Design, construction and management of Flood Refuge Mounds

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The Department of Agriculture and Fisheries proudly acknowledges all First Nations peoples (Aboriginal peoples and Torres Strait Islanders) and the Traditional Owners and Custodians of the country on which we live and work. We acknowledge their continuing connection to land, waters and culture and commit to ongoing reconciliation. We pay our respect to their Elders past, present and emerging.

Contents

Foreword

Although widespread flood events are infrequent in Australia, when they occur, the resulting losses on the impacted communities are substantial and devastating. Such an event occurred in north and north-west Queensland during the early months of 2019.

Record-breaking rain fell continuously for more than a week in the Southern Gulf Catchments and the Northern Lake Eyre Basin, causing extensive flooding locally and in the vast catchments downstream.

The *North-west Queensland Monsoon event of 26 January – 9 February 2019: report of a landholder survey into impact and recovery*, produced by the Department of Agriculture and Fisheries, estimates 457,000 cattle, 43,000 sheep, 710 horses, and over 3,000 goats died during this event with floodwaters impacting more than 11 million hectares of grazing land.

While not all those animals died from drowning, the lack of high ground to escape the floodwaters is thought to have contributed enormously.

The information contained in this booklet describes how to make Flood Refuge Mounds (FRMs) to provide somewhere for stock to shelter in such a rare event as that which occurred in 2019.

Background

There is a high risk of significant loss of production and death of domestic livestock during most natural disasters. This document provides some preliminary guidelines on the design, construction and management of FRMs to reduce livestock deaths during floods.

It is important to realise that not all deaths of livestock during floods are due to drowning. Significant deaths can result from exposure (wet animals followed by low relative humidity, moderate or higher wind-speeds and low ambient air temperatures after the rain stops); and sickness induced in weakened animals e.g. pneumonia.

Risk management of paddocks containing floodplains or major waterways

The key recommendation to protect livestock is to adopt a risk management approach when stocking paddocks on floodplains or adjacent to major watercourses during the December to March period.

Paddocks close to major watercourses or on floodplains often have high fertility land types that have experienced heavier stocking rates. Removing all stock from these areas during the wet season provides an opportunity for a recovery in land condition while mitigating the risk of losing livestock in a flood event.

Additionally, in some instances, relatively minor re-arrangement of fences will provide livestock with access to existing high ground not previously in the paddock.

Grazier experience indicates that one to two year-old steers and heifers have higher survival rates than other classes of livestock. However, the loss of heifers may have a longer-term impact on the enterprise, making steers the preferable class of livestock if floodplains are to be stocked during the December to March period.

If flood-prone paddocks are stocked with breeders, and the size of the paddocks are too large to be destocked over the wet season, calves from early calving mobs of breeders (October to December calving) will be two to three months old by the time of the occurrence of large floods in late January to March. These calves have a much better chance to survive a flood than newborns from late calving breeders.

Widespread floods in western catchments usually afford some notice to graziers that floods are 'on the way'. This time may be as short as one or two days, or as much as several weeks in the Lake Eyre rivers of south-western Queensland. Usually, there is enough time* to move cattle to higher ground, or to adjacent paddocks with higher ground. For localised floods caused by intense storms, e.g. more than 100 mm overnight, notice of floods can be very short (i.e. minutes to several hours), so the options to move livestock may be very limited.

Observations of the movement of low-pressure systems in the Gulf of Carpentaria will also provide early indications of potential severe flood events. Under such circumstances, gates on floodplains can be opened and helicopters hired to move cattle to higher ground before the high demand and inevitable rush to hire aircraft reduces their availability which often occurs during severe floods.

The following guidelines in this booklet are for paddocks where the construction of FRMs is deemed necessary, or the preferred course of action. It is important to realise that these structures could be used to save other items located in flood-prone areas that cannot be readily moved to higher ground. This includes earthmoving machinery and capital infrastructure materials such as pallets of fencing materials, fuel and stock feeds.

Locating a stockpile of fodder, a tractor with hay-forks and fuel (diesel and Avgas) on an FRM prior to the wet season will improve the efficiency with which livestock can be fed during a major flood.

