Horizons Regional Council:

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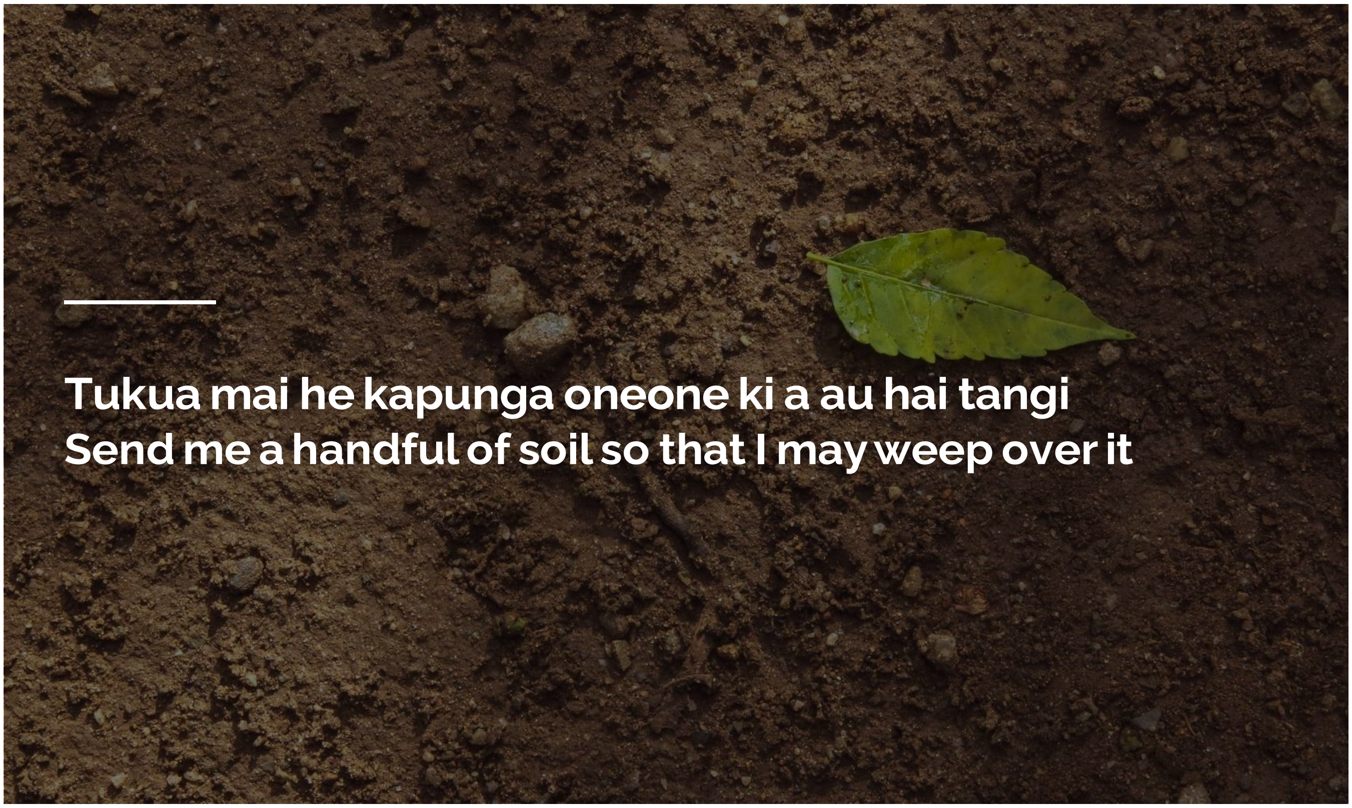
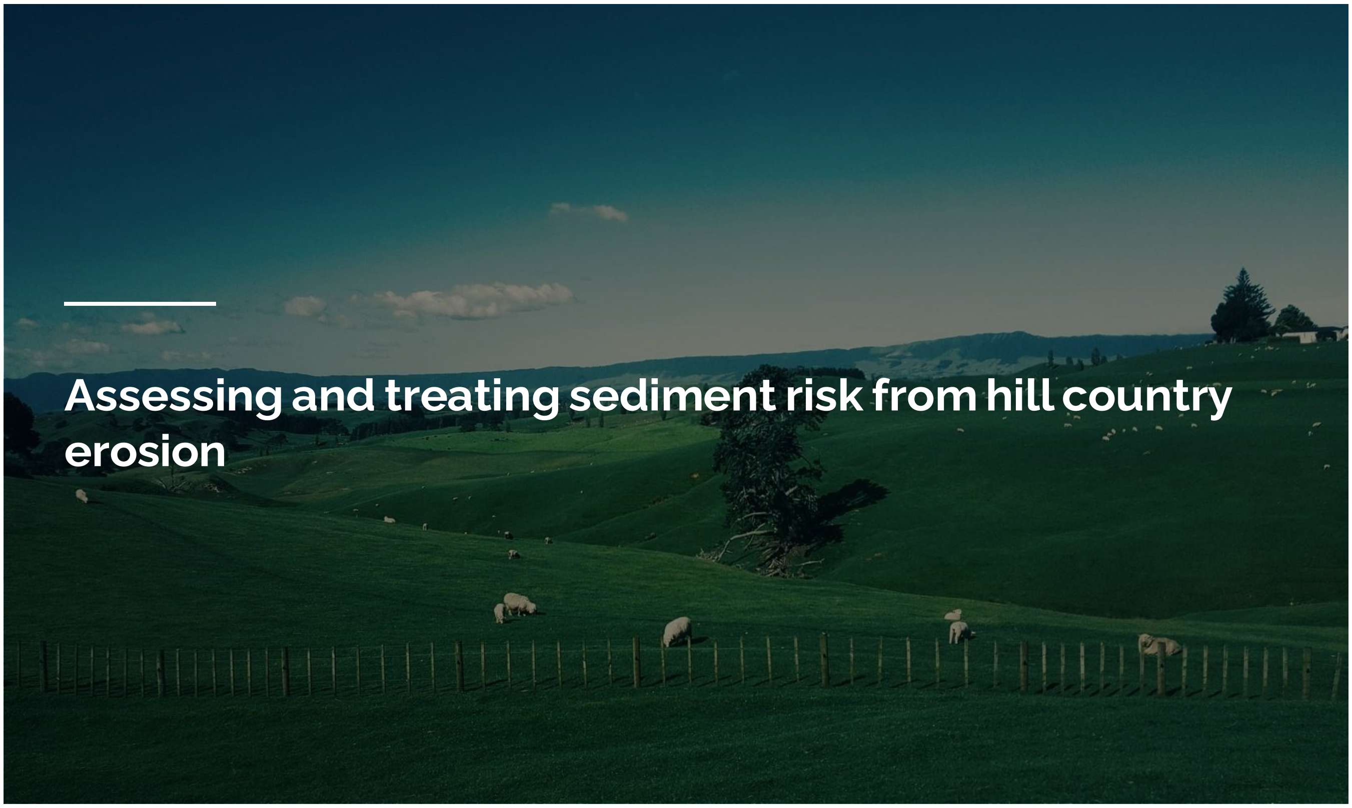
Lesson 1 - Introduction



