



# Ngā tino takiwā mātāpuna

## Critical source areas

Guidance for intensive winter grazing



Ministry for the  
**Environment**  
*Manatū Mō Te Taiao*



**Te Kāwanatanga o Aotearoa**  
New Zealand Government

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# 1. Executive summary

This document synthesises scientific evidence into guidance to inform intensive winter grazing (IWG) activities in accordance with the Resource Management (National Environmental Standards for Freshwater) Regulations 2020 (NES-F). It provides recommendations on practical actions that farmers, land managers and councils can take to plan, manage and mitigate adverse effects from IWG activities, with a focus on critical source areas (CSAs).

Phosphorus, sediment and faecal microorganisms are the contaminants most susceptible to surface run-off from winter grazing. Nitrogen is mainly lost via drainage but can be found in surface run-off on heavy or compacted soils. Livestock treading damage due to winter grazing results in decreased infiltration capacity. This, in turn, leads to higher sediment and P losses in surface run-off and more chance that ponding of water on the soil surface will occur.

Critical source areas are areas within a paddock or catchment that contribute a disproportionately large (relative to their area) quantity of contaminants to water, negatively impacting water quality. The IWG regulations target critical source areas that accumulate surface run-off from grazed winter forage crops and deliver one or more contaminants to rivers, lakes, wetlands, surface drains or their beds. Targeting relevant mitigations specifically to critical source areas is an efficient and cost-effective approach to reduce nutrient loss from the whole farm.

The simplest way to assess potential critical source areas is to perform a visual inspection of contaminant sources and transport pathways. This 'walkover survey' involves walking around prospective IWG paddocks or a whole farm, usually during wet weather, looking for run-off-generating areas and their connectivity to waterways, and marking this information on a map.

The NES-F requires livestock to be excluded from critical source areas from 1 May to 30 September in order to meet permitted activity conditions. Even when lower stocking rates are used to graze forage crops in winter, wet conditions in critical source areas are usually sufficient to cause pugging and compaction. Critical source areas, therefore, can be significant sources of contaminant loss if left unprotected.

At the end of the season, reviewing the measures that functioned well, and what did not, is a vital step that is part of continuous improvement for future planning.

## 2. Introduction

### 2.1 Purpose

The purpose of this guidance is to help farmers, land managers and councils to manage and monitor intensive winter grazing (IWG) activities in a way that is consistent with IWG regulations and that minimises the impacts on the environment. This technical guidance will provide recommendations on practical actions that can be taken, within the context of different farm systems and conditions, to plan, manage and mitigate adverse effects from IWG activities.

The focus of this document is critical source area (CSA) management as part of IWG, in accordance with the NES-F regulations. However, it is important to remember that regional plans may also address IWG issues and if the plan rules are more stringent than the regulations, they will apply. Council rules should therefore also be checked.

### 2.2 Document structure

This document is structured as follows:

- [Section 3](#) defines CSAs and the impacts of IWG on them.
- [Section 4](#) presents the IWG regulations, as they relate to critical source areas.
- [Section 5](#) summarises the impacts of critical source areas on contaminant losses to waterways.
- [Section 6](#) provides guidance on implementing the regulations, as well as good practices for managing critical source areas before and during IWG.
- [Section 7](#) presents a decision framework, which outlines the main steps in the IWG cycle, along with case study examples of critical source area management from different regions.

## 3. What are critical source areas?

### Key points

- Critical source areas are areas within a farm or catchment that contribute a disproportionately large quantity of contaminants to water (relative to their extent), leading to poor water quality. Targeting relevant mitigations specifically to critical source areas is an efficient and cost-effective approach to reduce nutrient loss from the whole farm.
- Intensive winter grazing in critical source areas generates sources of nutrients through the deposition of dung and urine, while animal treading mobilises sediment particles and creates pugging and compaction, which can increase surface run-off.
- The IWG regulations target a specific group of critical source areas that accumulate surface run-off from adjacent winter cropped land and that deliver, or have the potential to deliver, one or more contaminants to one or more rivers, lakes, wetlands or surface drains, and/or their beds.

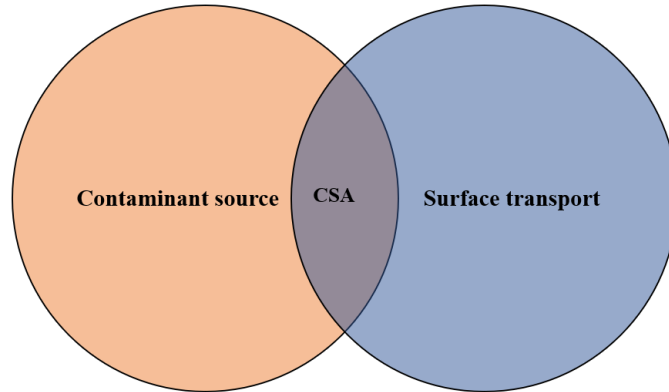
### 3.1 General concept of critical source areas

Not all locations on a farm contribute equally to the delivery of contaminants, and hence water quality degradation. Studies have found that a relatively small fraction of a farm or catchment can generate a disproportionate amount of contaminant load (Pionke et al, 2000; Gburek et al, 2000). Moreover, field observations have established that most stormflow (ie, run-off during and shortly after rainfall) is generated by a small proportion of the catchment area (often less than 10 per cent; Freeze, 1974). Identifying these hydrologically active areas is central to the design and implementation of water quality management.

Critical source areas are those areas within a farm or catchment that contribute a disproportionately large quantity of contaminants to water (relative to their extent). They are generally places where contaminant sources overlap with areas that are hydrologically active and connected to a waterway (Gburek et al, 2002; McDowell and Srinivasan, 2009). In other words, a critical source area is the combination of both a source of contaminants (eg, nutrients, sediment or faecal microorganisms) and a transport pathway (eg, surface run-off, ephemeral drainage) (see [figure 1](#)). Minimising either the source or the transport pathway will decrease the risk of contaminant losses.

Once sources and pathways have been identified, mitigation strategies can be more efficiently targeted to critical source areas than using 'blanket' approaches that restrict farming practice across entire catchments (Buczko and Kuchenbuch, 2007). However, it is important to incorporate a whole-farm management approach as the critical source area concept may not apply equally to all contaminants. For example, critical source areas are less relevant to reducing nitrogen losses as subsurface drainage is generally the main pathway for the transfer of nitrogen to water (Monaghan et al, 2016).

**Figure 1: The concept of a critical source area**



Critical source areas occur where a contaminant source in the landscape coincides with an active surface transport mechanism.

(CSA: after Walter et al, 2000)

### 3.2 Critical source areas and intensive winter grazing

Winter in Aotearoa New Zealand is an especially high-risk season for critical source areas because rainfall is high and evapotranspiration is low. This leads to frequent activation of surface transport pathways (Smith and Monaghan, 2003). Intensive winter grazing generates contaminants by depositing dung and urine in a concentrated area (Hively et al, 2005; Lucci et al, 2012), and via animal treading, which dislodges soil particles and creates pugging and/or compaction (Curran-Cournane et al, 2011; Monaghan et al, 2017). These effects are increased when a relatively large number of livestock is concentrated in a small area, resulting in stocking densities that can exceed 1000 cows/ha (Houlbrooke et al, 2009; Monaghan et al, 2017).

#### Winter grazing situations to avoid



In the critical source area example above, sediment is visible running down the bank, and surface run-off (the transport pathway) which connects the wider contaminant source from IWG to a



surface drain is clear. Contaminants invisible to the naked eye, such as phosphorus and faecal microorganisms, are also likely to be present in the surface run-off exiting this paddock. Next time, this area where surface run-off accumulates (ie, CSA) should be fenced off and left ungrazed to maintain vegetation during the winter.



