Graded Banks | Technical Note No. 17

Northern Territory Government

Erosion and Sediment Control Guidelines

Description

A graded bank is a compacted ridge of soil constructed across slope to form a channel for interception of sheet flow, and redirection of surface water into a stable receiving area.

Application and Function

Graded banks are genearlly used in broad acre horticultural or agricultural farming developments, to control erosion by limiting runoff velocity and catchment size. Banks are constructed at regular intervals across the slope on a set grade off the contour, usually with a broad-based 'roll-over' profile to aid trafficability for farm vehicles and irrigators.

Limitations

Earth moving machinery such as a grader or bulldozer is required to construct graded banks. Adequate soil moisture is required for compacted earthworks formation and seasonal conditions may limit construction opportunities.

Construction of multiple banks can be costly, and frequent maintenance may be necessary depending on land use (e.g. horticultural crops and pivot irrigation). Incorrect siting, unsuitable soils or poor construction can lead to gully erosion.

Advantages

Material for the construction of graded banks is obtained on site. Graded banks are permanent structures and will last many years if maintained, especially in low traffic areas such as improved pasture.

Alternatives

Retention of native vegetation buffers with suitable groundcover, at similar intervals to those calculated for bank spacing, can be a cheaper and more site-appropriate option in some situations.

Site Assessment & Planning

Determine the location and boundaries of the proposed development, and measure slopes. Survey the paddock to obtain elevation / contour data and use the design methodology (below) to calculate suitable bank spacing.

Take particular care to identify stable sites for graded bank discharge. These should be undisturbed, low gradient areas with intact vegetation and good ground cover, that direct flow into natural drainage lines.

development activity, including clearing, cultivation, fence line and fire access trail formation, and erosion control earthworks. Soil characteristics that indicate high erosion potential include very sandy texture or a dispersive/slaking reaction when wet.

Obtain an air photo map of the site, preferrably at a scale of 1:5000 to 1:7000, A3 format, with a coordinate grid (UTM) for datum GDA94. If contour information is available for vertical intervals between 1 m and 5 m, have this overlaid on the map. Otherwise use levels surveyed on site and locate on the map by coordinates obtained with a handheld GPS unit. Alternatively, engage a suitable consultant for this purpose .

For further assistance with air photos and other mapping information contact the **Department of Lands Planning & the Environment** at: www.lands.nt.gov.au/land-info/topographic-mapping.

For further information on land units, vegetation and soils, contact the **Department of Land Resource Management** at: www.lrm.nt.gov.au/nrmapsnt.

Design

The key design factors are **spacing** between banks and the **cross-sectional area** of the profile of the bank/channel formation.

1. Bank Spacing

This is largely a function of land slope and can be calculated using:

Spacing (m) = (90 / $\sqrt{}$ % slope)

Where % slope is defined by the fall in metres over a 100 m horizontal distance; e.g. a 2 m fall is 2/100 = 2%

> **Note 1:** For landuse such as improved pasture, tree crops or forestry, bank spacing may be doubled if good ground cover is present and cultivation / mounding is not orientated downslope.

Calculated spacings enable an initial plot of banks on the site map, to determine catchment area for each bank and the maximun drainage length for each bank catchment. This is the longest flow path, from the furthermost upslope point in each bank catchment area, to the bank and along the bank to the discharge point.

2.Bank / channel Cross-section Area

This is detemined using the **peak runoff discharge** for a given land area (catchment) subject to a particular rate (intensity) of rainfall, and an appropriate flow **velocity** (see below).

Peak discharge is calculated using:

Q (m^3/sec) = C.i.A / 360

Where **C** is a runoff coefficient (Table 3, next page);
i is rainfall intensity (Graph 1, next page)
A is catchment area, for each bank, in hectares

To use the **rainfall intensity chart** (see Graph 1) a Time of Concentration (ToC) calculation is required to determine a **duration** value (horizontal axis), so the selected **storm recurrance line** can be used to read a **rainfall intensity** figure from the vertical axis. Rainfall Intensity – Frequency - Duration charts are available at www.bom.gov.au.

ToC (mins) = (flow length / velocity) / 60

Where **flow length** is the maximium flow path length, downslope and along the bank to the discharge point ;
and **velocity** is selected as the maximum permissible for soil erodibility class (see Table 1).