This document explains how different landforms influence erosion type and sediment loss, and how to mitigate or treat those sediment sources. Erosion processes that are strongly linked to landform will be examined, along with those with less landform influence. You will gain an understanding of the following:

1. The links between hill country erosion types and sediment in rivers
2. How to target treatment actions to the right place and issue
3. How to use Horizons SLUI sediment priority classes to check the prioritisation of actions.

Lesson 2 - Understanding the links between hill country erosion types and sediment contamination in rivers



Introduction to erosion types

Land Use Capability (LUC) is a national system of land mapping. It provides a useful way of standardising assessment of land and soil features relevant to erosion, soil damage and productive use (called the Land Resource Inventory) and a standardised way of grouping these into consistent Land Use Capability Units (LUC units). Refer to the Land Use Capability Survey Handbook (Lynn et al, 2021 available on www.landcareresearch.co.nz keyword LUCS Handbook), chapter 2.4, and appendix 2 for further description and illustration of these erosion types. Also, refer to the relevant LUC legend for the area of the farm. There are three main LUC legends in the Horizons region; Taranaki-Manawatu, Southern Hawkes Bay-Wairarapa and Wellington. See the Regional Information document for where to find these.

Mass movement types

Soil slip

Horizons most common erosion type, responsible for the majority of sediment movement to waterways.

Earthflow and slump

Less common than slips but can discharge far greater quantities of sediment per hectare if combined with gully or streambank undercutting.

Debris avalanche

Slips inside forest with both wood and soil moving. These are often natural rather than accelerated erosion.

There has been erosion in New Zealand ever since some of the landmass was first uplifted out of the sea. As such, erosion is a natural process caused by plate tectonics. Natural erosion continues even in remaining areas of native forest. However, in the last several hundred years, clearance of native forest and introduction of farming, logging, grazing animals, and other human activities has resulted in the rate of erosion speeding up.

This is most evident in hill country and steep land. This ‘speeded up’ proportion of the erosion, often termed accelerated erosion, is what occurs in modified land use, over and above what would have occurred prior to human intervention.

Fluvial erosion types

Gully

Gully erosion can be a significant source of sediment in unconsolidated sand, jointed mudstone, and argillite hill country as well as in pumice, particularly river terraces composed of water-sorted pumice.

Gully or streambank erosion often occurs at the base of earthflow or slump movements, resulting in a dramatic increase in sediment delivery to water. Gullies, earthflows and slumps are a top priority erosion type, with the priority in proportion to the severity of the gully and earthflow activity.

Fresh severe gully erosion in a recent large slump in jointed mudstone

Streambank

Some streambank erosion is natural, but the rate of erosion can be accelerated by over-straightening rivers or streams and by shrinking the width or the length of the channel over time.

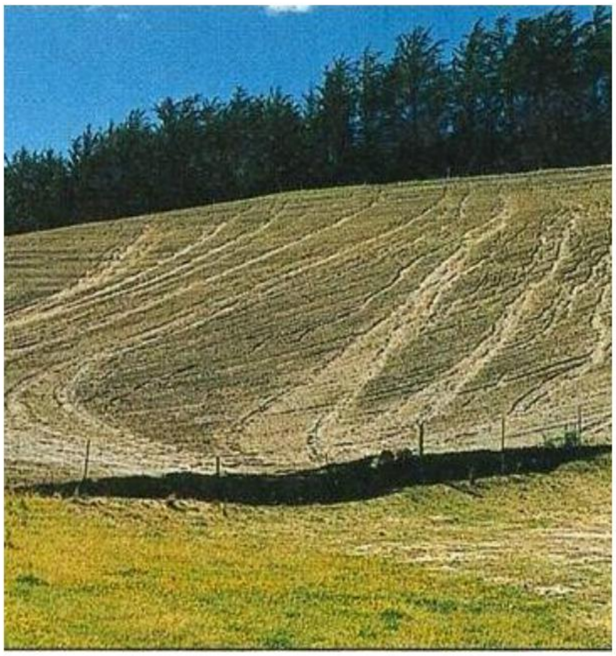
Fresh severe streambank erosion in alluvium near Weber

Tunnel gully

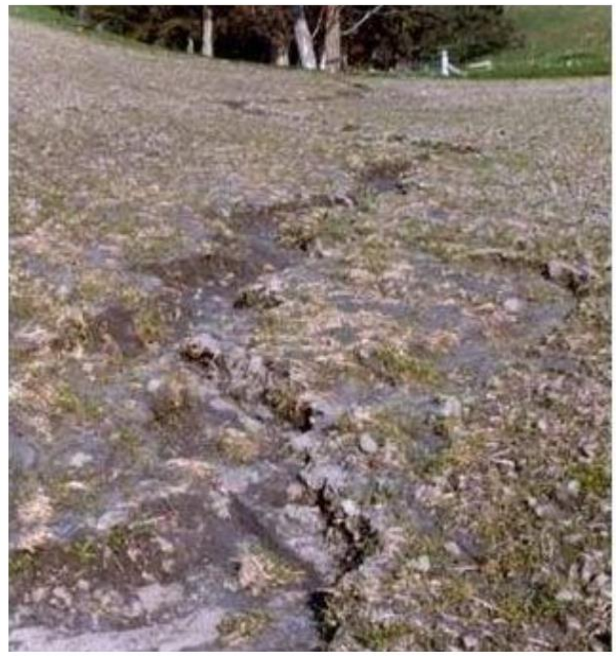
Under-runners due to lateral flow in sandy subsoil are a relatively minor contributor to sediment.