Those located within the Flinders River Catchment may be interested in the Flinders River Catchment Flood Rules of Thumb (page 25).

**Note: Data on the speed with which flood peaks move downstream can be obtained from the Department of Resources or the Bureau of Meteorology (BoM). This data will improve as more flood height gauging stations are installed. Forecasting of extreme rainfall events and possible floods are also available from the BoM and some commercial weather forecasting providers.*

Location

Choosing the right location for an FRM is essential.

Observations made during previous floods may provide a guide to where cattle have congregated, drowned or perished in the past.

Riverbanks

Where major watercourses traverse paddocks, it is recommended that FRMs are located on both sides of the main channel on natural levees which are often the highest locations on a floodplain. This is because even low flows will prevent livestock from crossing to the other side. In such circumstances, using helicopters to push livestock across flooded watercourses, may increase the chance of additional stock losses.

Floodplains

Where floodplains are wide (greater than two kilometres), livestock that are still alive and in deep water are likely to be floating rather than swimming. Therefore, construct FRMs on the outside curves of preferential floodflow-paths as this is most likely where livestock will be floating along. Floodwaters will 'drift' floating/swimming livestock towards the FRM, increasing their chances to gain footing and walk out. This may be a double-edged sword – as flood-flows will be faster in preferential flow-paths which may erode the sides of the FRM. Rock armouring the side batters of the FRM will reduce this problem, but at an extra cost.

Livestock are likely to be isolated by floodwater when flood levels reach the stage where higher ground is out of sight of livestock, or the distance to high ground is to too far for livestock to swim.

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Avoid locations where high-speed flows make it difficult for livestock to escape the current and move towards an FRM. In this instance, livestock will simply be swept downstream, although grazier observations indicate most cattle in floodwaters are on the floodplains, not in major river channels.

Identify higher locations on the floodplain that are already established cattle camps to which livestock naturally gravitate. While they may still be submerged during a large flood, a mound that is located on naturally higher ground on the floodplain will make effective site as reduced volumes of earth (and finances) will be needed to build an FRM.

Select areas that are relatively free of woody weed infestations. Large prickly acacia and rubber vine can trap and drown livestock that are attempting to move towards an FRM.

While graziers have observed livestock (cattle) in floodwaters may occasionally swim upstream, most livestock will move downstream in flowing water. Therefore, locating FRMs at the downstream ends and corners of paddocks may increase the chances of livestock finding them.

Be aware that floodplains are highly dynamic natural systems where what was high ground after one flood may be significantly changed after a major flood. New preferential flow-paths will often establish after a major flood. Floodwaters can behave in unexpected ways, such as flowing upstream against the land slope when large flows come down major tributaries into a near-empty receiving watercourse.

Photograph courtesy of Lew Markey, DAF Rockhampton.

Using dam walls as Flood Refuge Mounds

Dam walls can be expanded to construct FRMs. However, as dams in drainage lines will be surrounded by the deepest water during a flood, this makes access challenging for livestock.

Avoid using silt excavated from the dam to expand the wall into the FRM. Silt can be structureless and may not compact very well to form a stable FRM.

The installation of a designated dam entry point with a batter of 1 vertical (V): 6 horizontal (H) that is capped with road-base material will enable livestock to access drinking water without bogging as the flood recedes.

Expanded dam walls will also require similar low sloping batters on the downstream side to allow livestock to walk onto the FRM during a flood.

Drinking water

Supply of stock water is important as livestock are generally reluctant to re-enter the water unless a ramp capped with road-base is constructed on a slope no steeper than 1V:6H to allow access to an adjacent borrow-pit.

While the FRM should remain firm underfoot and relatively dry, the surrounding floodplain may remain an expansive area of saturated soil for several days/weeks once floods recede with long walking distances to stock water.

Attempting the walk will become a death trap for weakened stock. Therefore, water will be required close to or on the FRM. This could be achieved by either reticulating water through tanks and troughs at a modest cost (if a suitable supply is close by), or by locating the FRM close to a watering point or existing dam.