Note 2: Soil erodibility relates to the susceptibility of soil particles to detach under rainfall and be transported in runoff. Erodibility varies with soil type and structure, and is largely a function of soil texture. See examples of soil type erodibility class in Table 2.

Table1. Maximum permissible velocity values

Soil Erodibility Class	Maximum velocity m/sec
Low	0.60
Moderate	0.55
High	0.45
Very high	0.35
Extreme	0.30

Area of cross-section for the graded bank channel is then calculated using the peak runoff discharge figure and the maximum permissible flow velocity selected for the soil erodibilty class.

A_{cs} (m^2) = Q (m^3/sec) / V (m/sec)

The design cross-section area is then used to develop a working profile for bank height/depth of cut and channel capacity.

Example

Clearing and development is proposed on a property in the Katherine district for the purpose of grazing on **improved pasture,** using **no till** establishment. Soil texture is **sandy** and soil **erodibility** is deemed to be **moderate to high**. The area has a slope of **2%** and measures **1080 m** across slope by **380 m** downslope. A design rainfall intensity with an average recurrance interval (ARI) of **1 in 10 years** is used to determine peak discharge.

Bank Spacing

Spacing = (90 /1.41) *x 2* **-** *see* ***Note 1*** *above*

= 127 m

Rainfall Intensity

1. ToC = (127 m +1080 m / 0.5 m/sec) / 60

   = 40 min

Where 0.5 m/sec is derived from Table 1, intermediate value for moderate – high erodibility.

From Graph 1, a 40 min duration storm with a 10 year ARI rainfall intensity (**i**) is 85 mm/hr.

Peak Discharge

Q = C.i.A / 360

= (0.8 x 85 x 13.75) / 360

= 2.60 m^3/sec

Where 0.8 is derived from Table 3, 85 mm as above (from Graph 1) and 13.75 is the area in hectares.

Design Cross-sectional Area

A_{DS} = Q / V

= 2.60 / 0.50

= 5.2 m^2

Working Cross-sectional Area

To develop a profile that equals or exceeds the design cross-section, nominate dimensions (see Figure 1 below) and calculate the area of the central rectangle and the adjcent triangles.

For example a 0.6m depth of cut, 6.5 m channel width, a 1(V) : 4 (H) bank batter gradient and a 1(V) : 6(H) upslope batter gradient.

A_{WS} = (0.6 x 2.4)/2 + 0.6 x 6.5 + (0.6 x 3.6)/2

= 5.7 m^2 (i.e. 10% more capacity than A_{DS})

Where A_{WS} = area of left side triangle + area of central rectangle + area of right side triangle (Figure 1).