In the example above, livestock have access to a critical source area (CSA), directly contaminating an ephemeral waterway (surface transport) with dung and urine (contaminant source). Next time, livestock should be excluded from the critical source area to avoid the deposition of contaminants in the waterway. Livestock should be excluded from the steep, erodible edges of the critical source area using an approximately 5-metre buffer (see section 6.2).

### 3.3 Other critical source areas

Other critical source areas in and around the farm that are not covered by IWG regulations include:

- raceways or laneways (Lucci et al, 2010; Hively et al, 2005; Monaghan and Smith, 2012)
- in-paddock stock congregation sites (eg, feeding areas, stock campsites, water troughs and gateways) (Lucci et al, 2010; Hively et al, 2005)
- stream and river crossings (Davies-Colley et al, 2004)
- silage pits or feed bunkers (Gebrehanna et al, 2014)
- yards and animal holding areas (Hively et al, 2005).

These areas are proven sources of sediment, phosphorous, nitrogen and faecal contamination and should be noted in walkover surveys (see [sections 6.2.1, 7.1](#) and [appendix 1](#)). Land managers should be mindful of any winter grazing activities adjacent to these areas to ensure surface run-off from them is not exacerbated by winter grazing. [Appendix 2](#) has more information on these other critical source areas.

# 4. Regulation requirements

## 4.1 Intensive winter grazing regulations

The purpose of the Essential Freshwater package is to stop further degradation of Aotearoa New Zealand's freshwater resources, start making immediate improvements and reverse past damage within a generation. In May 2022, amendments to the National Environmental Standards for Freshwater 2020 amended the requirements for land managers and regional councils relating to intensive winter grazing activities. The amendments include a new permitted activity condition requiring critical source areas (CSAs) that are within or adjacent to an area being used for IWG to be protected. For clarity in this document, the terms in the regulation are defined below (see [box 1](#) and [box 2](#)), and taken from the Resource Management (National Environmental Standards for Freshwater) Regulations 2022 (NES-F).

### Box 1: Definitions from the Resource Management (National Environmental Standards for Freshwater) Regulations 2022:

**Annual forage crop:** A crop that is grazed in the place where it is grown, but does not include either pasture or a crop that is grown for arable land use or horticultural land use.

**Intensive winter grazing:** The grazing of livestock on an annual forage crop at any time in the period that begins on 1 May and ends 30 September of the same year; includes activities on a farm that support intensive winter grazing and may occur year-round, such as the preparation and sowing of land for grazing and the cultivation of annual forage crops.

**Critical source area:** Means a landscape feature such as a gully, swale or depression that accumulates surface run-off from adjacent land; and delivers, or has the potential to deliver, one or more contaminants to one or more rivers, lakes, wetlands, or surface drains, or their beds (regardless of whether there is any water in them at the time).

The IWG regulations use the same concepts in their definition of critical source area, emphasising both the *contaminant source* and *surface transport*.

Three pathways can be followed when undertaking intensive winter grazing (Ministry for the Environment, 2022):

**Pathway 1 – Permitted activities through satisfying conditions:** IWG activities are permitted if a farmer complies with the default conditions set out in the NES-F IWG regulations. See [Box 2](#).

**Pathway 2 – Permitted activities through freshwater farm plan:** IWG activities are permitted if a farmer obtains a certified freshwater farm plan (FW-FP) made under Part 9A of the RMA that applies to IWG and under which any adverse effects in relation to the IWG are no greater than would be allowed for by the default conditions set out in Pathway 1. Note that at this time FW-FPs made under Part 9A of the RMA have not yet been rolled out. See [section 4.2](#).

**Pathway 3 – Unable to comply with permitted activity standards:** a resource consent is required (restricted discretionary activities) for IWG.

Although this document mainly provides guidance appropriate for following pathway 1, the recommendations in [section 6](#) and [section 7](#) could also help regional councils in evaluating resource consent applications for risk considerations and the appropriateness of IWG mitigation measures.

### **Box 2: Conditions for permitted IWG activities (pathway 1):**

**The area** of the farm that is used for intensive winter grazing must be no greater than 50 ha or 10 per cent of the area of the farm, whichever is greater: and

**The slope** of any land under an annual forage crop that is used for intensive winter grazing must be 10 degrees or less, determined by measuring the slope over any 20-metre distance of the land: and

**Livestock** must be kept at least 5 metres away from the bed of any river, lake, wetland, or drain<sup>1</sup> (regardless of whether there is any water in it at the time); and

On and **from 1 May to 30 September** of any year, in relation to any critical source area that is within, or adjacent to, any area of land that is used for intensive winter grazing on a farm:

- (i) the critical source area must not be grazed; and
- (ii) vegetation must be maintained as ground cover over the whole critical source area; and
- (iii) maintaining that vegetation must not include any cultivation or harvesting of annual forage crops.

Resource consent or a certified freshwater farm plan (when available) will be required if you can't comply with all Pathway 1 permitted activity conditions. For more information refer to the [Ministry's \(2022\) fact sheet](#).

Note that regional plan rules may cover IWG activities but may differ from the permitted activity conditions. These regional rules may be more stringent than national regulations. If they are, the more stringent rules must be followed — it is important to check with your regional council.

## **4.2 Freshwater farm plans**

Pathway 2 is an alternative to following the conditions for permitted activities (pathway 1, [box 2](#)) or obtaining a resource consent (pathway 3). If the farm has a certified freshwater farm plan (ie, a freshwater farm plan under Part 9A of the RMA) that applies to intensive winter grazing, the activity must be undertaken in accordance with that plan. According to this pathway, any adverse effects allowed for by the freshwater farm plan must be no greater than those allowed for by the conditions for permitted activities (pathway 1).

Although freshwater farm plans are in the process of being rolled out, any data collected and plans made for managing critical source areas for IWG will help prepare future plans. This could include walkover surveys (see [section 6.2.1](#)) and other information captured in the template (see [appendix 1](#)), along with spatial elevation data such as LiDAR (see [section 6.1.1](#)). Over subsequent years, the plan would show emerging critical source areas across variable

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<sup>1</sup> Any artificial watercourse designed, constructed or used for the drainage of surface or subsurface water, but excludes artificial watercourses used for the conveyance of water for electricity generation, irrigation, or water supply purposes (Ministry for the Environment, 2019).

climatic conditions. More information about freshwater farm plans can be found [on the Ministry's website](#).

## 5. Impacts on the environment

### Key points

- Phosphorus, sediment and faecal microorganisms are the contaminants of greatest risk to water bodies from IWG. Nitrogen is mainly lost via drainage but can be found in surface run-off in heavy or compacted soils.
- Livestock treading damage due to winter grazing results in decreased infiltration capacity, and higher sediment and P losses in surface run-off, and ponding of water at the soil surface is more likely to occur.
- Surface transport pathways that can connect contaminant sources with receiving waters include surface run-off, ephemeral waterways and springs.
- Contaminant sources without connectivity to a receiving water body pose a relatively low risk to water quality.

### 5.1 Critical sources and pathways

Most animals in Aotearoa are grazed outdoors year-round, which requires careful animal management, particularly over winter. This is the wettest time of the year, when the risk of soil treading damage is high, causing an increased risk of surface run-off losses of suspended sediment, phosphorus and faecal microorganisms (Monaghan et al, 2017; McDowell 2006).

The loss of nutrients and sediment from land can cause a decline in surface water quality due to effects like eutrophication<sup>2</sup> (Carpenter et al, 1998). Most surface run-off is likely to originate within wet areas (eg, swales and gullies) where the soil is vulnerable to damage. Protecting and managing these critical source areas to minimise soil damage has been found to reduce the risk of surface run-off and contaminant transport to waterways. Understanding the transport pathway linkages between the contaminant sources and the waterways is an important factor in developing an evidence base for robust environmental management.

