed. The existing slope and the proposed use of the land will largely determine the contour bank spacing. What needs to be determined is in which direction the contour banks will flow and where they will discharge.

Ridge lines have been identified on Figure 2.5. However it should be noted that they are very 'broad' and it is open for debate as to whether or not these features should be called 'ridges'. However, such lines define run-off flow patterns and related catchment boundaries and they need to be considered in the planning process.

Waterways will need to be constructed to collect the discharge from the contour banks unless they can discharge onto an adjacent grassed area or a stream riparian zone. Waterways can be constructed either in, or away from, natural drainage lines (as discussed in Chapter 9).

Those constructed away from natural drainage lines are referred to as 'perched' waterways.

Another consideration is the safe length of contour banks. This is primarily governed by land slope. In each of the options outlined below, only key contour banks are shown. On the ground, additional contour banks will be required between the key banks with spacings according to land slope and other factors. Chapter 7 provides detailed information on recommended bank length and spacing for different slopes.

Figures 2.7 to 2.13 provide different options of how the area could be planned. The advantages and disadvantages of each option are discussed below. The option that is eventually implemented will be the one that the landholder considers to be most suitable for their chosen enterprise and which is technically and sustainably sound subject to the agreement of neighbours where required. An indication is given when it would be advisable to seek the agreement of a neighbouring owner (refer also to Section 2.4).

When comparing different options, it is useful to evaluate how each option meets the following criteria:

- Water disposal—do suitable locations already exist to dispose of run-off or will it be necessary to wait until waterways have been constructed and stabilised? What is the likelihood and potential cost of damage if there is a delay in implementing works?
- Construction and maintenance costs
- Workability—is the layout easy to manage with on-farm equipment and the current enterprise?
- Fences—will the layout accommodate the fencing needs of the property?
- Access tracks—are they in locations that best suit the needs of the property?
- Neighbours—are they in agreement with the proposed plan? Are there alternatives that may be more acceptable to the neighbour?
- Road and rail cross-drainage—are any additional works required, and if so, how will they be funded and when can they be implemented?
- Watering points—if the property is used for grazing are there sufficient watering points and does their location contribute to degradation problems?

Figure 2.7: Layout option 1 Emoh Ruo

Contour banks are the maximum length possible for this paddock.

Agreement to divert run-off out of its natural catchment should be sought from Gunnadoo's owner.

It will be necessary to check that the outlets E1, E2, and E3 are suitable outlets for contour banks (including the banks between E1–E2 and E2–E3).

Access tracks on the eastern and southern boundaries are well located at the top end of contour banks.

Gunnadoo

Waterway G1–G2 is located in what is currently a minor drainage line.

Access tracks are well located at the top end of contour banks on the northern and eastern boundaries.

There is a water spreading area into the pasture below G2. The entry point into the watercourse will need to be checked for stability.