Rill

Small channels common in sandy slip scars or intensively winter grazed or cultivated paddocks.



Rill erosion in cultivated land



Intensively winter grazed soil

Surface erosion types

Sheet

Includes erosion from raindrop impact on any bare land, treading or wheel impact on saturated bare land or during wet weather, overland flow from tracks and other bare or cultivated land, intensive winter grazing, grazing in wet swales.

Sheet erosion in cultivated land (left) and on a farm track (right)

Wind

Not a major source of sediment affecting water quality.

Lesson 3 - Target treatment actions to the right place and issue

This section provides a guide to recognising and prioritising erosion to treat water quality issues for Horizons region.

Prioritising land for treatment of soil slip

Slips are a familiar landscape feature to most people. They tend to occur after hours or days of intense rainfall. The rain infiltrates the soil and at some point down the hill saturates the upper (usually 1 to 2 metres depth) soil, which fluidises reasonably suddenly and flows downslope, often as a liquid with lump.

Soil slip on very steep slopes

- Due to accelerated erosion caused by native forest removal, on land with over 35 degrees slope, skeletal soils dominate; meaning that virtually the whole surface is slip scars or healed scars.

- Very steep land has the greatest risk of soil slip erosion and the greatest risk of sediment going to water because most to all of the slip debris drops into a waterway.

- In the LUC system, where an entire hillslope is over 35 degrees it is often classed as 8e land; meaning not sustainable for forestry or farming due to slip erosion. Although class 8e slopes can contribute large quantities of sediment, much of the erosion is 'natural'. That is, it still occurs under native tree cover, in the form of debris avalanche erosion, albeit producing less sediment than where there is no tree cover.

  Appropriate treatment:
  - Where there is very steep hill with direct fall to a stream the best solution is native regeneration and retirement from grazing. Sheep grazing for weed control e.g., for old man's beard may be required in some areas.
  - Where forestry slash is unlikely to fall directly into a stream afforestation is usually a good option, depending on rooting ability of large trees.

Example of severe slip erosion from 2004, on steep to very steep 7e siltstone, Parikino. The upper section of the slope is mainly very steep, while the lower section is mainly steep. All slip debris was retained on the flat, making this hill lower priority for sediment than if there was sediment going into a waterway.

Soil slip on steep slopes

- From 26 to 35 degrees slope, steepland soils dominate.
- These have a severe risk of slip erosion.
- There is a high risk of sediment going to water because the lower slopes tend to be moderately steep to steep. Depending how close the hill is to a gully or stream, anywhere from all to virtually none of the slip debris drops into a waterway.
- This is where the greatest reduction in sediment from afforesting slip country can be achieved. Native regeneration can also control erosion.
- Planting poplar or willow poles may not be possible due to lack of soil and dry conditions, causing difficulty of ramming poles in and drought mortality. Wind is also a significant issue on exposed slopes in this region. The presence of these steep dry shallow soils severely limits the effectiveness of spaced planting to control slip erosion on spurs, north faces, and windy faces and slip scars. Spaced planting can be effective on parts of the hill where the steep soil is moist or on weakly consolidated sandstones. Otherwise afforestation is the only long-term effective option.
- Where most of a hill is steep, it is generally LUC Class 7e land; meaning it has severe limitations to forestry or farming due to slip erosion.
- On farmland steep slopes are distinguishable from moderately steep (21 to 25 degrees) by the presence of stock tracks.

Example of severe slip erosion from the 2004 storm, on steep to very steep 7e unconsolidated sandstone, near Pohangina. Most slip debris was initially retained in the swale. Swales have been accumulating sediment in this country since deforestation. This accumulated sediment does however slowly re-mobilise by sheet, rill or gully erosion if a dense forest cover is re-established with no willow, grass or other protection for the bare ground.