**Table 1: Contaminant sources in intensive winter grazing**

Contaminant	Description
<b>Phosphorus (P)</b>	Sources of phosphorus loss from winter grazing are mainly soil-bound phosphorus and dung (McDowell et al, 2003). Annual losses of up to almost 4 kg P/ha have been measured from winter grazing areas (Monaghan et al, 2017). Phosphorus in dung is especially mobile (McDowell and Sharpley, 2002), and phosphorus in cattle faeces may range from 10–23 g P/cow/day (Betteridge et al, 1986).
<b>Sediment</b>	Sediment losses of up to 3700 kg/ha/yr have been measured from winter forage grazing systems (McDowell, 2006; McDowell and Stevens, 2008; Monaghan et al, 2017).

<sup>2</sup> Excessive richness of nutrients in a lake or other body of water, frequently due to run-off from the land, which causes a dense growth of plant life.

<b>Faecal microorganisms</b>	Animal faeces and effluent are a source of faecal microorganisms, which are a public health concern (Ministry for the Environment, 2002). Surface run-off can transport large numbers of faecal micro-organisms (Muirhead et al, 2006).
<b>Nitrogen (N)</b>	Urinary nitrogen, rather than fertiliser nitrogen, is usually the source of nitrogen loss from winter grazing (Di and Cameron, 2002; Smith and Monaghan, 2003). Nitrogen is mainly lost via drainage but can be found in surface run-off on heavy, or compacted soils (Monaghan et al, 2017).
<b>Surface transport</b>	
<b>Surface run-off</b>	Treading by livestock often leads to increases in soil bulk density, and decreases in soil porosity, macroporosity and hydraulic conductivity (Mulholland and Fullen, 1991; Singleton et al, 2000; Drewery and Paton, 2005; Curran-Cournane et al, 2010). Areas with treading damage have decreased infiltration capacity, higher sediment and phosphorus losses in surface run-off (Nguyen et al, 1998), and ponding of water at the soil surface is more likely to occur (Sheath and Carlson, 1998). Moreover, reduced soil infiltration due to cattle treading can persist for more than six weeks after the grazing (Monaghan et al, 2017).
<b>Ephemeral waterways</b>	Ephemeral waterways do not convey or retain water year-round but are only active during, or immediately following, rainfall events (Shanafield et al, 2021). Multiple run-off areas can converge in ephemeral waterways.
<b>Springs and seeps</b>	Springs originate where groundwater discharges to the surface, forming flow paths and small channels. A spring is commonly referred to as a seep when it discharges at a lower, and potentially ephemeral, flow rate (O'Driscoll et al, 2019).
<b>Connectivity</b>	
The extent and efficiency of the pathways that transport contaminants to surface water bodies are measures of the connectivity to the surrounding landscape (Moloney et al, 2020). Conversely, dis-connectivity is the isolation of such landscape zones. Contaminant sources without connectivity to a receiving water body pose a relatively low risk to water quality. The extent or risk of connectivity will influence the size of the critical source area required.	

## 5.2 Intensive winter grazing and critical source areas

During intensive winter grazing, surface run-off is likely to originate in areas that are typically wet during winter and where soil disturbance is high: eg, swales, gullies and depressions. These are critical source areas where seepage and infiltration-excess run-off flows converge and are thus targeted by the IWG regulations.

### Swale:

- Swales are found in lightly sloping to rolling paddocks and concentrate water flows from the surrounding area into a shallow channel.
- Swales only conduct water during or after rainfall events and may act as ephemeral flow paths connecting contaminants with waterbodies.
- Soils in this part of the paddock are often very wet, possibly marshy and are thus at substantial risk of generating run-off during rain events.

**Photo:** Sheep grazing a winter forage crop, with an unprotected, grazed swale. The swale is evidenced by the ephemeral waterway snaking its way through the bare, grazed soil in the middle of the photo. (Note this photo was taken before IWG regulations came into effect.)



### **Gully:**

- In contrast to a shallow swale, a gully is deep trench, or channel, where the soil has been carried away, exposing bare ground.
- On sloping land, shallow gullies sometimes form where surface run-off from vegetated ground flows onto patches of bare soil. The run-off picks up soil particles, initially rilling the bare surface (Hicks, 1995). With each subsequent rainfall event the rills deepen, eventually forming gullies which cut back and undermine surrounding earth. Very deep gullies can form on hill country if the underlying base is weathered rock, rich in clay.
- Small, shallow gullies are of main concern for grazed winter cropping, as deeper gullies are unlikely to be sown in a winter forage crop, and do not meet the permitted slope conditions of less than 10 degrees. However, if deeper gullies are adjacent to winter grazing areas, appropriate management should be in place to protect these areas from livestock grazing (see section 6.2).

**Photo:** Post-winter grazing of an unprotected gully. (Note this photo was taken before IWG regulations came into effect).



**Depression:**

- A depression is a low, possibly marshy area in the landscape that becomes saturated periodically.
- During and after rainfall events, depressions may become hydrologically connected to waterways via ephemeral flow paths and can be significant contributors of nonpoint source pollution to downstream waters.
- Depressions vary in both size and depth and are most easily identified by the presence of temporary standing water (or ponding) during wetter months.

**Photo:** A grazed depression with bare soil and erodible sediment in the centre of the photo.  
(Note this photo was taken before IWG regulations came into effect.)



# 6. Implementing the regulations

## 6.1 Identifying critical source areas

### Key points

- The simplest way to assess potential critical source areas is to visually inspect possible contaminant sources and transport pathways during or soon after heavy rain (ie, walkover surveys).
- Hydrological modelling can help delineate critical source areas and target areas for walkover surveys, but many catchments lack the resources and data to support this.
- Visually examining the soil moisture level after rainfall can help delineate the approximate extent of depressions and swales. One sign to look for is that soils in these areas often stay wet for prolonged periods after heavy rain. A soil moisture probe, or even gumboots, could be used to check if depressions fill up with water.

Approaches to identifying critical source areas range from simple inventories to complex models. The most basic and accessible way to identify them is to walk the farm while looking for sources and pathways (ie, walkover survey). Hydrological modelling can help to narrow down and identify specific farm areas likely to be critical source areas, but many farms or catchments lack the resources and data to support this approach. Where hydrological modelling cannot be performed, potential contaminant transport pathways can be identified by examining the following:

- farmer knowledge
- aerial photos
- maps of waterways
- information on soil types
- location of compacted areas
- topography.

### 6.1.1 Spatial and hydrological modelling approaches

A brief description of frequently used hydrological approaches used to delineate critical source areas is given below. All approaches vary in how applicable they are to delineating critical source area, and all have limitations (Srinivasan and McDowell, 2007). Several factors should be considered before choosing a method, including data availability, process represented, ease of implementation and economic impacts.

#### *Topographic wetness index*

Topographic wetness index (TWI) is an estimate of the potential for soil saturation of a land area (and therefore generation of surface run-off) based on slope and drainage area (Beven and Kirkby, 1979). TWI is calculated by using a digital elevation model in a geographical information systems (GIS) software programme (eg, ArcGIS), then using several tools within the programme to calculate the slope, flow direction, flow accumulation and TWI using a



simple equation (Beven and Kirkby, 1979; Grabs et al, 2009). The resulting TWI spatial data layer depicts areas where water is likely to accumulate. Smaller TWI values indicate less potential for ponding while larger values reflect a greater risk due to the drainage from larger upslope areas, for example (Wolock and McCabe, 1995). TWI has been widely used as a conceptual tool to simulate saturation-excess run-off areas at a catchment scale. Simplicity and adaptability to various physiographic regions has allowed the topographic index concept to be widely applied.

#### *Topographic wetness index plus impervious area*

This approach includes both saturation-excess run-off as identified using TWI, and infiltration-excess run-off (ie, run-off generated when rainfall intensity exceeds soil infiltration capacity) (Srinivasan and McDowell, 2007). Compacted areas (eg, deer wallows) are considered as infiltration-excess run-off areas.

#### *Phosphorus index*

The phosphorus index approach assumes a fixed distance on either side of waterways as hydrologically active during rainfall events, and hence critical to contaminant transport (Gburek et al, 2000).

