2 Managing water flow

From the moment rainfall hits the land it has the potential to cause soil erosion. Raindrops hit the soil surface with some force, and the impact can dislodge soil particles. Once dislodged, the particles move with the water. Understanding how movement of water causes erosion is essential to managing water for the greatest benefit to soil and plants. This chapter outlines management strategies to reduce the erosion potential of overland and concentrated water flows.

Overland flow

Water moving as overland flow through a paddock.

Overland flow is visible as a thin layer of water flowing over the soil surface. It occurs when rain falls faster than the soil's capacity to absorb it. If the soil is bare the water picks up and carries soil particles from the top of the soil, creating a thin layer of erosion known as sheet erosion. Overland flows and sheet erosion can be reduced by increasing the soil's capacity to absorb water, and slowing water flow.

Increase soil moisture capacity

The most effective way to improve soil moisture capacity is to increase groundcover. Vegetation intercepts and slows water so that it has time to soak into the soil and infiltrate through the soil profile where it becomes available to plant roots. Higher and denser vegetation encourages more infiltration. Vegetation also improves soil health and structure, further improving soil moisture capacity.

Other ways to improve infiltration include reducing soil compaction, and ripping along slope contours to encourage infiltration and prevent build-up of surface water. However, on land prone to mass movement where soil is already waterlogged, attempting to increase infiltration could increase the potential for land slips.

Contour ripping promotes infiltration. Source: Peter Solness NSW DPI

Slow down water flow

As overland flows speed up they become more erosive, so it is important to slow down overland flows to minimise erosion. Flow speed is determined by:

- surface roughness
- slope steepness
- slope length.

A rough surface intercepts flowing water, breaks up its force and slows it down. Roughness is best achieved with dense vegetation close to the ground. Slope steepness has a major effect on soil erosion because water runs faster down steep slopes. It is difficult to change the natural slope so it is important it is to use other techniques such as groundcover and banks to slow water speed. On long slopes, water flow builds up speed and volume, so slopes need to be broken up into shorter sections to keep water flows manageable. This can be done by planting vegetated strips across the slope to slow the flow, or building banks to intercept the water and convey it to a water course or storage area.

Install interception structures

There are a range of options for intercepting and conveying water. The choice depends on the purpose, site and enterprise. Expert advice on layout, design and spacing of interception structures may be needed, but all property drainage plans need to follow these basic principles.

- Use stable, naturally occurring flowlines where possible.
- Use constructed waterways where natural flowlines are unstable or do not exist.
- Avoid using flowlines or areas with active gully headcuts.
- Keep flows within their natural catchment. Don't divert water from one catchment to another, even if both catchments areas are within the property.
- Obtain a written agreement from all affected neighbours before altering the point at which water leaves the property.

Types of interception structures

Vegetation strips

Vegetation strips are bands of permanent, dense, low vegetation, usually grasses, planted across slopes to intercept runoff before it develops into a concentrated flow and trap sediment before it has a chance to move into watercourses. The strips are most useful where the land use precludes permanent groundcover.

Subsurface drains

These are trenches filled with gravel and a perforated pipe, often called 'ag drains'. While they are expensive to construct, they are useful for intercepting groundwater seepage and for making land trafficable.

This subsurface drain manages low flows to allow vehicle traffic through.

They are usually designed to carry a proportion of water flow within the gravel media and pipe, and to carry additional surface flow during heavy rain events.

Constructed banks

Banks are the most common structures used to direct water flows on farms. They break up slopes into shorter lengths to reduce depth and speed of runoff flow, and convey water to a stable watercourse, water storage or water absorption area.

They reduce peak runoff flows from catchments by slowing the speed of the water and forcing it to travel longer distances to move through the property.

The shape and type of the bank depend on the situation and land use and the need for trafficability by different types of machinery, but there are some basic principles.

- Choose the correct type of bank for the job it has to do.
- Make the channel created by the bank large enough to carry runoff from heavy rain.
- Design the bank outlet so that it discharges water without causing more erosion.