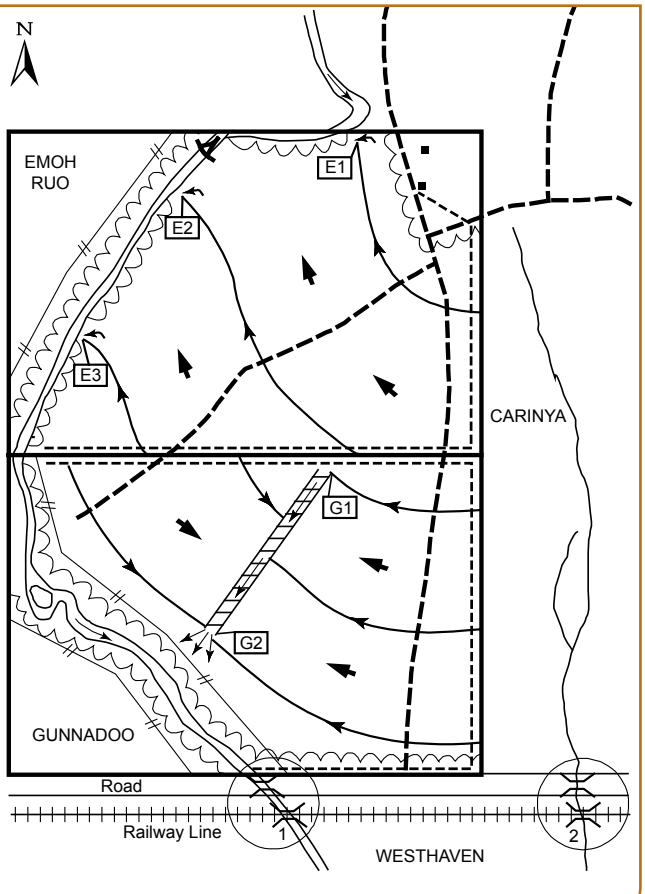


Figure 2.8: Layout option 2

A feature of this option is that contour banks cross the boundary between Gunnadoo and Emoh Ruo. It will be necessary to obtain the agreement of the owner of Emoh Ruo before implementing the plan. This practice is generally not recommended since contour bank maintenance on boundary fences can be an issue and they could be a source of future ill-feeling between neighbours. It will also mean that the access track on the northern boundary of Gunnadoo and the southern boundary of Emoh Ruo will need to cross over the contour banks. Ideally, contour banks should not be crossed by access tracks except at the top end.

This option could be suitable if both properties are under the same ownership and bank lengths are not excessive. Under this scenario, the fence between the two properties may be removed (taking care to ensure that the subdivision pegs are retained). If the properties are eventually sold as separate entities, it would be possible to modify the plan and construct a waterway along the northern boundary of Gunnadoo (as in option 3).

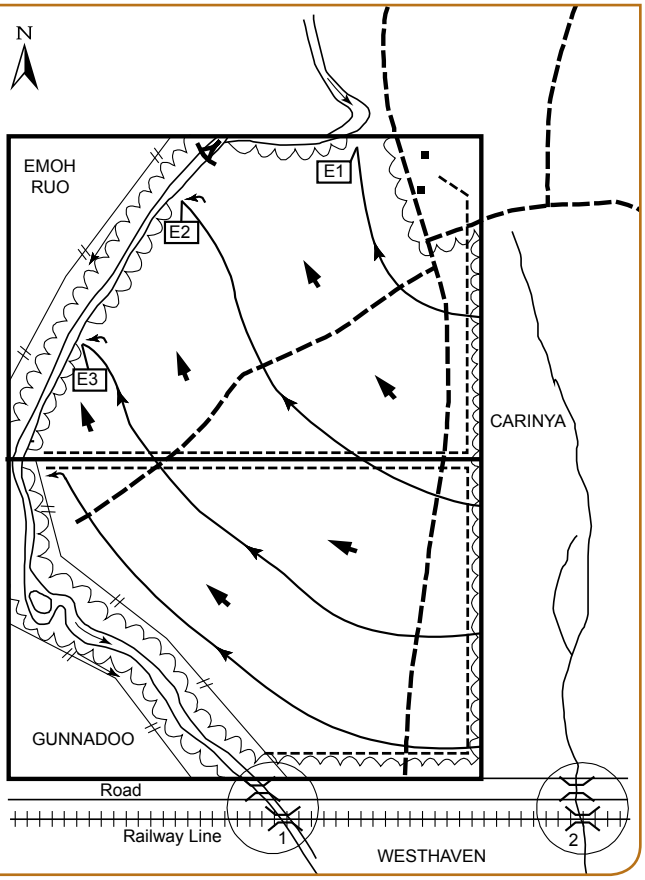


Figure 2.9: Layout option 3

Emoh Ruo

Same layout as for Option 1 except that the paddock has been subdivided, with a fence to be built below the contour bank leading to E2.

Gunnadoo

Provides maximum contour bank length for this paddock.

G3–G4 is a perched waterway (runs diagonal to the slope). Special construction techniques are required to ensure an adequate spread of run-off across the width of the waterway and additional contour bank capacity will be required where the banks enter the waterway. The suitability of the entry point into the watercourse at point G4 will need to be checked.

For row crops there are difficulties in having rows discharge into the perched waterway, so there is a need for special care in maintaining the contour bank outlets, and removing any silt deposits near the outlets.