#### *Drainage density*

The drainage density (DD) method of delineating critical source areas is similar to the phosphorus index method and hence assumes that critical source areas occur in near-stream zones on either side of streams. Unlike the PI, which is independent of catchment and rainfall properties, the extent of critical source area calculated by a DD model is dependent on the size of rainfall event selected and antecedent rainfall conditions. This method allows for variable critical source areas with varying rainfall and catchment wetness conditions (Gburek et al, 2002).

#### *Curve number*

The curve number (CN) is empirically-based approach (Soil Conservation Service, 1972) and does not represent any specific surface run-off generation process. It uses hydrological soil group and land-use and/or land-cover information to calculate run-off. Thus, the transport areas delineated using this approach are specific to a land use and soil group.

#### *Modified universal soil loss equation model*

The universal soil loss equation (USLE) method delineates high-risk areas for sediment export (Sivertun and Prange, 2003) based on at least five landscape and climatic characteristics: (1) soil erodibility; (2) slope steepness and slope length; (3) proximity to watercourses; (4) land cover and (5) rainfall erosivity.

### **6.1.2 Walkover surveys**

The simplest way to identify and assess potential critical source areas is to perform a visual inspection of contaminant sources and transport pathways during wet weather. During a so-called 'walkover survey', one is on the lookout for features which may accelerate or decelerate contaminant delivery to waterways (Reaney et al, 2019). Identifying such sources and sinks

enables critical locations (ie, critical source areas) to be targeted with effective mitigation strategies.

Walkover surveys can provide useful, highly detailed, site-specific information on a range of potential sources and pathways of contaminants (see [appendix 1](#) for a walkover survey guide). This method involves walking around a paddock, farm or catchment, usually during wet weather, looking for run-off-generating areas and their connectivity to waterways then marking this information on a map. A mobile-phone app has been used by Reaney et al (2019) to record features as either enhancing (a source/pathway) or decelerating (a sink/barrier) contaminant mobility. Such data can be mapped and analysed using computer software (eg, ArcGIS) (Reaney et al, 2019). These surveys provide a snapshot of water flows and the extent of ponding at the time during those conditions.

Gullies, swales and depressions (see [section 5.2](#)) should also be noted in the walkover survey and factored into the farm's IWG strategy to comply with regulations (see [section 4.1](#)). Muddy conditions are more likely to occur in areas of low elevation (eg, swales and depressions) because surface run-off tends to accumulate in these areas. In lieu of a soil moisture probe being available, visually examining soil moisture levels after rainfall events can help delineate the approximate extent of depressions and swales. Some signs to look for are:

- soils in these areas often stay wet for prolonged periods after heavy rain. Gumboots could be used to check if depressions made fill up with water
- a lack of oxygen in frequently waterlogged soils may produce the smell of rotten eggs (Fraser et al, 2018).
- Wetter soil conditions can result in differences in vegetation leaf colour or plant composition (Clarkson, 2014).

Identifying the extent of a critical source area could depend on a number of factors, including weather conditions, topography and soil type. In certain landscapes, such as U- or V-shaped valleys where the boundaries of the critical source area may not be well defined (as opposed to gullies), identifying indicators such as differences in vegetation, leaf colour, plant composition and soil moisture could help identify the full extent of the critical source area.

Other areas to note in the walkover survey include:

- **Bare soil:** When exposed to a rain event, bare soil can become quickly eroded, leading to sediment movement into adjacent waterways. Significant areas of bare soil can be a major source of sediment. If the entire area of IWG is grazed to bare soil, especially where roots are also removed by grazing and trampling, the risk is increased.
- **Pugged soils:** These have low infiltration rates and hence high potential for surface run-off. Pugged areas with strong connectivity to waterways can act as a critical source area.
- **In-paddock congregation sites and tracks:** Sites of heavy stock use that are compacted or pugged (eg, troughs, gates, livestock camps and tracks) have high concentrations of nutrients and low infiltration rates.
- **Farm machinery tracks:** These are often compacted, unvegetated areas that are at high risk of run-off, especially when aligned up and down a slope.
- **Surface drainage ditches:** Drainage ditches that usually run perpendicular to the slope can act as a major conduit of agricultural contaminants (sediments, nutrients and faecal material) to receiving water bodies (Nguyen and Sukias, 2002; Moloney et al, 2020).

## 6.2 Managing critical source areas

### Key points

- Planning and preparation, before the start of the IWG period on 1 May, includes considering site factors like slope and soil type, along with the proximity of IWG to waterways and critical source areas, to select appropriate locations for grazed winter forage crops.
- Protecting and fencing off critical source areas and waterways should be considered before intensive winter grazing. Cultivation methods will also reduce the risk of contaminant loss from grazed winter forage crops.
- During intensive winter grazing from 1 May to 30 September, there must be some form of vegetation covering the critical source area, and livestock must be excluded from critical source areas. A buffer around a critical source area acts as a filter to trap sediment from cultivated areas and slow surface run-off before it reaches the critical source area.
- Appropriate paddock selection for grazed winter cropping can be an effective way of minimising the risk of surface run-off and associated contaminant transport.

### 6.2.1 Management before winter grazing

Permitted activity conditions for critical source areas during intensive winter grazing relevant to the planning and preparation stage before 1 May are:

- **Slope:** The slope of any land under an annual forage crop that is used for IWG must be 10 degrees or less, determined by measuring the slope over any 20-metre distance of the land. Any areas of land that are at or below the slope threshold of 10 degrees can be used for IWG.
- **Waterways:** Livestock must be kept at least 5 metres away from the bed of any river, lake, wetland or drain. Selecting paddocks well away from any waterways will minimise the risk of contamination impacting water quality, and the need for additional fencing.

Other good management practices to consider during the planning and preparation stage are as follows.

#### Paddock selection

- **Heavy soils:** Heavy or poorly drained soils are at greater risk of pugging, compaction and structural damage, and increased surface run-off due to winter grazing (Drewry et al, 2008). Therefore, on heavy soils IWG should be on the flattest areas of the farm to minimise surface run-off and associated contaminant transport. Buffer areas around critical source areas on rolling, heavy soils will need to be larger to account for the increased surface run-off (see case studies 1 and 4 in [section 7.2](#)).
- **Light soils:** Lighter or more freely draining soils are at less risk of producing surface run-off. However, lighter soils may pose a risk of increased nitrogen leaching (Malcom et al, 2022). If the farm is in a nitrogen sensitive catchment, selecting a paddock with less free-draining soil will reduce the risk of nitrogen leaching.

## Critical source area protection

- **Fencing:** Livestock grazing critical source areas risks soil damage and direct deposition of dung and urine. This risk is minimised by excluding livestock from critical source areas with either a temporary or permanent fence. Ideally, the critical source area should be permanently removed from production with a permanent fence. However, if the area is to be sown in crops and grazed outside the winter grazing period, a temporary fence is appropriate.
- **Traffic:** Machinery and stock access points are compacted areas frequently trafficked by vehicles or animals and can become muddy during winter, posing a significant risk of contaminant mobilisation (see case study 2 in [section 7.2](#)). Therefore, intensive winter grazing should be located safely away from these points to minimise the risk of surface run-off from these mobilisation areas.
- **Vegetation cover:** Bare, unprotected soil is at risk of sediment loss, especially in critical source areas during winter. Therefore, leading into autumn, efforts should be made to establish and maintain vegetation cover in critical source areas ahead of the intensive winter grazing period, although this will be difficult in gullies.
- **Vegetated buffers:** A buffer around a critical source area acts as a filter to trap sediment running off cultivated areas and reduces contaminant loads before they reach the critical source area (see [box 3](#)). The optimal buffer width required for nutrient and sediment removal can be highly variable (Zhang et al, 2010). In general, wider buffers are needed on steeper farms and poorly draining soils because these all tend to generate fast-flowing surface run-off. Concentrated flow of surface run-off from agricultural fields may limit the capability of buffer strips to remove contaminants (Dosskey et al, 2002). In such situations, performance may be boosted by simply redistributing the buffer area, ie, creating a larger buffer area where there is greater run-off load, or a smaller buffer area where the run-off load is less (Dosskey et al, 2005).