Contour banks

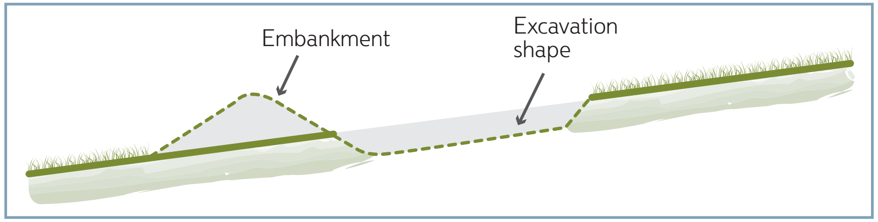
Contour banks run across the slope along the contour to intercept water and pond it behind the bank to increase infiltration and trap sediment. The banks are not generally used in cropping enterprises as the ponded water makes farming difficult. Care must be taken to ensure water overflowing the bank can be redirected without causing more erosion. Contour banks should not be constructed in dispersible soils because of the risk of failure through tunnel erosion.

Graded banks

Graded banks run across the slope on a slight grade so that water can drain to a more stable area or watercourse. The grade is designed so that water flows quickly enough to carry sediment with it, but not so quickly that it causes erosion in the channel. The grade is up to 0.3% for bare earth channels, and can be steeper if the channel is well vegetated.

A graded bank breaks up a long slope of blueberry rows.

How soil is moved in constructing a graded bank. The dashed line shows the shape of the finished graded bank and channel.
Adapted from Earthmovers Training Course, Soil Conservation Service of NSW, 1992



Graded banks are constructed by ripping along the intended channel and pushing the loosened soil into a bank downslope of the channel excavation. On long slopes there are often several graded banks that divide the slope into smaller catchment areas so that the runoff can be safely intercepted and drained. The further apart the banks, the larger the catchment for each bank, so larger banks with greater channel capacity are required. Smaller banks spaced more closely require less channel capacity.

Diversion banks

Diversion banks are graded banks built to intercept and convey concentrated runoff water. They are usually higher and wider and need to be grassed to carry the high speed flows safely.

A diversion bank stops water from the upslope orchard from causing erosion in the block below. Source: Ian Clapham

Back-push diversion banks

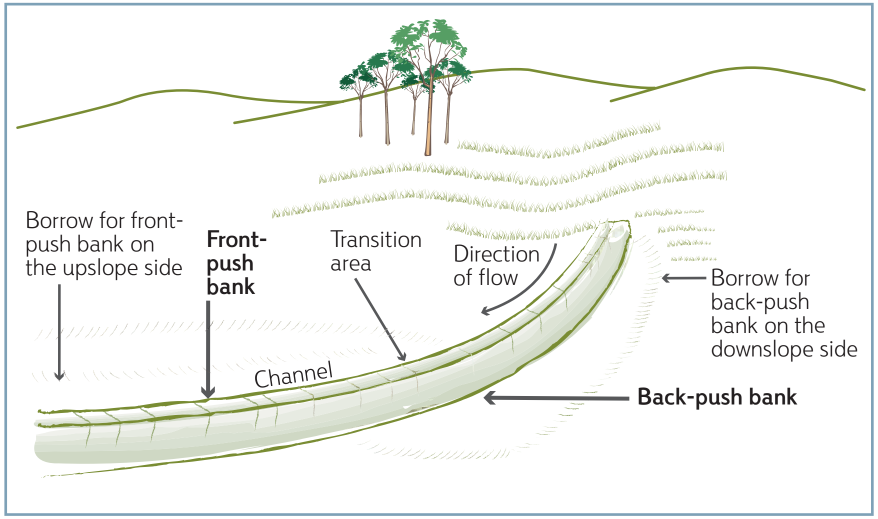
Back-push diversion banks intercept water from natural drainage lines on low sloping land. Soil is pushed up from the downslope to form a bank across the natural flowline.

The water then flows along undisturbed ground and is guided by the bank into natural drainage depressions. This type of bank is not suitable on steeper slopes as the force of the flowing water tends to undercut the bank.

Back-push trainer banks

Back-push trainer banks intercept concentrated flows of water on steeper slopes. The bank initially runs along the natural flowline and gradually cuts across the flowline to guide the water into a flatter diversion bank.