Figure 1. Bank & channel cross-section

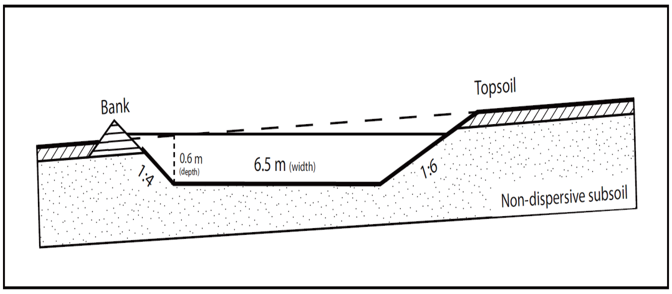


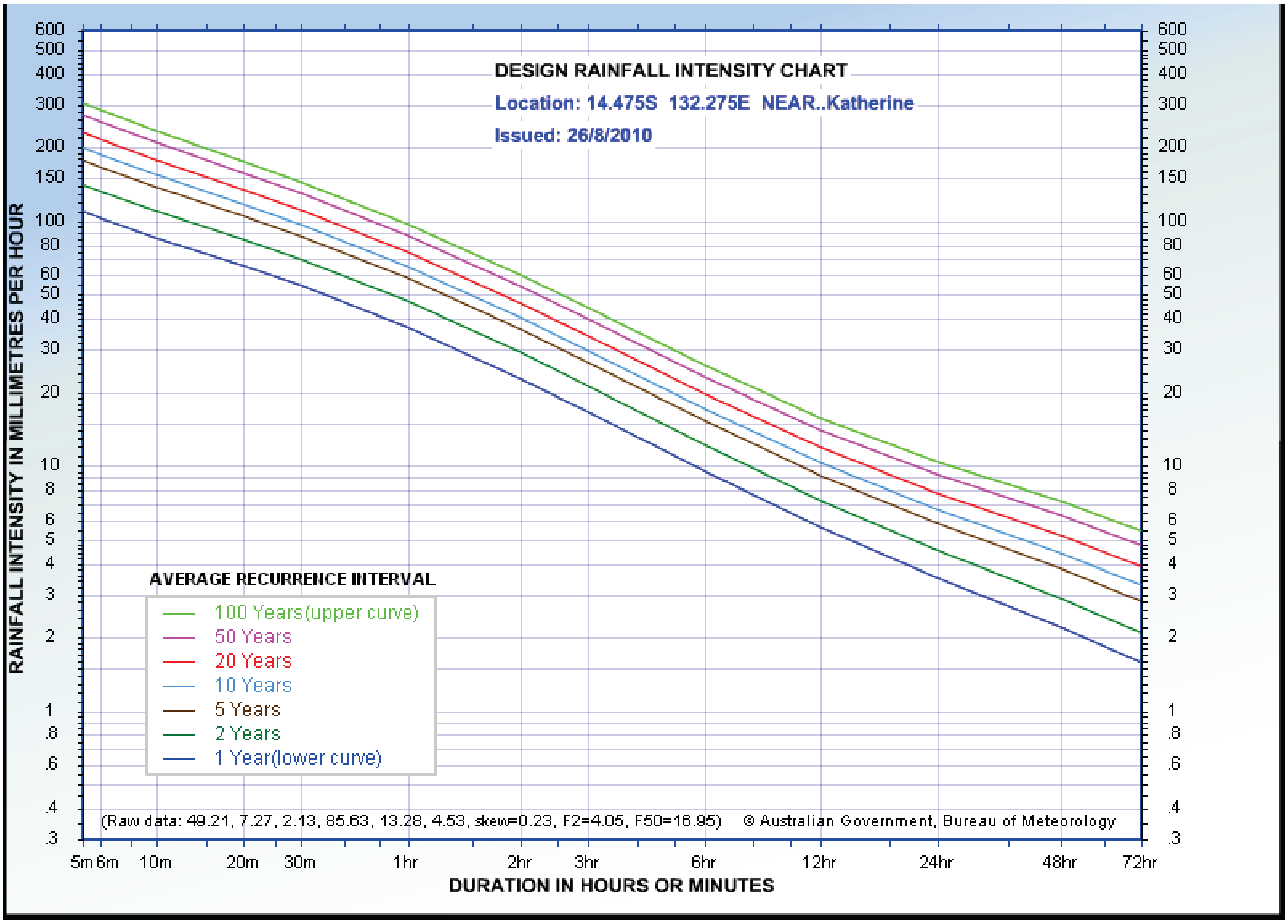
Table 2. Erodibility Classes for Typical Soils Darwin - Katherine Areas

District	Soil Family	Soil Description	Erodibility Class
Darwin	Koolpinyah	Shallow gravelly brown soils (Kandosols)	Moderate
Darwin	Berrimah	Deep lateritic Red Earths (Kandosols)	Low - Moderate
Darwin /Adelaide River / Marrakai / Daly	Burrell	Shallow gravelly brown soils (Kandosols & Rudosols)	Moderate
Adelaide River / Marrakai	Heaton	Alluvial Red Earths on Adelaide River levees (Kandosols)	Low - Moderate
Katherine / Daly	Claravale	Shallow gravelly brown soils (Kandosols)	Low - Moderate
Katherine / Daly	Elliot	Poorly drained mottled soils (Hydrosols)	Low - Moderate
Katherine / Daly	Blain	Fine sandy Red Earths (Kandosols)	Moderate - High
Katherine / Daly	Blain	Coarse sandy Red Earths (Kandosols)	Low
Katherine / Daly	Oolloo	Loamy Red Earths (Kandosols)	Moderate
Katherine / Daly	Tippera	Clayey Red Earths – massive (Kandosols)	Low
Katherine / Daly	Tindall	Clayey red earths- structured (Dermosols)	Moderate - Very High