### Box 3: What is a 'buffer'?

In this context of this guidance, a buffer is the strip of land that surrounds a critical source area ([figure 2](#)), where the land-use activity is modified to prevent adverse effects on water quality (cf Parkyn et al, 2000). Buffers use vegetation to slow water movement and enhance the removal of sediment, nutrients and faecal microorganisms from surface water run-off through filtration, deposition, adsorption and infiltration (Dillaha et al, 1989).

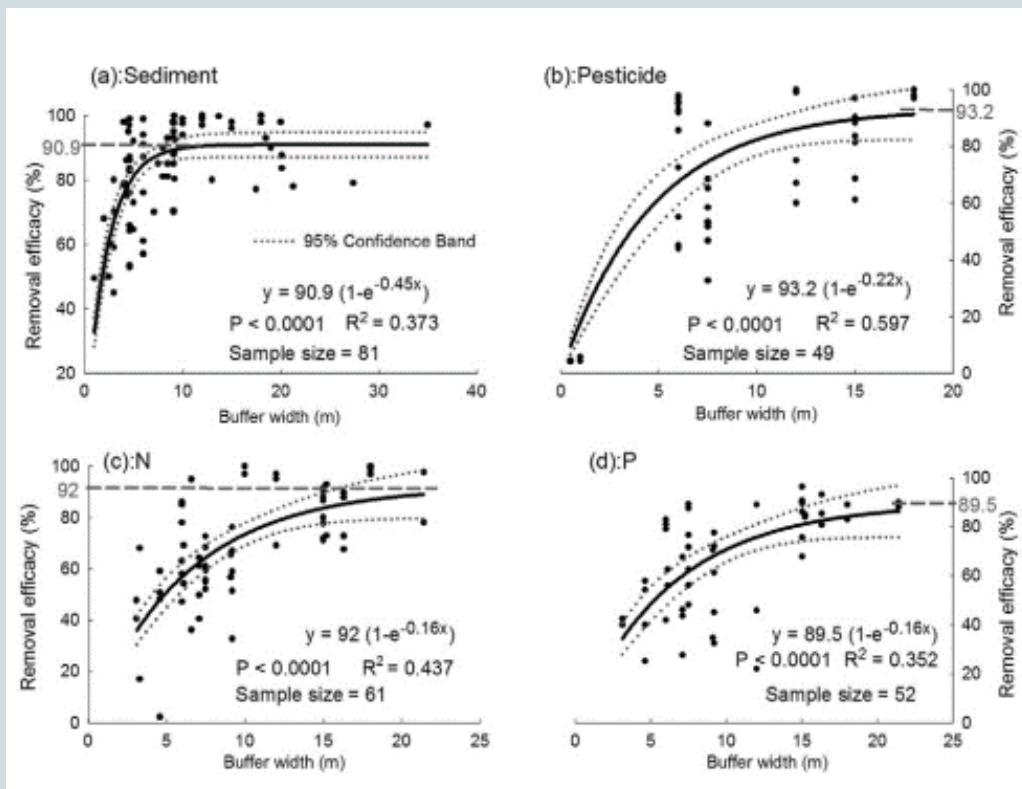
New Zealand examples of vegetated buffers show benefits such as improved soil infiltration capacity (Cooper et al, 1995), reduced sediment and nutrient concentration in surface run-off entering the waterways (Smith, 1989) and elevated faecal microbe retention (Collins et al, 2004). Our literature review found very few studies relate to buffer widths for specific land uses or management. A meta-analysis by Zhang et al (2010) of how efficient vegetated buffers are in mitigating adverse effects on water quality ([figure 3](#)) has been widely cited as a source of data on buffer widths, including in the Government's Action for Healthy Waterways (Essential Freshwater) decisions (Ministry for the Environment, 2020).

Despite wide data scatter, the meta-analysis shows that for a land slope less than 10 degrees, a buffer width of 5 metres can potentially remove more than 60 per cent of sediment and less than 50 per cent of nitrogen and phosphorus in surface run-off ([figure 3](#)). In all cases, the ability of the buffer to remove contaminants and sediment increases quickly as it gets wider with this rate of increase slowing as the buffer width increases until the effectiveness approaches a maximum value. Note, this meta-analysis was not considered in the context of IWG areas where contaminant run-off is typically higher than in areas of grazed pasture.

Figure 2: An example of buffer strip on either side of a critical source area



Figure 3: Contaminant removal efficacy versus buffer width for: (a) sediment, (b) pesticide, (c) nitrogen and (d) phosphorus



Black dots are data and solid lines are model predictions. Dotted lines indicate the 95 per cent confidence band. Grey numbers with dashed lines are maximum removal efficiency.  
Source: Zhang et al, 2010.

## Cropping methods

- **Reduced tillage:** Establishing winter forage crops with reduced tillage (eg, no tillage, shallow non-inversion tillage or strip tillage) can reduce the risk of pugging and compaction during winter grazing (Thomas et al, 2004; Hu et al, 2020).
- **Cultivation:** If cultivating on sloping land, cultivate across the slope. Cross-slope cultivation creates a barrier to surface run-off, thereby reducing flow velocity, and providing more time for water to infiltrate (Ghimire et al, 2021; Quinton and Catt, 2004). Soil loss from contour-cultivated fields is usually reduced by at least 30 per cent, and often 90 per cent or more, compared with fields that are cultivated downslope (Hudson, 1981).

### 6.2.2 Management between 1 May and 30 September

The NES-F includes permitted activity conditions for any critical source area that is within, or adjacent to, any area of land that is used for intensive winter grazing on a farm. These conditions include the following:

- **CSA livestock exclusion:** A critical source area cannot be grazed to reduce the risk of soil damage and contaminant run-off. Grazing outside this period is permitted but local councils may have additional regulations that must be complied with.
- **CSA vegetation cover:** Vegetation must be maintained over the entire critical source area during this period. This is to protect the soil and slow surface run-off.
- **No CSA cultivation or harvesting:** Critical source areas in land used for IWG should be left intact and not cultivated. Cultivation during this period could damage soil structure and further increase sediment losses.

Other good management practices to consider during winter grazing include:

- **Grazing direction:** Considering the direction of grazing can minimise the risk of contaminant loss from non-critical source area areas. Grazing towards the location of the critical source area will maximise the buffering opportunity of the un-grazed crops between the herd and critical source area (Monaghan et al, 2017).
- **Fencing:** Back-fence to confine areas of damaged soil as much as possible. A back fence will reduce animal pacing and therefore limit soil damage through unnecessary stock movement (Drewry and Paton, 2005). Back fencing is not appropriate for deer.
- **Livestock:** In general, heavy soils are at greater risk of pugging, compaction and structural damage. Consider only grazing lighter classes of stock on heavy soils during winter.

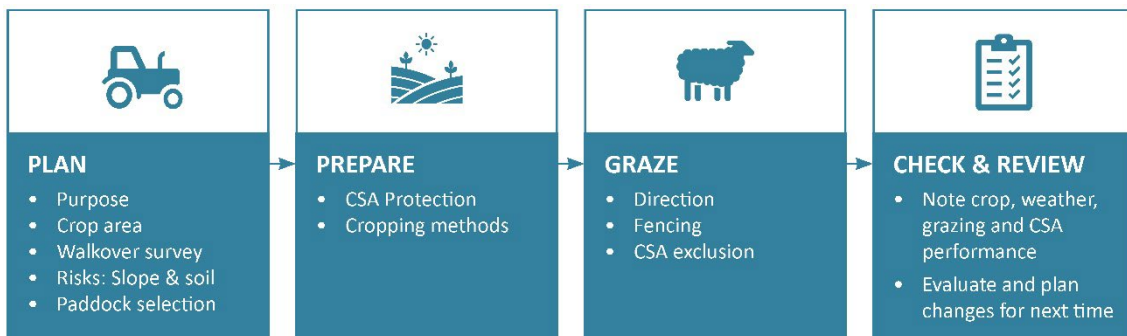
If critical source areas need to be grazed (requiring a resource consent), soil damage, surface run-off and contaminant loss could be minimised by limiting the extent of crop grazing. This could be achieved by delaying grazing of critical source areas until as late as possible in winter (thereby potentially avoiding rainfall events that are likely to produce surface run-off and associated contaminants loss), and by implementing a time-restricted (on-off) grazing regime (McDowell and Houlbrooke, 2009). Most surface run-off is likely to occur in winter when soil water content is at or above field capacity (Curran-Cournane et al, 2011).