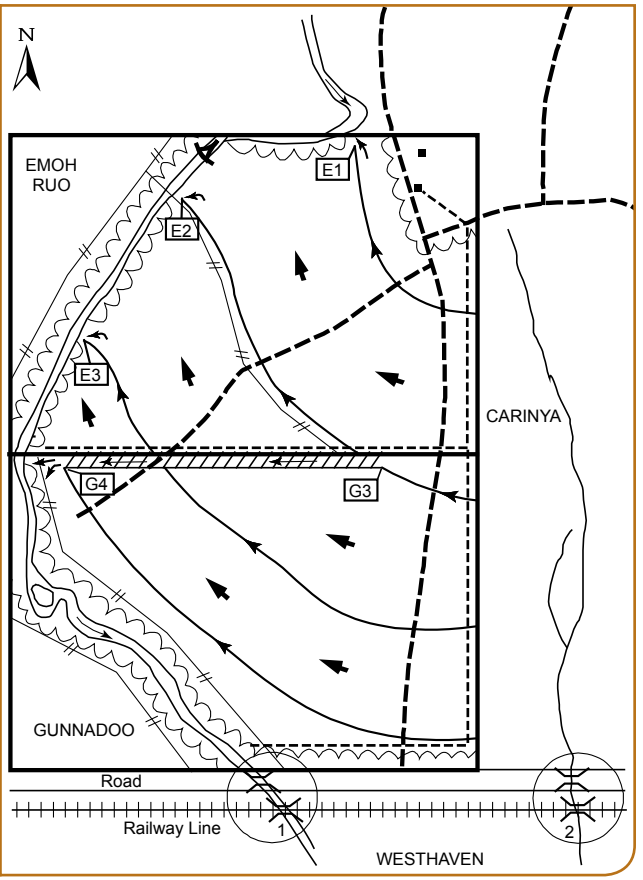


Figure 2.10: Layout option 4

Emoh Ruo

Contour banks are split on a vegetated ridge line. The ridge provides a suitable location for an access track. If required, a fence could be provided along the access track.

E4–E5 is a perched waterway virtually up and down slope.

An undesirable feature of this plan is that contour banks below E5 would need to cross through a boundary fence.

Agreement to accept run-off at E5 and from the contour banks below E5 should be obtained from the owner of Gunnadoo.

Gunnadoo

The diversion bank G5–G6 accepts run-off from waterway E4–E5 as well as the contour banks below design point E5 and diverts it to waterway G6–G7. Some cut and fill may be required to ensure that the diversion bank has sufficient gradient to cross the ridge line.

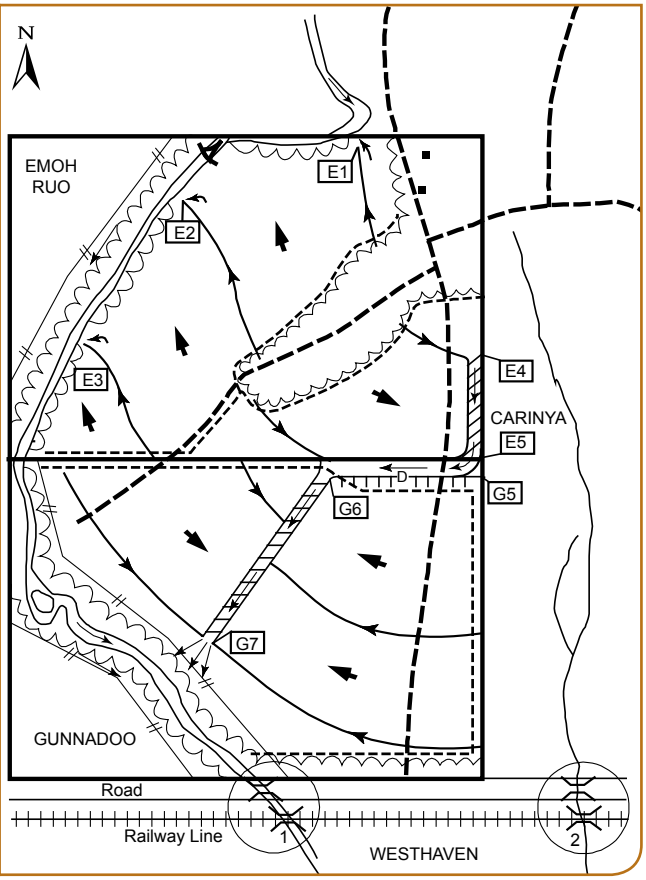


Figure 2.11: Layout option 5

Emoh Ruo

As for option 4 except that the contour banks below E5 discharge into the perched waterway E5–E6. The waterway has sufficient gradient to allow it to cross the ridge between E5 and E6 (if not, some cut-and-fill may be required).