Table 3. Runoff Coefficients (*Source: Conservation Commission NT, 1990*)

Treatment	Coefficient
No till (single spacing)	0.6
No till (double spacing)	0.8
Conventional (single spacing)	0.8
Conventional (double spacing)	0.9
Minimum till (single spacing)	0.7
Improved pasture	0.7
Native woodland (ungrazed & undisturbed)	0.2

Graph 1. Rainfall Intensity-Frequency-Duration Chart, Katherine



(*Source:* http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml)

Bank Layout

Plot the banks on a map with an appropriate scale and use this as a guide for survey and pegging out of banks. For further information see Department of Land Resource Management (DLRM) Fact Sheet ***Model Erosion and Sediment Control Plans for Rural Developmenmt***.

Contour banks should be spaced as calculated, and located in relation to suitable discharge areas, where ground cover vegetation will reduce velocity, filter sediment and encourage infiltration. Discharge areas should be able to accommodate the formation of a **level sill** (see below) to dissipate discharge and prevent development of concentrated flow paths, which encourage rill and gully erosion.

Use a laser or dumpy level and peg out banks at a grade of **0.2%** off the (level) contour line. For a 0.2% grade, every 100m along the contour the bank will drop 0.2m down-slope of the contour line (see Table 2).

Table 2. Fall per 25 m interval for 0.2% gradient

Length (m)	0	25	50	75	100
Fall (cm)	0	5	10	15	20

Construction

Where practical, strip topsoil and stock pile to one side for re-spreading on completed earthworks.

Rip the base surface of the bank and then form a shallow flat-bottomed channel on a grade of **0.2%** using a laser level or surveyed/pegged line for each bank. Use the design calculations as a guide to the depth and width of this cut.

Use excavated material to form a compacted earth bank on the down slope side of the channel with even batters, no greater than 1(vertical):4(horizontal). The bank creast can level or gently rounded, and be formed to provide a minimum 300 mm freeboard above the channel water level.

A **level sill** should be constructed at the outlet end of each bank. This is formed as an open section of channel (no bank) with a 0% gradient sill approximately 10m long, that allows water to disperse along the length of the sill and not form concentrated flows. There should be **no disturbance** to the ground surface down slope of the sill.

For multiple banks it may be necessary to stagger the discharge points to avoid acumulating concentrated flows in the receiving area. The bank at the top of the slope should extend further into undisturbed vegetation than the bank at the bottom of the slope. Alternatively, every second bank could discharge to the opposite side of the paddock, into a suitable buffer zone.

Revegetation of Earthworks

Retain and re-spread topsoil over earthworks to enhance ground cover establishment. Use of suitable grass species to establish ground cover over all disturbed soil surfaces is recommended.

For permanent ground cover, a mix of annual and perennial species is recommended. Creeping or mat-forming species are preferred on channel floors. Include of a quick cover species in the seed mix (e.g. Japanese millet) if working in the early wet season.
For more information on species and seed mixes, see ***Roads SoR July 2014: 16 Landscape*** at www.nt.gov.au/infrastructure/techspecs/roads/specifications.shtml .

Small, lighweight machinery is preferred for sowing of ground covers on newly formed earthworks. Large cropping machinery may cause damage to batter and channel surfaces.

Maintenance

Depending on land use, banks are likely to require seasonal maintenance works. All banks and outlets should be inspected regularly, before and during the wet season in particular. Banks under horticultural cropping are likely to require more frequent maintenance than banks under pasture.

Graded banks should be checked periodically for

- water ponding after rain
- erosion at outlets
- excessive sediment build up at outlets
- scouring between banks.
- bank damage from cultivation or other causes

Low spots may require re-grading, additional banks may be required, banks may require reforming, or may need to be realigned with less gradient. Outlet and receiving areas may require addition erosion controls and revegetation.

Clear sediment build up at outlets which will reduce flow capacity and can cause over-topping of banks or other erosion issues.

Contact Details

For further information contact the DLRM Land Management Unit in your region. Additional Fact Sheets, Technical Notes and Erosion and Sediment Control Guidelines are available at:
http://www.lrm.nt.gov.au/soil/management

Land Management Unit - Rangelands Division

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