A back-push trainer bank catches and directs runoff from a natural drainage line into a channel formed by a graded bank.
Adapted from Earthmovers Training Course, Soil Conservation Service of NSW, 1992



Bank design

Bank shape

The shape of the earth bank depends on the situation and land use. Generally, the flatter the slope the broader the bank. Broad banks are more stable and require the least maintenance. They take the most space, but can be cultivated and driven over.

A semi-broad bank can be driven over by some vehicles (usually 4WD), and some or all of the bank can be farmed.

A peaked bank takes up the least space but should not be driven over or disturbed. Peaked banks are less stable and more prone to failure, so should only be used where the slope is too great for a broader bank.

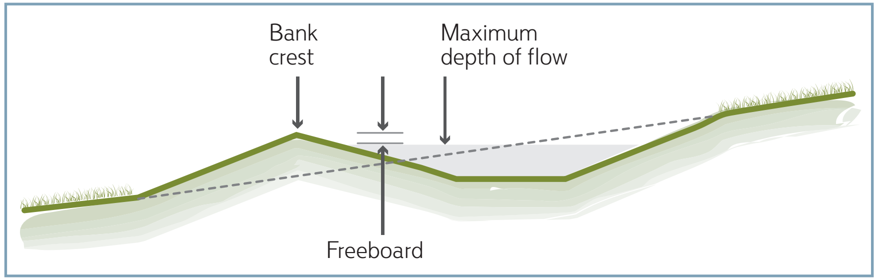
Type of bank shape recommended for different slopes.
Adapted from Earthmovers Training Course, Soil Conservation Service of NSW, 1992

Bank shape	Land slope	Slope of bank batter to channel	Example
Broad	0–3%	1 : 6 or flatter	
Semi-broad	3–8%	1 : 4	
Peaked	8–20%	1 : 1.5	

Channel capacity

The channel capacity must be greater than the peak discharge from the bank outlet, with a minimum freeboard on the bank of 0.2 m or 50% of the depth of flowing water in the channel – whichever is greater. Freeboard is the space between the top of the bank and the water level.

Profile of a bank with enough freeboard to reduce risk of overtopping the bank.
Adapted from Earthmovers Training Course, Soil Conservation Service of NSW, 1992



The catchment area and peak discharge for the outlet of a bank can be estimated using the worksheets at the end of this handbook. See page 168, 172.

Channel shape

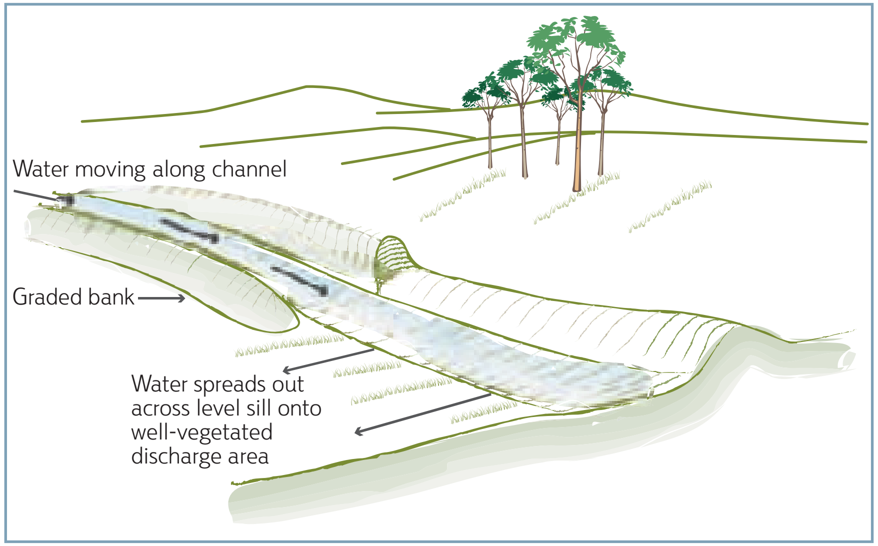
Least erodible channel profiles are either a broad curve (parabolic) or a flat bottom with tapered sides (trapezoidal). Steep V-shaped profiles have a high erosion risk. The sides of the channel should not be steeper than a 1:3 slope.