For additional points on locating stock waters on FRMs, refer to the section in this booklet: Management of Flood Refuge Mounds (page 19).

Design of Flood Refuge Mounds

Shape

Four options are recommended, including:

1. square shape with battered sides
2. circular shape with battered sides – these have the advantage that corners will not be eroded, therefore are more stable in locations that experience high velocity floodflows
3. horseshoe shape with the front of the horseshoe facing into the current and the open end of the horseshoe on the leeward side to create an area of still back-water
4. existing dam banks (usually straight or crescent-shaped).

***Photo 1.** Livestock on a purpose-built bank (effectively an elongated rectangular flood refuge mound) during the 2019 Monsoonal Flood. High volumes of soil per animal area are required with this design. Square or circular FRMs are therefore more efficient per head. Photograph courtesy of A.A. Company Pty Ltd.*

Size

Several factors will determine the size of FRMs that are required, including:

- number and class of livestock likely to be in the paddock during the flood-prone period
- the area per head required on the FRM
- days before livestock leave the FRM
- distance to other FRMs in the paddock and the likelihood that livestock can access them as water levels rise
- the anticipated depth of floodwater, plus freeboard of 0.5 m.

Guidelines for FRMs have been developed for the floodplains of coastal New South Wales by Glenda Briggs. However, the *Australian Animal Welfare Standards and Guidelines for Cattle* have been used in this publication.

These guidelines* state in S10.1 that *"A person in charge must ensure a minimum area of 9 m^2 per Standard Cattle Unit for cattle held in external pens."*

It should be noted that a Standard Cattle Unit (SCU) is a beef animal of 600 kg liveweight or 1.5 adult equivalents.

Obviously the two scenarios mentioned above are very different: flood affected livestock are most likely to be under severe nutritional and adverse climatic stresses, while livestock in feedlot pens under the current regulations and guidelines, should be under minimal stress by comparison.

Therefore, the Australian Welfare Standards for lot fed cattle should be a starting point for:

- further discussion
- review of published findings
- expert opinion
- industry consultation
- the development of Queensland recommendations for Flood Refuge Mounds.

Using the Australian Welfare Standards at 9 m^2/adult beef animal (i.e. 3.0 m x 3.0 m), the corresponding size for 200 adult cattle is 0.18 ha in area, or 42 x 42 m.

*For more information on these guidelines, visit: www.animalwelfarestandards.net.au

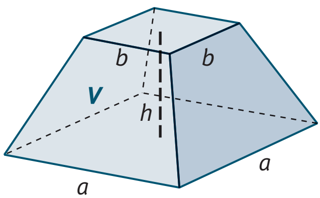
The volume of earth in a square FRM is best demonstrated by example. Continuing with an FRM to hold 200 adult cattle:

- 9 m^2/adult beef animal
- FRM height 2 m (including 0.5 m freeboard)
- crown gradient for drainage on top of FRM of 1.0% (1 m fall in 100 m)
- side batters 1V:6H
- the volume of earth required is 6,050 m^3 (3,600 m^3 FRM ex-batters + 2330 m^3 batters + 120 m^3 crown but excluding road-base capping material).

The geometric shape of a square FRM is a truncated square-based pyramid. The formulae for calculating the volume and surface area of such shapes are shown in **Figure 1**.

The volume and surface area of a range of shapes (e.g. a circular FRM or circular truncated cone) can be found on the following website: https://keisan.casio.com/menu/system/000000000280

Figure 1. *Formulae for calculating the volume of soil and lateral surface area of a Flood Refuge Mound.*



Truncated square pyramid

(1) *volume* : $V = \frac{1}{3}(a^2 + ab + b^2)h$

(2) *lateral area* : $F = 2(a + b)\sqrt{\left(\frac{a-b}{2}\right)^2 + h^2}$

(3) *surface area* : $S = F + b^2$

Note 1: the lateral area in formula (2) is the surface area of the sides of an object; it does not include the area of the base or the top. The area of the top is needed as a part of calculating the volume of road-base required for capping an FRM.

Note 2: formula (3) has been modified from that shown in the website, to include the area of the top only, not the base.