# 7. Integrating critical source area management with the winter forage crop cycle

## 7.1 Winter forage planning

Best practice may be to integrate the management of critical source areas into the entire winter forage cropping cycle, from planning to execution as well as future planning of winter crops (figure 4). This section presents a holistic approach to grazed winter forage cropping. It integrates the relevant IWG regulations with the main decision points of the grazed winter forage cropping cycle. This process is focused on meeting the conditions for permitted activities (pathway 1; box 2). If the conditions for permitted activities (box 2) are not met, and IWG is not managed as a permitted activity under a certified freshwater farm plan (see section 4.2), then applying for a consent will need to be added to the planning stage of the cycle. Remember that regional plans may also address related issues, and whichever rules are more stringent apply.

Figure 4: Overview of the stages and key decision points in the grazed winter forage cropping cycle



(These stages and key questions are expanded on in table 2.)

Planning begins with considering the purpose for planting a winter forage crop, how much feed is needed and therefore how large an area is required. Paddocks with a low risk of contaminant loss in surface run-off should be prioritised for winter forage cropping. Factors such as soil, slope, proximity and connection to water should all be considered.

Recommended actions for managing critical source areas before and during grazing is detailed in section 6.2 and in the framework below (table 2).

At the completion of the grazed winter forage cropping cycle, it is important to check and review outcomes to help improve future winter grazing plans. This includes documenting what worked well and any critical source areas that might have been missed in the initial planning.

Table 2 provides a framework to navigate the key decisions in IWG planning, from planning through to review (figure 4).

**Table 2: A decision framework for intensive winter grazing, covering the planning phase through to the review stage**

This template can be used to capture the decisions made at each step and could potentially be used for compliance checks.

		Questions	Notes
PLAN	Purpose	<p><b>1. What is the purpose of your winter forage crop?</b></p> <ul style="list-style-type: none"> <li>• Additional feed over winter?</li> <li>• Keep livestock off the rest of the farm?</li> <li>• Part of the pasture renewal cycle?</li> </ul>	
	Crop choice	<p><b>2. What crop are you choosing to grow and why?</b></p>	<p>A high-yielding winter forage crop like fodder beet leads to higher intensity grazing and greater risk of soil damage.</p> <p>Companion planting, such as plantain sown with a brassica, can reduce the period of bare soil after winter grazing (see also the <a href="#">Ministry's groundcover guidance</a>).</p>
	Area required	<p><b>3. What area of crop (Q2) do you need to meet your need and/or purpose (Q1)?</b></p>	<p>If this area is &gt;50 ha or 10% of your farm, you will need to apply for a resource consent. The area must also be no greater than the maximum area of land used for IWG in the reference period (1 July 2014 and 30 June 2019).</p> <p>Alternatively, revisit Q1 and Q2 and rethink crop choice based on purpose.</p>
	Walkover survey	<p><b>4. What features are in your prospective IWG paddocks that have the potential to accelerate contaminant delivery to waterways during intensive winter grazing?</b></p> <p>(See <a href="#">section 6.2.2</a> for features to note and use the walkover survey guide in <a href="#">appendix 1</a>.)</p>	<p>The walkover survey includes identifying critical source areas and waterways that are important for paddock selection. Critical source areas must be protected, and livestock must be kept at least 5 metres away from waterways from 1 May to 30 September (see <a href="#">section 4</a>).</p>
	Risk factor: Slope	<p><b>5. What is the slope in the paddock you plan to crop?</b></p>	<p>If this is more than 10 degrees, you will need to apply for a resource consent.</p> <p>Alternately, you can choose not to crop the steeper sections of the paddock.</p>
	Risk factor: Soil	<p><b>6. Is it a heavy soil in the paddock you plan to crop?</b></p> <p>If yes:</p> <p><b>6a. How do you plan to mitigate the risk of soil damage?</b></p>	<p>In general, heavy soils are more susceptible to damage from winter grazing compared with free-draining stony soils (Drewry et al, 2008). See also <a href="#">section 6.2</a>.</p>
	Paddock selection	<p><b>7. Choose the location best suited to grow and graze your preferred crop with minimal impact on the environment.</b></p>	<p>Also check local regional plans that may address related issues, and whichever is more stringent applies.</p>



PREPARE	Cropping methods	<b>8. What preparation does the selected paddock(s) require? How will you minimise the risk during the establishment period?</b>	<p>Ensure clear communication with any external contractors by indicating sites to protect or avoid.</p> <p>Establishing winter forage crops with reduced tillage (eg, no tillage, shallow non-inversion tillage or strip tillage) can reduce the risk of pugging and compaction during winter grazing (Thomas et al, 2004; Hu et al, 2020). See <a href="#">section 6.2.1</a>, and also the <a href="#">Ministry's pugging guidance</a>.</p>
	Critical source area protection	<b>9. What is your plan for protecting the CSAs identified in your walkover survey?</b> <ul style="list-style-type: none"> <li>• Is it worth permanently fencing off the area?</li> <li>• How large a buffer area around the CSA should you allow for based on site factors and previous experience?</li> <li>• Is there good vegetation cover in the CSA?</li> </ul>	Fence off CSAs temporarily to graze the area outside the winter grazing months (from 1 May to 30 September), or fence permanently.
GRAZE	Grazing	<b>10. How will you graze your forage crop to reduce the risk of contaminant loss?</b>	<p>Grazing during winter when soil is very wet can significantly increase the potential for contaminant loss in surface run-off. To reduce this risk, the stocking rate can be reduced, and lighter animals used on wetter areas.</p> <p>Considering the direction of the grazing can be helpful. Grazing towards the CSA location will maximise the buffering opportunity of the un-grazed crop still standing between the herd and CSA.</p>
CHECK	Crop	<b>11. How well did your crop choice and sowing methods work?</b> <ul style="list-style-type: none"> <li>• Was the crop sown in the intended place?</li> <li>• Was there good establishment?</li> <li>• Did you use the right spray and fertiliser regime?</li> <li>• Were there any animal welfare issues?</li> </ul>	<p>Note that vegetation must be established as groundcover on land used for intensive winter grazing as soon as practicable after livestock have finished grazing.</p> <p>See also the <a href="#">Ministry's groundcover guidance</a>.</p>
	Weather	<b>12. What was the weather like during this winter, and how might that have influenced IWG outcomes?</b> <ul style="list-style-type: none"> <li>• Was it wetter/dryer/warmer/colder than normal?</li> <li>• Did it rain for longer than normal?</li> </ul>	

	<b>Critical source area</b>	<b>13. Were the CSAs where you expected?</b> <ul style="list-style-type: none"> <li>• Was the area fenced sufficient?</li> <li>• Were there any 'new' surface flow paths or wet areas not marked on the map?</li> <li>• Did any surface flow bypass the buffer or CSA?</li> <li>• Did you take photos of the CSAs for next time and consider where they are stored?</li> </ul>	
<b>REVIEW</b>	<b>Crop, fencing and critical source areas</b>	<b>14. What would you change for next time?</b> <ul style="list-style-type: none"> <li>• Was enough, or too much, feed grown?</li> <li>• Did wet conditions result in low use of feed?</li> <li>• Would it be better to fence in another place?</li> <li>• Do you need a bigger or smaller buffer area?</li> </ul>	

## 7.2 Case studies of critical source area management

Critical source areas are not always easy to spot, and their size and extent will vary from year to year depending on climate conditions. Five case studies of critical source areas are presented below, representing protected and unprotected critical source areas on different soil types in different regions, evaluated according to the stages in the winter forage cropping cycle outlined in [figure 4](#).