A broad curve is the most stable shape for a channel. Source: Grant Witheridge

Water discharge

The bank needs to discharge to a stable watercourse or well-vegetated disposal area via a level sill. Level sills spread the water out to slow the water before it runs onto the disposal area.

A graded bank ending at a spreading sill.
Adapted from Earthmovers Training Course, Soil Conservation Service of NSW, 1992



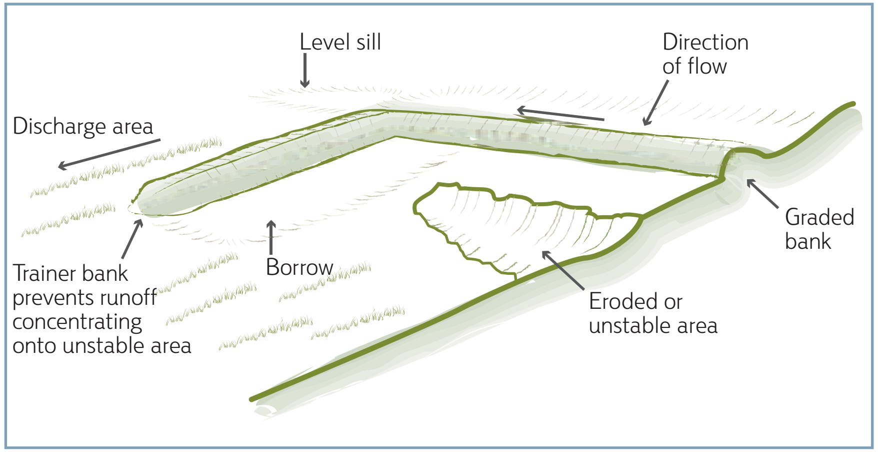
The length of sill will vary according to volume of water to be discharged, grade of the disposal slope and vegetation cover. In most circumstances a flow rate of 1.5 m^3/s onto a well-vegetated disposal area will not cause erosion. Sometimes it may be necessary to construct trainer banks to ensure the discharge water does not run into unstable areas.

Length of sill required (in metres) to achieve various flow rates onto the disposal area.
Adapted from Earthmovers Training Course, Soil Conservation Service of NSW, 1992

		Slope of the disposal area (%)					
		1	2	5	10	15	20
Peak discharge (m^3/s)	0.25	0.5	0.7	1.1	1.7	1.9	2.1
	0.5	1.0	1.3	2.3	3.4	3.7	4.2
	1.0	1.9	2.6	4.5	6.7	7.4	
	2.0	3.8	5.2	9.0	13.4		
	5.0	9.5	13.0	22.5			

A trainer bank ensures that water discharged from the graded bank does not cause further erosion to an unstable area.

Source: Earthmovers training course - Contour and graded banks, p14



Troubleshooting banks

Below are remedies for common problems that landholders experience with interception banks.

Water overtopping the bank

- Check the bank for low points and build up where necessary.
- Check channel for high points and remove them.
- Check for obstacles or sediment build-up in the channel and remove.

Insufficient channel capacity for water flow

- Check that channel capacity is adequate for the expected flow of water by estimating catchment area and peak discharge for the bank.
- Increase channel capacity or bank height if necessary.

Protect persistently scouring channels with rock.

Erosion of channel

- If the velocity of the water flow is too high, it will scour the channel. Slow down water flow by widening the channel, reducing the grade or placing check structures in the flowline.
- If there is inadequate groundcover, seed or nutrients may be insufficient. Check the soil for major nutrient deficiencies and pH, rectify soil problems and resow seed. Prune or remove overshadowing vegetation that inhibits grass growth.
- Protect persistently scouring areas with hard surfaces like rock or concrete.

Erosion of sill or discharge area

- Check that the sill is level and remove any dips causing concentrated flow.
- Repair any minor erosion of the sill.
- Ensure good vegetation cover on the sill and discharge area, revegetate as necessary, and fence to exclude stock if grazing or tracking is a problem.