Care would need to be taken with the construction of the right-angled bend at point E5.

Gunnadoo

G8–G9 is a perched waterway running up and down slope.

The eastern side of waterway G10–G11 is a suitable location for an access track (and fence) as they are located at the top end of the contour banks.

Negotiations will be required with road and rail authorities to determine if cross-drainage may be provided at point 3.

Negotiations will also be required with the owners of Westhaven in relation to the need for them to construct diversion bank W1–W2 (they may prefer to deal with this run-off in other ways).

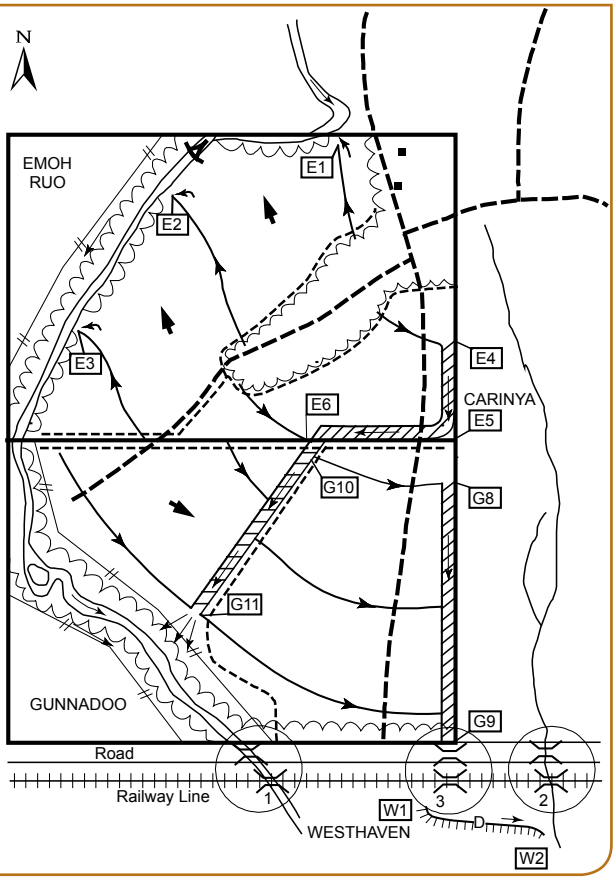


Figure 2.12: Layout option 6

Emoh Ruo

As for option 1.

Gunnadoo

Contour banks go across the fence between Gunnadoo and Carinya and discharge into a grazing paddock. This could be an acceptable option if both properties are under the same ownership and if the relevant agencies agree to the additional run-off being received at the road and rail cross-drainage structures at point 2. However, the disadvantages of having contour banks cross boundary fences should be noted. It would also be undesirable for any access track that may be required on the Gunnadoo–Carinya boundary.

If the properties are under different ownership, then the agreement of the owner of Carinya will be required (additional run-off for the dam at C1 could be an incentive). A future alternative could be to construct a waterway G8–G9 (as in option 7) if the land use in Carinya changed from grazing to cultivation — or G8–G9 as in option 5.