The website https://keisan.casio.com/exec/system/1223368185 has a facility to enter the dimensions and perform the calculations; however, the area of the top of the FRM must be added to the lateral area (area of the batters) to obtain the surface area of the structure.

An FRM of this dimension with the capacity for 200 adult cattle equates to 30.3 m^3 of soil/head. As the dimensions of the FRM increases, economies of scale improve as the proportion of soil required in the batters decreases; for example, an FRM for 500 adult cattle requires 26.2 m^3 of soil/head.

The above calculations are for square FRMs; however, rectangular and horseshoe shapes or even long banks (with a flat crest) and dam banks may be better for aerial delivery of stockfeed as livestock can move to one end without having to re-enter the water, while the drop is made at the other end. FRMs that are linear (horseshoe, dam banks and long banks) should be 250 m long to allow for hay to be spread during and after dropping from a helicopter.

Dimensions

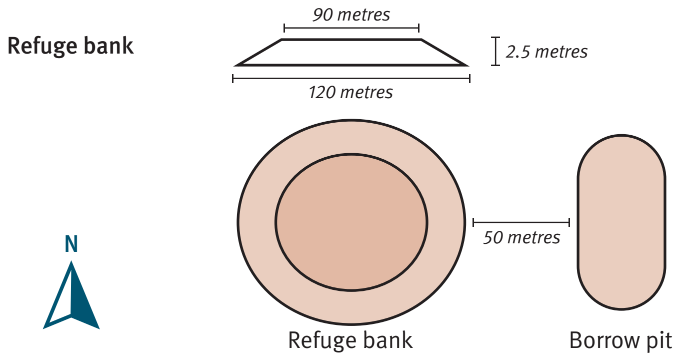
The steepness of batters is an important consideration as steep batters are difficult for weakened animals to ascend and are prone to severe erosion from storm rains and floodwaters. Therefore 1V:6H is recommended as the maximum slope for batters. Flatter would be better, but would add significantly to the cost.

As graziers become more experienced with constructing and managing FRMs, batters could be lengthened to further reduce the gradient, particularly on the upstream and downstream facing batters, which will be easier for livestock to access. Rounding the upstream facing batter (like the bow of an inverted round-nosed boat), will reduce eddies and back currents and minimise erosion damage on the corners of FRMs. A normal straight batter on the downstream of the FRM will create still backwater for easier access out of floodwater by livestock.

Beware that silt may also accumulate in this location making the area boggy. Constructing steeper batters (1V:2H) with designated low sloping ramps (1V:6H) will significantly reduce the volume of earth required, and cost less. Depending on the size of the FRM, two to four ramps will be required. Livestock will naturally move towards a ramp as a longer length of the ramp will be visible above water compared to a steep batter.

To ensure the top of the FRM drains and does not pool water, the structure must be crowned. This is also a compromise as a steeper crown will ensure rapid drainage but will be prone to erosion damage, so a crown slope of 1.0% (1V:100H) is recommended. Formula (1) in **Figure 1** (page 11) can be used to calculate the volume of soil required to construct the crown by making ‘a’ equal to zero in the formula, making it $V = \frac{1}{3} b^2 h$.

Figure 2. *Diagram and dimensions for a circular FRM with batter slopes of 1V:6H*



Note: Diagram is not to scale. Diagram and design provided by A.A. Company Pty Ltd.

Height

The height of the FRM must be based on known flood heights and frequencies; this information can be obtained from:

- flood height data that is available from gauging stations from the Queensland Department of Resources, Bureau of Meteorology or local councils
- interpretation from remote sensing e.g. satellite imagery at the time of maximum flood heights during major floods
- observation of high-water marks on tree trunks or debris lines across floodplains
- discussions with helicopter pilots and long-term local graziers and shire councils.

It is recommended that FRMs be built at least to the 1-in-100-year flood level i.e. a flood with a 1.0% recurrence probability. It should be noted that floods with longer return periods, while being higher, will not result in floods of proportionally greater height. This is due to the nature of floodplains becoming wider as the flood height rises. The same principle applies to a stock water dam i.e. the top metre of water represents a much greater volume than the metre below. Therefore, relatively small increases in the height of an FRM will significantly reduce the chances of it being submerged in a flood of significantly longer return period without adding excessively to the volume of soil required for construction.