### Case study 1: Protected critical source area on rolling slope

**Plan and prepare:** In this example of good practice, a critical source area has been identified in a low-lying area of the paddock where surface run-off collects.

**Graze:** The critical source area has been fenced to exclude livestock and protect the critical source area.

**Photos:** Pre-grazing (above) and post-grazing (below).



## Case study 2: Unprotected critical source area on (mostly) flat slope

**Prepare and graze:** In this example, surface run-off has accumulated in the compacted margins of the paddock (ie, farm tracks), and surface flow runs through the paddock connecting the contaminants with a waterway in the distance (indicated by the blue line).

**Check and review:** Future plans for IWG should consider excluding livestock from the paddock margins to preserve ground and limit surface run-off. The critical source area where the surface runoff enters a waterway should also be protected from grazing, including a buffer area (see case study 1).

**Photo:** A grazed swale with bare soil and erodible sediment. The blue line represents the surface flow connecting the contaminants with a waterway. (Note this photo was taken before IWG regulations came into effect).



### Case study 3: Flat, unconnected depression

**Plan:** In the example below, ponding and pugging is visible through the middle of the paddock. However, this area does not appear to be connected to surface water and therefore is a lower risk of becoming a critical source area, except in extreme weather.

**Prepare and graze:** Winter crop could be sown in this paddock, and the grazing strategy should take into account the wetter areas of the paddock, with grazing in drier weather. Be prepared to remove stock from this paddock if extreme weather occurs and there is any risk of critical source area connectivity.

**Review:** Reflect on the winter season: was the extent of ponding in the depression larger than expected? Were there periods when surface flow did connect, or was at risk of connecting, with a drain or other waterway? Mark out the extent of ponding and surface flow pathways and consider if during the next grazed winter crop rotation some areas might not be cropped. See also the Ministry's pugging guidance.

**Photo:** Pasture with ponding and pugging running through the centre.



#### Case study 4: Unprotected critical source area on rolling slope

**Plan:** In this example, surface run-off is clearly visible, and the swale channels the run-off across a laneway and into a surface drain. Sediment and nutrients from winter grazing have a clear pathway to impact water quality during rainfall events. Note the slope is greater than 10 degrees in some areas of this paddock, and a resource consent would be needed (if there was no freshwater farm plan). Alternatively, the steeper areas of the paddock could remain in pasture while the rest is used for intensive winter grazing.

**Prepare and graze:** Protecting the critical source area through vegetation cover and by excluding livestock will minimise the loss of contaminants from winter grazing. The area shaded in blue the photo below represents an estimate of the critical source area that should have been protected from grazing within the IWG paddock.

**Check and review:** How well did the protected area stop the flow of sediment from the surrounding grazed area? For the next grazed winter cropping rotation consider if the protected area should be larger or smaller, based on the observations from this year.

**Photo:** A grazed winter forage with bare soil and erodible sediment. The area shaded in blue represents an estimate of the critical source area that should have been protected from grazing. (Note this photo was taken before IWG regulations came into effect).



### Case study 5: Protected critical source area on rolling slope

**Plan and prepare:** In the example below, the low-lying areas of the paddock were left in pasture. This area will intercept contamination from surface run-off (blue arrows) from the cropped area, while excluding livestock will help protect this area from pugging and soil compaction.

**Graze:** This critical source area will remain ungrazed from 1 May to 30 September but can be opened for grazing afterwards using good management practices.

**Check and review:** Reflect on the winter season. Was the size of the area left in pasture large enough to cover the critical source area? Were there any unexpected ephemeral flow paths that bypassed the protected critical source area?

**Photo:** An ungrazed winter forage with critical source area in the foreground, left in pasture. The blue arrows represent the surface run-off that will occur when the winter forage crop is grazed.



## 8. Knowledge gaps and limitations

### **Delineating critical source areas is challenging**

Delineating critical source areas is challenging as the areas generating run-off expand and contract in response to rainfall. A practical approach may be to define areas that are active (ie, generate significant amounts of run-off) during much of the winter, but are small enough to retire to allow productive land use, without compromising surface water quality (eg, McDowell and Srinivasan, 2009). The optimum critical source areas for environmental outcomes need to be assessed for different soil types, topographies and climates.

### **More methods needed to identify critical source areas**

Although the walkover survey is a more practical approach for identifying critical source areas, it is often challenging due to the need to collect data across seasons and in different weather conditions. Modelling approaches can help narrow down some of these challenges. For example, technology such as LiDAR can be used to create three-dimensional, digital, elevation models of a farm, which can be used to identify surface run-off pathways and waterway networks. However, to the best of the authors' knowledge, no study has evaluated different techniques for identifying critical source areas in the context of IWG. Further research is recommended to evaluate different methods for identifying critical source areas and help confirm the optimum criteria.

### **Contaminant transport in run-off is spatially and temporally non-uniform**

Contaminant transport in run-off is spatially and temporally non-uniform. Heavy rainfall can produce surface run-off that is funnelled through micro- and ephemeral channels which may limit the capability of buffer strips to remove contaminants (Dosskey et al, 2002). In such situations, performance may be boosted by redistributing the buffer area, ie, creating a larger buffer area where there is greater run-off load and a smaller buffer area where the run-off load is low (Dosskey et al, 2005). However, there is a lack of quantitative methods that enable evaluation of field surface run-off patterns and their impact on buffer effectiveness in the context of intensive winter grazing.

### **Cross-slope cultivation can be less effective on heavy soils in regions subject to intense rain**

Cross-slope cultivation can be less effective on heavy soils (with high clay content and low infiltration rates) in regions subject to intense rain. In these cases, run-off can pond in furrows until it breaches the cultivation ridges, forming downslope rill erosion. In such situations, wider buffers may be needed around a critical source area. Further research under different soils and climates is recommended to determine the effectiveness of cross-slope cultivation.



# Appendix 1: Walkover survey guide

## Purpose

To observe and identify landscape features with the potential to accelerate contaminant delivery to waterways during intensive winter grazing. The main focus of this survey guide is sediment, as it is relatively easy to observe.

## What to bring

A notepad and camera.

## Tips

- The bank of a stream is a good place to start gathering observations, but any place on the farm can serve as a starting point.
- Make your observations during or directly after a significant rainfall event, when soils are saturated.
- Walk around the area intended for intensive winter grazing and record observations like: Is there muddy water running off the paddock and entering the stream? Include areas next to intensive winter grazing areas as these may contribute to or mitigate contaminant losses. (This should be done for the whole farm, but the focus of this guide is intensive winter grazing areas on farms.)

## Farm walkover survey

Date and Time: \_\_\_\_\_

Weather during survey: \_\_\_\_\_

Has it rained in the past 24 hours?

No

Yes

### NOTES

*If the answer is yes, make a note of where and take a photo for later.*

#### 1. Intensive winter grazing critical source areas

Signs to look for: Often stay wet for prolonged periods after heavy rain (depression or swale) and steeply eroded banks (gully). (See [section 5.2](#) for definitions.)

- |                  |                             |                              |
|------------------|-----------------------------|------------------------------|
| a. Gully/gullies | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| b. Swale(s)      | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| c. Depression(s) | <input type="checkbox"/> No | <input type="checkbox"/> Yes |

#### 2. Transport pathways/connectivity

Signs to look for: Evidence of flow or run-off — trace back to source and correct the problem. (See [section 5.1](#) for definitions.)