Water should be discharged onto well-vegetated areas.

Source: Michael Frankcombe IECA

Concentrated flow

Concentrated flow occurs when overland flow forms a single flowline or a number of connected flowlines. Concentrated flows occur naturally or are constructed to direct flows into dams or other areas. Most erosion problems associated with constructed flowlines can be addressed using options outlined in the troubleshooting section above. Naturally occurring flowlines require greater intervention to reduce their erosivity.

The erosive power of concentrated water flows is a function of water volume and velocity. Agricultural land experiences greater volumes and velocity of storm runoff compared with unmodified landscapes, and this can lead to erosion in previously stable watercourses.

Manage overland flows

The first step in managing erosive water flows is to manage overland flows upslope of watercourses to reduce the volume of water that accumulates as concentrated flow.

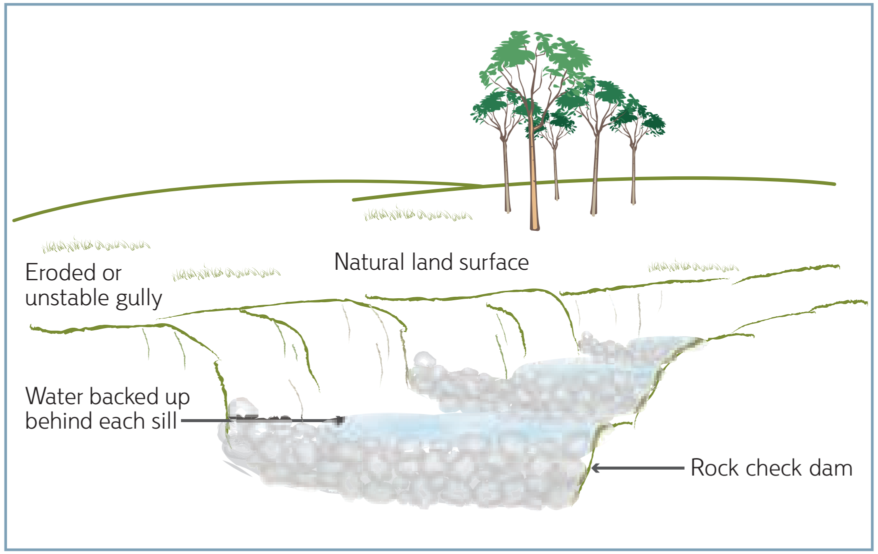
Install check structures and ponds

If overland flows are managed well, but concentrated flows are still causing erosion, it may be necessary to install check structures and ponds in the flowlines to reduce velocity and prevent soil losses and downstream sedimentation.

A check structure is an obstacle, usually permeable, placed in a watercourse to slow water velocity down and reduce scouring of the channel. In high flows, water will back up behind the structure, allowing a small degree of ponding and sedimentation. The structure spans the entire watercourse, so that the intended overflow point is the lowest point in the channel.

Check structures are not intended to hold or store water after high flow events, and should only be used in small watercourses.

In a rapidly eroding flow line, space the check structures so that ponded water backs up to the base of the upslope structure.



The number of check structures needed to reduce erosion depends on the grade of the watercourse and landholder needs. The lower the grade of the watercourse, the fewer check structures required, and more stable flowlines may need less frequent check dams. Ideally, the base of each structure is at the same level as the overflow of the next one downstream, so that in high flows ponds form between the structures. The ponds protect the downstream side of structures from scouring out. Where ponding is impractical, the downstream scour area can be armoured with rock or other hard material.

Most check structures are temporary, and constructed from degradable materials. Even when constructed with durable material such as rock, their lifespan is limited to the time it takes for the pond area to fill with sediment. The choice and location of structures and materials is determined by the design limitations of the material and site.

Types of check structures

Natural debris

Debris structures form when a branch or other material lodges in a channel, collecting other debris to create a small check dam. The usefulness of these dams depends on how the water overflows. If the debris narrows the channel, it can divert water to one side of the channel and cause scouring.