Photo 2. *Footprint of a circular FRM and borrow-pit marked-out on the ground with construction underway. Photograph courtesy of A.A. Company Pty Ltd.*

Number of FRMs needed

Factors that determine the number of FRMs include:

- number and class of livestock likely to be in the paddock during the flood-prone period
- physical condition of the livestock (assume that livestock will be in less than optimum condition)
- the size of the paddock
- the distance that livestock will walk through shallow water, or swim/float through deeper water to reach an FRM.

Assuming a stocking rate on flooded country in land condition A of 10 ha/head in western Queensland, 200 head will graze an area of 2,000 ha or a paddock 4.5 km x 4.5 km. The reality (or otherwise) of livestock in a weakened condition traversing 2.2 km (half of 4.5 km) of floodwater would need to be ascertained by consulting long-term graziers in flood-prone areas and experienced Biosecurity Officers with long-standing western Queensland experience.

Paddock sizes exceeding 10,000 ha or 10 km x 10 km are not uncommon on floodplains in Western Queensland. Therefore, cattle numbers of 1,000 head or larger may need to be accommodated on FRMs in such paddocks. Under the 10,000 ha paddock scenario, five 200 head FRMs would be required. Two 500 head FRMs would carry the same total numbers, but the distance apart would be excessive resulting in the survival of fewer animals.

In any event, it is not possible to predict how many head will arrive at an FRM, although moving stock with a helicopter may enable some distribution across several FRMs on a floodplain. Therefore, FRMs to accommodate up to 1,000 adult cattle may be preferable to smaller structures that can hold only 200 head.

Construction of Flood Refuge Mounds

The requirements of an FRM are:

- remain stable in the intervening years between floods so that they are in good condition when required
- not become boggy when in use
- withstand the effects of floods when they occur.

There are several construction techniques that will help FRMs to meet these criteria:

- topsoil
- capping
- crowning
- rock rip-rap.

Stripping, stockpiling, and replacing topsoil over the batters of the FRM will allow grass establishment to occur, thereby reducing erosion of the structure. Saving and replacing topsoil to a depth of 100 mm is adequate. Fencing FRMs will maximise grass growth but fences must be removed once the pasture cover is well established to allow for open access by livestock during floods.

Capping the top with road-base material will provide a non-boggy surface that will dry out much quicker after rain, decreasing the stress on livestock. Similarly, capping sections of the batters with road-base material will reduce the incidence of bogging as livestock walk up and down the FRM. All road-base material will require compacting with a sheep's-foot roller to resist erosion from rainfall and floodflows while remaining firm underfoot for livestock, even when fully saturated. Capping to a compacted depth of 0.3m should be sufficient to prevent break-through by livestock.

The crowning of the FRM is crucial.

If batters are also suffering from erosion, they may require capping with road-base material to the same depth. The availability of capping material will be limited in many situations as floodplains are often tens of kilometres from a suitable source. However, triple side-tippers can transport 75 to 90 cubic metres of material on each trip. For an FRM that can accommodate 200 head, 540 m^3 of road-base will be required to cap the top and 780 m^3 to cap the batters i.e. 15 to 20 loads for a triple trailer side-tipper.

Controlling erosion of the FRM

In locations where fast-flowing floodwaters are adjacent to the FRM, some erosion of the structure may occur.

Compacted road-base material will not be sufficient to resist such forces and serious erosion may occur. In this instance, rip-rap consisting of mixed size large rock (up to 0.4 m diameter) placed over erosion prone areas will control erosion and preserve the FRM.

The risk with using large rock is that livestock attempting to exit floodwaters in this location will flounder in the rocks. Therefore, a permanent fence may be required around the rip-rap areas only, or a review of the location in the first instance to find a site that is away from fast currents. The cost of rip-rap is very high and requires placement with a loader or excavator to be most effective; therefore, its use should only be considered as a last resort.