- |  |                             |                              |
|--|-----------------------------|------------------------------|
| a. Waterways: rivers, lakes, wetlands, or surface drains | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| b. Ephemeral waterways                                   | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| c. Springs and seeps                                     | <input type="checkbox"/> No | <input type="checkbox"/> Yes |

#### 3. Sediment mobilisation — accelerating features

Signs to look for: Areas of frequent ponding or standing water, areas that are heavily trafficked either by livestock or machinery and bare soil. (See [section 6.1.2](#)).

- |  |                             |                              |
|--|-----------------------------|------------------------------|
| a. Bare soil   | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| b. Pugged soil (see pugging guidance)                          | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| c. In-paddock congregation sites (eg, gateways, water troughs) | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| d. Concreted areas   | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| e. Farm machinery tracks                                       | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| f. Races or lanes  | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| g. Stream crossings  | <input type="checkbox"/> No | <input type="checkbox"/> Yes |

#### 4. Sediment mobilisation — decelerating features

Signs to look for: Vegetated areas that slow water flow, filter or trap sediment and protect waterways from contamination (see [section 6.2.1](#)).

- |  |                             |                              |
|--|-----------------------------|------------------------------|
| a. Buffer strips (could be unmanaged land) | <input type="checkbox"/> No | <input type="checkbox"/> Yes |
| b. Forestry or bush blocks                 | <input type="checkbox"/> No | <input type="checkbox"/> Yes |

# Appendix 2: Other critical source areas

The following critical source areas are outside the IWG regulations as they are not affected by management measures relevant to winter grazing. However, it is important to note these are also potential sources of contaminants to freshwater.

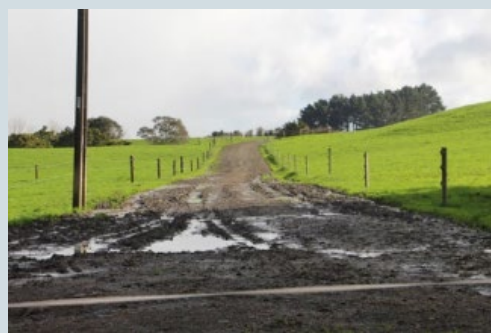
## In-paddock stock congregation sites

Feed areas, stock campsites, water troughs and gateways. These areas often have a build-up of manure and compacted, exposed soil and are source areas of N, P, sediment, and *E. coli* (Lucci et al, 2010; Hively et al, 2005).



## Raceways

Can directly transport or deposit (at crossing points) contaminants (bacteria, sediment and nutrients (mostly N and P) into surface waterways) (Lucci et al, 2010; Hively et al, 2005; Monaghan and Smith, 2012).



Waikato Regional Council, 2019

## Stream and river crossings

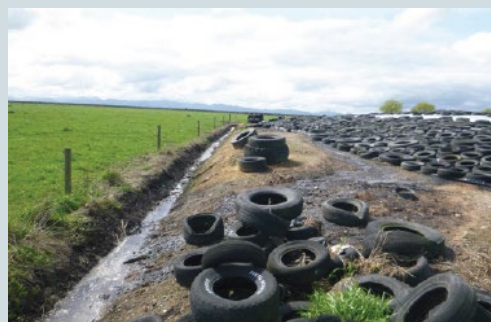
Due to their immediate proximity to surface water, the risk of contamination from these critical source areas is high (Davis-Colley et al, 2004).



Waikato Regional Council, 2019

## Silage pits or feed bunkers

Leachate from the storage of silage is a known source of nutrients and can contaminate ground and surface waters (Gebrehanna et al, 2014). Good design of pits and bunkers to capture and contain run-off will reduce the risk of these contaminants reaching waterways.



Waikato Regional Council, 2019

### **Yards and animal holding areas**

Due to the high concentration of livestock and deposition of faeces and urine, surface run-off from these areas is enriched in nutrients (Hively et al, 2005).



Waikato Regional Council, 2019

# Appendix 3: Quick reference guide to critical source area guidance

This is a plain language summary of the critical source area (CSA) guidance to help farmers identify and manage critical source areas.

Also refer to the intensive winter grazing module on the [Ministry for Primary Industries' website](#).

## What is intensive winter grazing?

Intensive winter grazing (IWG) refers to the grazing of livestock on an annual forage crop (a crop that is grazed where it is grown, excluding pasture, or a crop that is grown for arable land use or horticultural land use) from 1 May to 30 September.

## What are critical source areas?

The defining feature of a critical source area is the combination of a contaminant source (eg, nutrients, sediment or faecal microorganisms) and a transport pathway (eg, overland flow, ephemeral drainage or stream). Most surface run-off is likely to originate within wet areas (eg, swales and gullies) where the soil is vulnerable to damage.

According to the IWG regulations, a CSA is defined as a landscape feature that accumulates surface run-off from adjacent land; and delivers, or has the potential to deliver, 1 or more contaminants to 1 or more rivers, lakes, wetlands, or drains, or their beds.

Intensive winter grazing generates contaminants by livestock depositing dung and urine in a concentrated area and also via animal treading, which often causes pugging damage and the dislodging of soil particles.

## What are the conditions for permitted activities?

Conditions for permitted intensive winter grazing activities must meet all the following conditions for slope, area and livestock exclusion:

- **The area** of the farm that is used for intensive winter grazing must be no greater than 50 hectares or 10 per cent of the area of the farm, whichever is greater.
- **The slope** of any land under an annual forage crop that is used for intensive winter grazing must be 10 degrees or less, determined by measuring the slope over any 20-metre distance of the land.
- **Livestock** must be kept at least 5 metres away from the bed of any river, lake, wetland or surface drain (regardless of whether there is any water in the waterway at the time).
- From **1 May to 30 September** of any year, in relation to any critical source area that is within, or adjacent to, any area of land that is used for intensive winter grazing on a farm:
  - the critical source area must not be grazed

- vegetation must be maintained as groundcover over the whole critical source area
- maintaining that vegetation must not include any cultivation or harvesting of annual forage crops.

## Examples of critical source areas specific to intensive winter grazing

### Swale

- Swales are found in lightly sloping to rolling paddocks and concentrate water flows from the surrounding area into a shallow channel.
- Swales only conduct water during or after rainfall events and may act as temporary flow paths connecting contaminants with waterbodies.
- Soils in this part of the paddock are often very wet, possibly marshy and are thus at substantial risk of generating run-off during rain events.

**Photo:** Sheep grazing a winter forage crop, with an unprotected, grazed swale. The swale is evidenced by the temporary waterway snaking its way through the bare, grazed soil in the middle of the photo. (Note this photo was taken before IWG regulations came into effect).



## Gully

- In contrast to a shallow swale, a gully is a deep trench, or channel, where the soil has been carried away, exposing bare ground.
- On sloping land, shallow gullies sometimes form where surface run-off from vegetated ground flows onto patches of bare soil. The run-off picks up soil particles, initially rilling the bare surface (Hicks, 1995). The rills deepen with each subsequent rainfall event, eventually forming gullies which cut back and undermine surrounding earth. Very deep gullies can form on hill country if the underlying base is weathered rock, rich in clay.
- Small, shallow gullies are of main concern for grazed winter cropping, as deeper gullies are unlikely to be sown in a winter forage crop, and do not meet the permitted slope conditions of less than 10 degrees. However, if deeper gullies are next to winter grazing areas, appropriate management should be in place to protect these areas from livestock grazing (see section 6.2).

**Photo: Post-winter grazing of an unprotected gully. (Note this photo was taken before IWG regulations came into effect).**



## Depression

- A depression is a low, possibly marshy area in the landscape that becomes saturated periodically.
- During and after rainfall, depressions may connect to waterways through temporary flow paths. These can create pollution downstream.
- Depressions vary in both size and depth and are most easily identified by the presence of temporary standing water (or ponding) during wetter months.

**Photo:** A grazed depression with bare soil and erodible sediment in the centre of the photo. (Note this photo was taken before IWG regulations came into effect.)





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