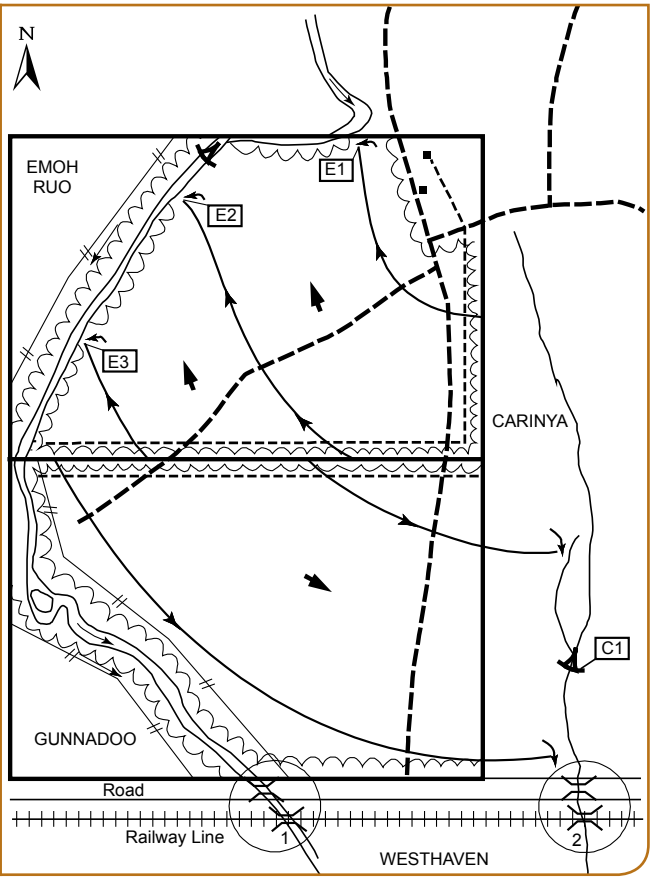


Figure 2.13: Layout option 7

Emoh Ruo

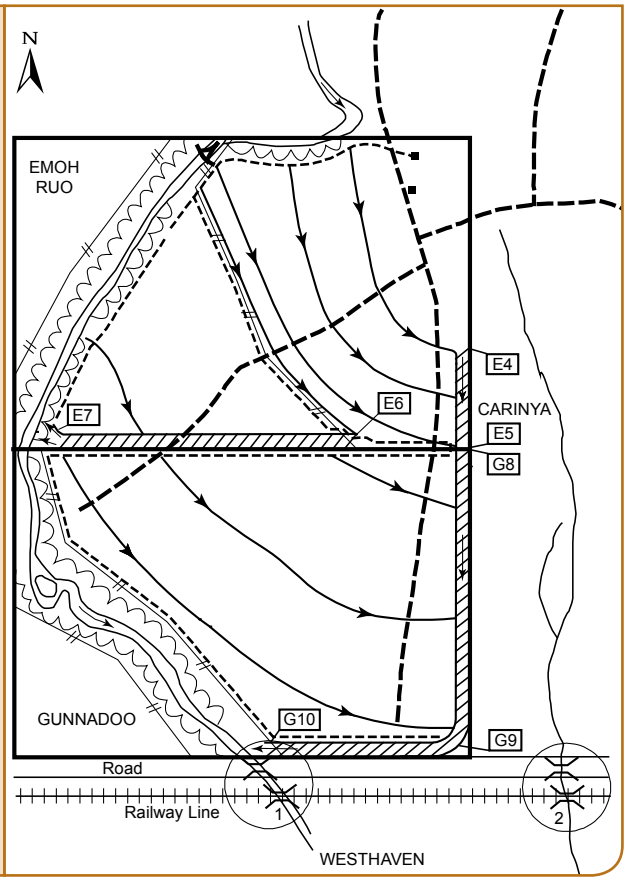
This layout may be suitable if outlets E1–E3 in previous options are unsuitable discharge points. However it will require that point E7 is stable or that action can be taken to ensure stability.

The paddock has been subdivided by a fence under a contour bank.

Agreement will need to be obtained from the owner of Gunnadoo, recognising that waterway G8–G10 will require a larger capacity.

Gunnadoo

Care will be required to ensure that the right-angled bend at G9 has sufficient capacity or alternatively, this waterway could discharge across the road/rail, as in option 5.



2.4 Designing soil conservation structures

Designing soil conservation structures proposed in a soil conservation plan involves two major steps. Firstly, the peak rate of discharge that the plan will be required to accommodate needs to be estimated. Secondly the size and nature of the structures and other works required to accommodate that discharge needs to be determined. The information below describes the design process in general terms. Detailed technical instructions on how to undertake these steps are provided in later chapters of these guidelines.

2.4.1 Selecting design points

Design points are critical locations requiring particular attention in the planning process. Design points should be noted on a property plan. They provide information essential in the specification of structures and also provide points of reference that are useful in any verbal or written communication about the plan. This information is vital for the implementation and construction process.

The following features are recommended positions for design points:

- any locations in the run-off control network where a special design is required
- the commencement and outlet of waterways
- points where a waterway enters and exits a property, paddock or unfenced property lot
- points where there is a significant change in the specifications for a waterway such as:
  - at a change in gradient
  - where there has been a significant increase in the catchment area
  - where two waterways join
- at a bend in a waterway
- diversion banks
- key contour banks requiring a specific design
- where key works are required for public utilities such as road/rail culverts, or access inverts
- spillways of dams.

When the designs have been completed, they should be documented for use by the landholder and subsequent owners of the property.