Soil slip on moderately steep land

- From 21 to 25 degrees slope hill soils dominate.
- Class 6e slip prone land averages out to around 21 to 25 degrees. It has moderate limitations to forestry or farming due to slip erosion. It can contain small areas of land over 35 degrees, as well as some land over 25 degrees, and land easier than 20 degrees on the lower slopes and in swales. The land over 25 degrees generates nearly all the slip erosion, while the easier slopes below frequently absorb most of the slip debris before it enters a waterway.
- These can also have slip scars, but generally only in seepage areas or very wet situations.
- These have a moderate risk of slip erosion and, unless directly above a waterway, will be low priority for reducing sediment in streams.
- Pole planting is often suitable for the lower slopes, where there is sufficient soil and moisture to grow poles. Pole planting requires good management to maximise the chances of survival. Pole mortality is particularly high on steep soil, which is where most slip scars occur. See the Poplar and Willow Research Trust website or a Horizons Land Management Advisor for advice.

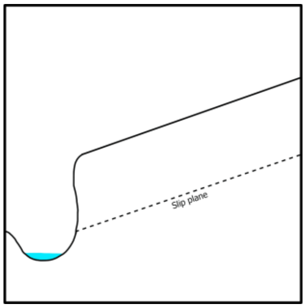
Example of moderate slip erosion on LUC class 6e hill soils on moderately steep sandstone and jointed mudstone, between Dannevirke and Weber.

Prioritising land for treatment of earthflow and slump erosion

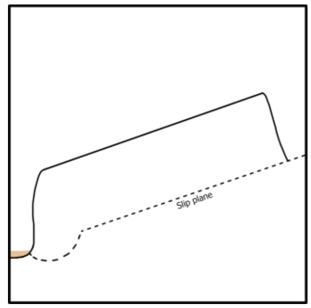
Earthflow erosion is the slow movement of saturated soil and associated regolith, usually along basal and marginal shear planes, with internal deformation of the moving mass. The saturated soil is in patches of a paddock where flow accumulates. Above the saturated zone the flow Movement rates vary from less than half a metre per year to over 25m and tends to occur after months of high rainfall. The original vegetated surface, though often still present, is hummocky and may contain numerous tension cracks.

Severe earthflow in bentonitic jointed mudstone with the toe of the flow being removed by the Totangi stream, Gisborne (Noel Trustrum). This movement could be treated by intensive poplar and willow planting.

Slumps are deep seated failures, usually of large blocks or rock and regolith. They involve rotational slide movement along curved failure planes, resulting in a raised lower (toe) slope relative to the upper part of the slope. This often results in the formation of ponds or lakelets at the head of a slump (Land Use Capability Survey Handbook). See images below and the LUC Handbook for further details.



Stream erosion undercuts the toe supporting an earthflow or block slide.



Once the slip plane is wetted, the flow slides into the stream, blocking and diverting it, as well as removing part of the base of the flow.

Earthflow and slump erosion features, if subject to erosion of the toe (or base of the flow – see photo below) by a gully or stream, can contribute the greatest quantities of sediment to rivers in Horizons region.

Earthflows sometimes continue for decades, or even hundreds of years, with large volumes of sediment regularly deposited in waterways. The highest rates of gullied earthflow movement measured in Horizons region are 10m per year and 80,000 tonnes of sediment per square km.

Unlike soil slip, the risk of earthflow and slump are not predictable by slope angle. However, they are recognisable by their distinctive landform shape.

They are determined by:

- Geology susceptible to this sort of failure e.g., bentonitic mudstone, jointed mudstone, or crushed argillite, all of which allow water to flow through the soil/rock and saturate parts of the lower slope. The Maxwell group moderately consolidated sandstone is also quite susceptible to earthflows and slumps.

- A build-up of soil water over a month or more; generally over a wet winter/spring.
- Undercutting at the base of the flow/slump by gully or streambank erosion.

Top priority for treatment of earthflow and slump erosion is where there is lots of obvious earth movement and sediment in the waterway downstream. This will be visible as surface cracks and disruption, particularly at the toe and back scarp, followed by the side scarps and middle of an earthflow or slump feature. Other visible signs are disruption of fences, tracks, yards, or trees.