Borrow-pits

Borrow-pits can be located 50 m from the FRM so that swimming/floating livestock can gain a footing before they reach the structure; or in shallow water, livestock can continue walking as they approach the structure.

- Borrow-pits that are close to FRMs should be fenced-off to reduce stock losses.
- Strip and stockpile topsoil from the footprint of the borrow-pit, so that only subsoil is used in the construction of the FRM.
- Replace the topsoil over the batters and the borrow-pit floor to re-establish the pasture.
- Excavate the borrow-pit in steps to avoid smooth-faced batters.
- Stepped batters will hold topsoil when it is replaced, smooth batters will not. Make the batter slopes 1H:6V or flatter to further reduce the movement of topsoil into the floor of the pit.
- Avoid excavating borrow-pits deeper than 1.5 m, unless shaley material is found that may be a suitable road-base for capping the FRM.

Equipment to construct FRMs includes:

- surveying equipment to ensure the FRM is built to specification and will function efficiently with minimal maintenance requirements
- a self-loading scraper for stripping topsoil, excavating borrow-pits and building the FRM
- road grader or a land plane to ensure that soil, topsoil and road-base is placed in uniform layers prior to compacting; this will ensure an even, free-draining surface on the top of the FRM
- sheep's-foot roller for compacting the layers as they are placed
- water truck if the soil is dry to maximise compaction by sheep's-foot-roller
- side tippers and front-end loader to excavate and transport road-base material.

Depending on the density of the road-base being quarried, a bulldozer may be required for deep-ripping and stockpiling. Using a loader for deep-ripping and stockpiling is very inefficient.

A knowledge of basic geometry is also essential.

Photo 3. Constructing FRMs using the ideal range of earthmoving machinery including self-loading scrapers, bulldozer and a road grader.
Photograph courtesy of A.A. Company Pty Ltd.

Photo 4. *Completed Flood Refuge Mound.*
Photograph courtesy of A.A. Company Pty Ltd.

Photo 5. *Hay being ferried by helicopter during the Lower Gulf country flood, 2023. Photograph courtesy of Jim Fletcher, Department of Agriculture and Fisheries, Mackay.*

Photo 6. *Hay dropped in a sling from a helicopter. Photograph taken during "Cowan Downs" 2009 flood.*

Management of Flood Refuge Mounds

It is important that animal behaviour is considered when managing FRMs.

Grazier observations suggest that when livestock find their own way to FRMs they are more inclined to stay; whereas stock that are aerially mustered by helicopter to FRMs may leave within hours. Therefore, actions that encourage stock to remain on an FRM must be a priority.

The following should be considered:

- Use FRMs as supplementary feeding points in all years so that livestock are familiar with their location and will naturally congregate to them during floods.
- If permanent watering points (tanks and troughs) are established on FRMs, be aware that gravity-fed watering systems with minimal head may not flow if the tank and trough is raised on an FRM two or more metres above the floodplain. Under this scenario, pumping will be essential. Livestock will drink from floodwaters if ramps are safe to walk up and down; therefore, capping with road-baseis recommended.
- Commence feeding hay (or other feedstuffs) as soon as livestock congregate onto an FRM during a flood. Hay storage in sheds on selected FRMs on floodplains will allow the feeding of fodder to commence much sooner than if hay has to be sourced and ferried long distances from flood-free bitumen roads (**Photo 5**). This encourages livestock to remain at the first FRM they encounter, rather than re-entering floodwaters to find feed.
- Spread hay out on the FRM as livestock may also use it for bedding. In such instances, ensure adequate hay is also available for feeding.

Feed supply to FRMs

A person who is trained in stock handling and animal behaviour should be landed on to the FRM before fodder delivery begins. Once onsite, they can release hay bales from slings while keeping livestock at bay.

Where possible, use bales bound with heavy-duty baling twine as they will maintain their integrity during aerial transport. When dropped close to the ground, the heavy duty baling twine breaks apart on impact to provide an efficient spread of hay which alleviates the need for a person on the ground.