2.5 Obtaining acceptance of a plan

During the preparation of the plan, it is normally necessary to consult with neighbouring property owners and agencies responsible for roads and railways and other infrastructure that may be affected by the implementation of the plan (e.g. tramlines in cane growing areas, power lines, oil or gas pipelines, and communication cables). Such communication is essential to ensure good cooperation between property owners and agencies.

As discussed previously, disputes between neighbouring landholders may make it difficult to progress a proposed plan. Ideally agreement can be reached on different points of view through a process of amicable discussion. However, if this is not possible additional support in resolving disputes between landholders is available through the mediation services provided by the Department of Justice and Attorney-General which has centres throughout the state. This service provides trained mediators who bring the parties in a dispute together so that they can talk over their differences and reach a settlement.

Once the preferred option for the plan has been selected and the works completed, it will be necessary to carry out final checks with any third parties. Table 2.1 provides a suggested insert to the signature block on the plan to record agreement of third parties.

While such agreement holds no legislative weight, it provides a permanent record of the acceptance by affected landholders at a point in time which could be helpful in mediating any future land management conflict (should that occur).

Table 2.1: Signature block for use in indicating agreement by neighbours

I//we the undersigned owners of the specified land, have no objection to this plan			
Specified land	Name of owner	Signature of owner	Date
Specifications for run-off control structures and/or essential management practices are contained in Specification Sheets identified by this plan number and form part of this plan.			

2.6 Implementing the plan

The planning process should include documenting a schedule (or timeline) of the actions required to be undertaken to implement the plan. These actions could include such things as relocating fences, constructing and stabilising waterways, and constructing contour banks. It may be necessary to delay the construction of contour banks for several years until suitable waterways have been constructed and stabilised.

Earthworks need to be surveyed and pegged out prior to implementation. The traditional method of marking out contour banks uses a survey level and staff. However, there are now far more sophisticated methods of surveying contour banks. These methods provide for much faster marking out of structures especially in the broadacre situation. Laser equipment came into use in the 1980s and more recently GPS equipment has been used. Information on how to survey soil conservation measures is not provided in these Guidelines; a number of reference books that are widely available provide much more detailed information than can possibly be provided here. These references are listed at the end of this chapter.

While some landholders carry out the necessary construction themselves, others choose to use a contractor. Works should be checked during and immediately after the construction to ensure that the works have been constructed to specifications. In checking works, special attention needs to be given to the following points:

- capacity of contour banks (especially where they cross old erosion lines)
- contour bank outlets into waterways, watercourses or grassed areas
- capacity of waterways
- perched waterways (their profile and locations where contour banks enter them)
- steps taken to stabilise waterways with vegetation.

2.7 Managing and maintaining soil conservation works

Erosion occurs episodically and it is easy to become complacent about the need to maintain soil conservation measures, especially during extended periods of drought when run-off is minimal. In fact these are the best times to monitor works and to carry out maintenance.

Poorly maintained contour banks and waterways are a liability and are likely to cause, rather than prevent, erosion. When a contour bank breaks, the outflow may cause severe erosion in the contour bay below and contribute to the failure of subsequent contour banks.

The first point where failure is most likely to occur will be any low spots in the contour bank. The weakest link in a contour bank is often a point where the bank has been constructed across an old erosion line. Settlement can be greater at this point and the effective height of the bank may become less than the average bank height. Such low points can be evident when looking upwards at the bank from a suitable distance below it.

Sediment deposited in contour bank channels should be removed if the capacity of the contour bank is below specifications. This is normally achieved by earthmoving equipment which moves the sediment onto the contour bank thus increasing its capacity. Contour bank outlets should also be checked. Blockages caused by sediment deposition and prolific growth of vegetation may restrict flows at the outlet and lead to overtopping.

Waterways should be monitored to ensure that there is no evidence of any activity, such as a cattle pad or wheel tracks, that may lead to rill or gully development. Appropriate and early action now may prevent a serious problem in the future. Slashing, grazing or burning a waterway and controlling woody weed regrowth should be part of a routine maintenance program. Poor grass growth may indicate the need for fertiliser to be added.