The most severe earthflow and slump movements are always associated with gully or stream undercutting. In some cases, if the undercutting of the toe of the movement is not able to addressed, the movement may not be able to be stopped. The earthflow or slump will move if the slip plane is exposed by stream or gully erosion.

An example of earthflow erosion east of Weber, Moderate earthflow in foreground on 6e jointed mudstone west of Herbertville, with severe earthflow and moderate to severe gully in the background on 7e jointed mudstone with potential for very severe erosion.

An example of severe slump in class 7e moderately consolidated sediments near Dannevirke (Noel Trustrum). In this sort of situation, if the stream cuts the base far enough, even afforestation will not stop further slumping.

Earthflow and slump erosion is generally easy to establish trees on unless it is very actively moving or extremely wet. Earthflows and slumps may also be stabilised by judicious drainage, although expert advice should be sought because it is very easy to initiate gully erosion in loose slump and earthflow material. Streams leaving active earthflow country always run cloudy. Earthflows may be episodic and close down in dry years.

Example of a moderate earthflow on 6e jointed mudstone. No undercutting is involved so there will be no resultant constant stream discoloration. These non-undercut movements are easily fixed with pole planting.

Severe earthflow/slump near in 7e jointed mudstone, near Herbertville, 2006. Poles have just been planted to stop gully erosion cutting the loose fill. Movement of the top left area of the earthflow has crushed some of the neighbouring pine block.
Destroyed pines such as this remain as a clear sign of earthflow movement after the bare ground has healed over.

The same place in 2021. The pines have been harvested. The movement has stabilised since 2006.

Gully erosion

Gully erosion is caused by water flowing or splashing downwards onto soft rock or sediment and removing material. It can be imagined as a series of little waterfalls (10cm to a few metres in height). Over time the base of the waterfall cuts down and back, and the waterfalls migrate upslope with each little collapse.

Gully erosion generates the greatest quantity of sediment where it undercuts a flowing or slumping hillside, as shown in the previous earthflow and slump photos and text. Frequently in such cases, the slumping or earthflow cannot be stopped unless the gully is stabilised. This may be achieved with debris dams. Installation of debris dams in actively eroding gullies is highly prone to failure. Advice should be sought from an expert.

With severe to very severe gully erosion, afforestation of the upstream catchment may be required. Afforestation reduces stream flow and soil water content relative to land under pasture.

A reasonably effective debris dam in unconsolidated sands Whanganui catchment. Note dam goes right up the bank so water cannot cut around the side.

How not to build a debris dam in unconsolidated sandstone. The dam will not fill, because the fine sand material is washing right through the large cracks. Even if it did fill, there is no low point to channel the flow to the centre and the top is not level. The flow would cut the bank and make the erosion worse. Also, it is too high; a debris dam should be 1m high maximum to minimize the waterfall and plunge pool effect eroding the base.

Moderate gully erosion in 6e jointed mudstone near Pongaroa.

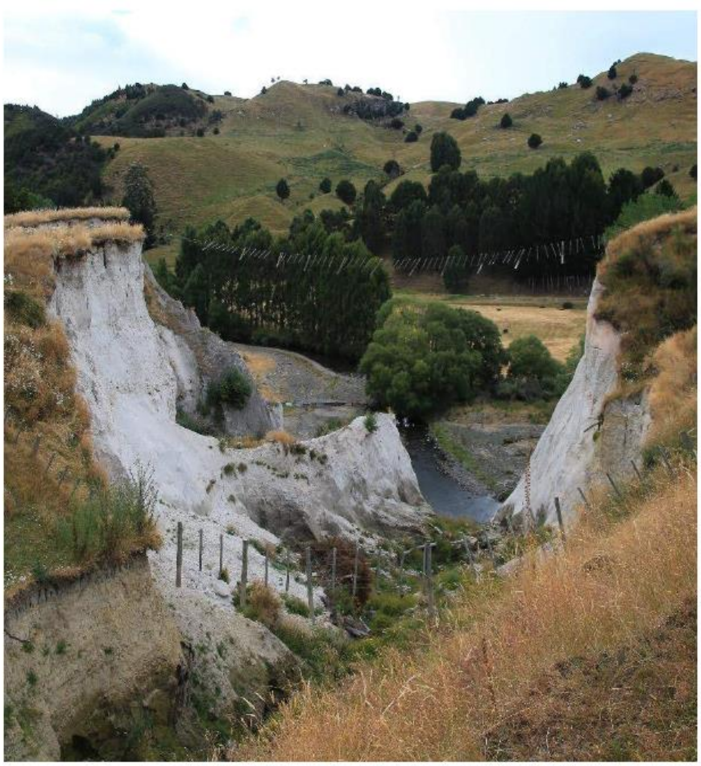
Gully erosion can be a significant problem in unconsolidated sand, jointed mudstone, or argillite hill country and in pumice country, particularly on water sorted pumice river terraces.