Net-wrapped hay bales will not break-up on impact if dropped from the air. To remove the need to have someone on the FRM, some experienced pilots remove the wrap from the hay before slinging into location. In addition, only one side of the sling net is attached to the release-hook, with the rest attached to the sling line itself. By doing so, there is no need for a person to be on the ground, or for cattle to recede into floodwaters.

FRMs should be inspected each year, especially the batters where soil erosion is most likely to occur. Ensure areas of erosion are repaired before the next wet season.

Reducing overland flow speeds

Although not a feature of the FRM, overland flow velocities on floodplains can be moderated by retaining high levels of pasture cover and high grass tussock densities. This can have significant implications for livestock reaching FRMs during a flood.

Table 1 shows the effects of pasture cover and tussock height on slowing the speed of runoff water.

Table 1. *Velocity of overland flow for a range of land slopes and flow depths*

Velocity of overland flow (m/sec)

Land slope	Pasture tussock height	Depth of flow		
		0.5 m	1 m	2 m
1:1,000 (Eastern Creek floodplain)	15 cm	0.22 m/s	0.35 m/s	0.5 m/s
	Nil*	0.85 m/s	1.3 m/s	2.1 m/s
1:2,000 (Walkers Creek)	15 cm	0.2 m/s	0.27 m/s	0.45 m/s
	Nil*	0.6 m/s	0.95 m/s	1.5 m/s
1:5,000 (Wondoola floodplain)	15 cm	0.15 m/s	0.23 m/s	0.38 m/s
	Nil*	0.6 m/s	0.6 m/s	0.9 m/s

Note 1: The floodplains named in the first column are examples of that land slope. Soil erosion is minimal where overland flow velocities remain at or below 0.5 m/sec.

Note 2: This is for broad overland/sheet flow, not channel flow.

* Denotes bare ground.

Lower floodflow velocities mean that livestock can move more easily to higher ground. Additionally, erosion damage in flooded paddocks is greatly reduced if water speeds are reduced by good pasture cover and tussock density.

Photo 7. *The 'swept' appearance in this paddock after the 2019 Monsoon Flood is still clearly visible in this 2022 photograph. High run-off velocities due to the low pasture cover prior to the flood would have had some bearing on the ability of livestock to reach high ground. Photograph courtesy of Bob Shepherd, Department of Agriculture and Fisheries, Charters Towers.*

Shade shelters on Flood Refuge Mounds

Depending on the results of recent research on the provision of shade for breeders during calving to reduce calf loss across northern Australia, there may be an opportunity to locate shade structures on FRMs. Additionally, if the shelter had a waterproof roof and was built to the appropriate cyclone rating, it could be used to store fodder during the wet season as a flood reserve or used in the dry season in a non-flood year.

Feral pests and weeds

Feral and native animals (e.g. pigs, buffalo, kangaroos, emus, snakes, dogs, etc.) will often be present with domestic livestock on FRMs. These animals will need to be managed appropriately to ensure the welfare of the domestic and non-domestic animals on the FRM (e.g. feral pigs and dogs) may start attacking weakened livestock, so need to be controlled. Pigs, dogs, and snakes may also be an issue for stock handlers on the ground!

Woody weeds such as prickly acacia, parkinsonia and calotrope are common on the floodplains of western Queensland; however, these same species thrive in borrow-pits where surface water remains for several months after rain. Large woody weeds become the major source of seed to infest broader areas and additionally can trap and drown livestock during floods. Therefore, early monitoring and control around FRMs is essential to keeping these areas weed-free.

A special note

Livestock may be reluctant to leave FRMs or other high ground, even when conditions are safe to do so; therefore, they may have to be mustered off and possibly moved to a different paddock to break the dependency on the FRM.

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Additional reading

Livestock flood refuge mounds

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https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/304491/livestock-flood-refuge-mounds.pdf

Or search *Livestock Flood Refuge Mounds* at **www.dpi.nsw.gov.au**

Australian Animal Welfare Standards and Guidelines for Cattle (2014)

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Or search *Flinders River Catchment Flood Rules of Thumb* at **www.futurebeef.com.au**

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