Sediment may need to be removed to ensure that the capacity of waterways remains adequate. The overall goal of any soil conservation works should be to minimise the loss of soil from cultivated lands. However, even minor levels of sheet erosion can, over time, reduce the capacity of a waterway. It may be necessary to periodically scalp the surface of a waterway to restore its capacity to that specified in the original design; or alternatively the bank may need to be topped up to increase its height to compensate for reductions in capacity due to sedimentation. Associated contour banks should also be checked at this time to ensure that they still have adequate outfall into a waterway.

2.8 Monitoring the plan

Periodically the plan should be reviewed to determine if any modifications are required. The following may need to be considered in any review:

- Have farming systems or machinery changed and as a result do any works need to be relocated?
- Are implemented structures performing as originally intended?
- Are banks appropriately spaced? Is there a need for additional banks or waterways or can some be removed?
- Are the access tracks located in the correct places?
- Have fences changed, or are changes required, and if so does the plan need to be modified as a result?
- Can additional land be brought into cropping or should some arable land be retired to pasture?
- Should some areas be established as permanent tree-crop areas or returned to native vegetation?
- Are run-off control works effectively coordinated with neighbouring properties or utilities?
- Have adjacent properties changed, necessitating modifications to the plan or new agreements with neighbours?

2.9 Further information

References

Crothers RB (1991) R*ural subdivision planning—guidelines for subdivision design*. Queensland Department of Primary Industries, Information Series QI91008.

Neale, T (2009) *GPS auto-steer helps in erosion and waterlogging control*. Available from: www.precisionagriculture.com.au/assets/ (accessed 17th April 2015).

Stone, BJ and Titmarsh, GW (1997) Farm and catchment planning. In *Sustainable crop production in the sub tropics—an Australian perspective*. AL Clarke and PB Wylie (eds), Department of Primary Industries, Queensland.

Other information

Fact sheets on a range of topics related to this chapter are available from the Queensland government webpages at www.qld.gov.au (click on 'environment, land and water' and search for the title in the search box).

Information about Queensland native vegetation (Regional Ecosystems) can be obtained from the DNRM website (www.qld.gov.au/environment/plants-animals/plants/ecosystems/about/). This website provides links to the Regional Ecosystems Descriptions Database (REDD) which contains detailed descriptions of each Regional Ecosystem. Maps of Regional Ecosystems can be obtained through links at this location or through the Queensland Globe (www.dnrm.qld.gov.au/mapping-data/queensland-globe).

Maps and information about soils can be accessed from the appropriate land management field manuals (available in PDF format by searching the Department of Environment and Heritage Protection library catalogue) or from the Queensland Globe (www.dnrm.qld.gov.au/mapping-data/queensland-globe). For more details about land management manuals check the Department of Natural Resources and Mines website (www.dnrm.qld.gov). Further information about soils and land use can be obtained from the Department of Natural Resources and Mines website www.dnrm.qld.gov.au, the CSIRO Land and Water Library in Adelaide (www.clw.csiro.au) or from NRM regional bodies.

The Queensland Government publication, *Surveying for soil conservation—a training manual* (Dickenson and Faulkner 1988), provides information on the traditional method of marking out contour banks using a survey level and staff.

The New South Wales Soil Conservation Service, Earth Movers Training Course has information on the surveying, implementation and construction of soil conservation measures. It was produced in 1991 as a series of 21 booklets and is available from the New South Wales Department of Primary Industries, Soil Conservation Service (www.scs.nsw.gov.au).

The following references are also useful sources of additional information about topics covered in this chapter:

Bass PA and Booth NJ (1995) *Broad-based bank construction with drawn graders*. DPI Farm Note Axdex 570/571, Queensland Department of Primary Industries.

Department of Primary Industries and Department of Housing, Local Government and Planning (1993) *Planning guidelines: the identification of good quality agricultural land. Queensland Government.*

Lehmann GM. and Bartels H (undated). *Build waterways with a farm dozer*. Soil Conservation Branch, Queensland Department of Primary Industries.

Marshall, JP and Rowland P (1987) *Contour bank construction using a bulldozer.* Soil Conservation Services Branch, Queensland Department of Primary Industries.

Department of Primary Industries (1990) *Guidelines for agricultural land evaluation in Queensland*. Land Resources Branch, Queensland Department of Primary Industries. Information Series QI90005.

Rosser, J, Swartz, GL, Dawson, NM, and Briggs, HS (1974) *A land capability classification for agricultural purposes*. Division of Land Utilisation Technical Bulletin No. 14, Queensland Department of Primary Industries.