Slight to moderate (and sometimes severe) gully erosion can usually be stabilised with willow or poplar pole planting. Willows provide a thicker root mat than poplars, which better resists downcutting of the gully. As a rule of thumb slight to moderate gully erosion can be recognised by being able to be stepped or jumped across.

Severe gullies are generally not fixable with trees alone. Debris dams or drop structures are required, or dewatering of the catchment above by afforestation or drainage. The rule of thumb is severe gully can only be scrambled across if you're agile.

If trying to control gully erosion in a stream with native fish, you may be able to slow gully erosion without interrupting fish passage by using a series of single punga logs held by stakes that don't cover the whole stream width. Living pungas and some native trees also have fibrous roots like willows.

Very severe v-shaped gully erosion in 7e jointed mudstone, Mangatu blocks, Gisborne.
Afforestation was the only way to stabilise this land.



Severe gully in alluvial pumice, near Taumarunui. Note that the gully degrade has left two fences hanging in mid air. At the time of the photo, it had tripled in areal extent in 10 years. The land was mapped as 4e13 in regional scale NZLRI pre initiation of the gully. It is now 7e19 pumice with potential for severe gully erosion. This movement could be controlled with a well constructed drop structure.

Gully erosion, credit Environment BOP Soil Conservation Technical Handbook

Streambank erosion

Streambank erosion is easy to recognise. It is associated with

- Grade of the river or stream. A steeper grade increases water velocity.
- Unconsolidated bank material. Most streambanks are unconsolidated river sediment.
- The outside bends of rivers or streams.

The most effective treatment, if affordable, is to let the river have some room to erode. When rivers or streams are over straightened or crowded in, flow rate has to increase, and so erosion increases.

Poplar planting at the top of a streambank can help armour a bank, but this does not always work. On larger or faster rivers or taller banks tree roots may not be able to armour the entire cutting-bank in a flood event. Roots frequently are only dense around the water table, so a 1 to 2m high fast flowing body of water will be able cut at the part of the bank where there are least roots.

In riparian areas, seek advice for the most appropriate vegetation for the stream bank.

An example of streambank erosion in hill country with associated sheet erosion and frittering of the bare jointed mudstone cliff. It is caused by decades of repeated very severe earthflow movement pushing a stream against a cliff, creating severe sheet erosion and frittering of the opposite bank. Bare cliffs such as this are a key sign of active earthflow erosion.

Tunnel gully

Tunnel gully erosion (also sometimes termed piping, under-runner, or tomo) is caused by subsurface scouring of loose subsoil or soil parent material. The scouring creates a widening pipe shaped void which may eventually collapse and open to form a gully.