Vetiver grass

Vetiver grass is a thick, clumping grass with an unusually robust root system. Lines of the grass established across a watercourse can form long-lasting check structures.

Vetiver grass can form living check structures. Source: Michael Frankcombe IECA

Straw or hay bales

Bales need to be placed on their narrow side, dug 10 cm into the channel surface to prevent water flowing underneath them, and secured with two stakes per bale.

Hay bale check structures

Sandbags

Sandbags can be used to build low walls. Pegs on the downstream side may be required to support the wall if several layers of bags are used.

Check structure made from sandbags
Source: Michael Frankcombe IECA

Flexible log/sock

A flexible tube is pinned into place across the channel or slope. Various products are commercially available, made from coir, hay, compost etc. The tube follows the shape of the channel well, with a natural low point in the centre of the flowline. Stakes are needed on the downstream side to prevent it being washed away in high velocity flows.

Biodegradable log
Source: Michael Frankcombe IECA

Mesh

Wide metal mesh supported by stakes will trap debris and form a check dam. The mesh needs to be set into the sides and base of the channel. Where the mesh is >1 m high it will need support from guy wires anchored upstream to prevent collapse.

Rock

Loose rocks can be placed across the channel with a low point at the preferred overflow point. Generally these structures include geofabric (a synthetic textile that does not allow fine soil particles to pass through it) underneath the rock. It is important to select geofabric in accordance with manufacturer's guidelines.


A rock check dam
Source: Michael Frankcombe IECA

It is best to use a mixture of rock sizes, with a large proportion in the 75–150 mm diameter range (like the rock used in gabions). Large rocks on their own are less effective as they tend to create turbulent water flow and concentrated flow through irregular gaps, which may increase erosion downstream. Small rocks and gravel on their own are likely to be washed away in high flows.


A small rock check structure

Troubleshooting check structures

Several common problems reduce the effectiveness of check structures.

Sediment build-up behind the structure

- Determine the source of sediment and take measures to prevent it accumulating.
- Remove sediment regularly to maintain the water-holding capacity of the structure.
- Increase the water-holding capacity of structure.


Sediment needs to be removed to maintain the effectiveness of this structure. Source: Michael Frankcombe IECA

Tunnelling under the structure

- Check the material under the structure for stability and add ameliorant (see page 75) or geofabric as required.

Water bypassing / outflanking the structure

- Make sure that the intended overflow point from the check structure is the lowest point in the channel.
- Check that the sides of the structure are higher than the intended overflow point.


This rock check dam is failing because the rock does not extend far enough up the channel sides, and the lowest point is not in the centre.
Source: Michael Frankcombe IECA

Ponds

Ponds differ from check structures in that they are designed to hold water, are constructed from impermeable materials and usually have a constructed outlet to the side rather than over the top of the structure.

Ponding water slows the rate at which water moves through the watercourse, reduces its power to erode, and traps sediment. As the water stills, soil particles sink to the bottom (except in dispersible soils, where a chemical flocculant or coagulant needs to be added) and the cleaner water can be discharged or harvested.

Ponds are commonly small dams with earth walls, so care is needed to ensure that the outlet or spillway does not cause new erosion (see page 67).

Ponds can be designed to store water for short periods (detention ponds) or extended periods (retention ponds). Both types increase water infiltration of water and reduce the rate and volume of runoff. Detention ponds catch and store storm flows for days to weeks while the water drains slowly into the soil or is discharged by a pipe. These ponds are mostly empty or have substantial freeboard (height between a pipe inlet and emergency spillway) to catch and store runoff. They reduce peak flows by storing runoff and releasing it slowly.

Retention ponds store runoff permanently, but can have temporary storage incorporated in their design by increasing the height interval between a trickle pipe and the spillway. Retention ponds are limited in their capacity to reduce peak flows because once full they will not catch any additional runoff.

Sediment ponds should be long, rather than broad.

Ponds can trap more sediment if they are long rather than wide between the inlet and outlet. To achieve specific targets for sediment control in runoff water, seek technical advice on the design of the sediment pond. Bear in mind that reducing erosion upslope is much cheaper and more effective than trapping sediment.