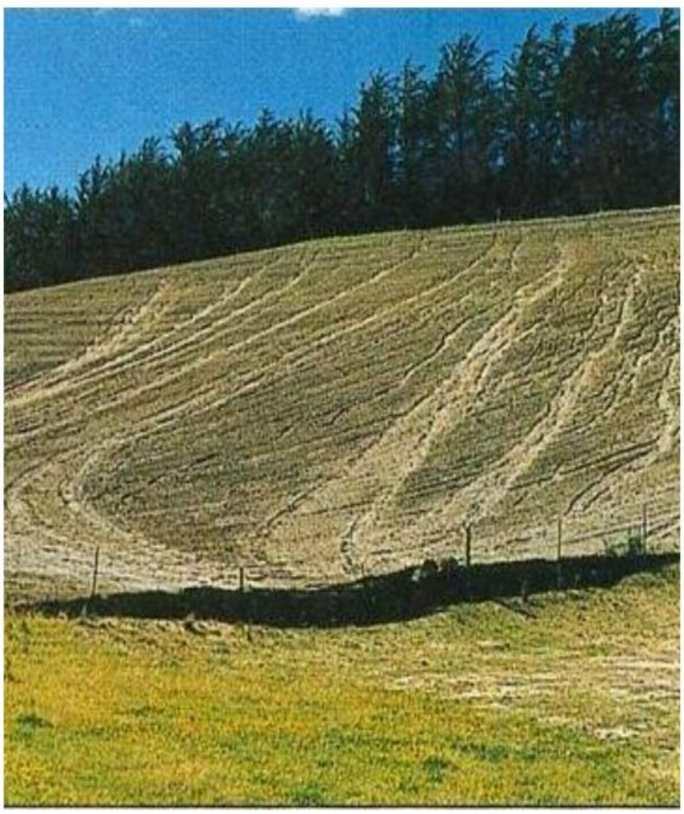
Development of tunnel gully

It tends to occur at the base of loose or sandy colluvial fill (slip debris) over harder bedrock, such as sandstone colluvium over sandstone rock. It also occurs on moderately steep lower to mid slopes. In Horizons region tunnel-gully is a minor contributor to sediment compared with the preceding erosion types. Treatment is by planting willows or poplar poles to get roots to armour the tunnel and catch moving sediment.

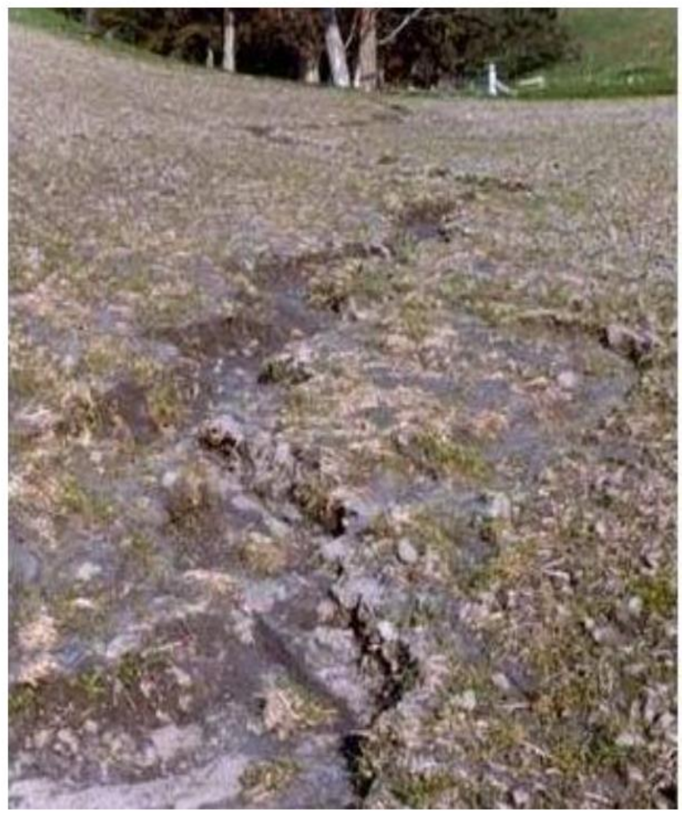
Rill erosion

Secondary rilling is often seen on unconsolidated sandstone slip scars, which cause the scars to be slower to heal (or regrass). It does not shift much sediment but is a useful sign that the rock type is unconsolidated sandstone. Treatment is by re-grassing, but is usually not economic in hill country.

Rilling can be severe in lower parts of hill paddocks cultivated for cropping. It is more severe on young soils with weak topsoil structure such as Ohakune soil.



Rill erosion in cultivated land



Intensively winter grazed soil

Sheet erosion

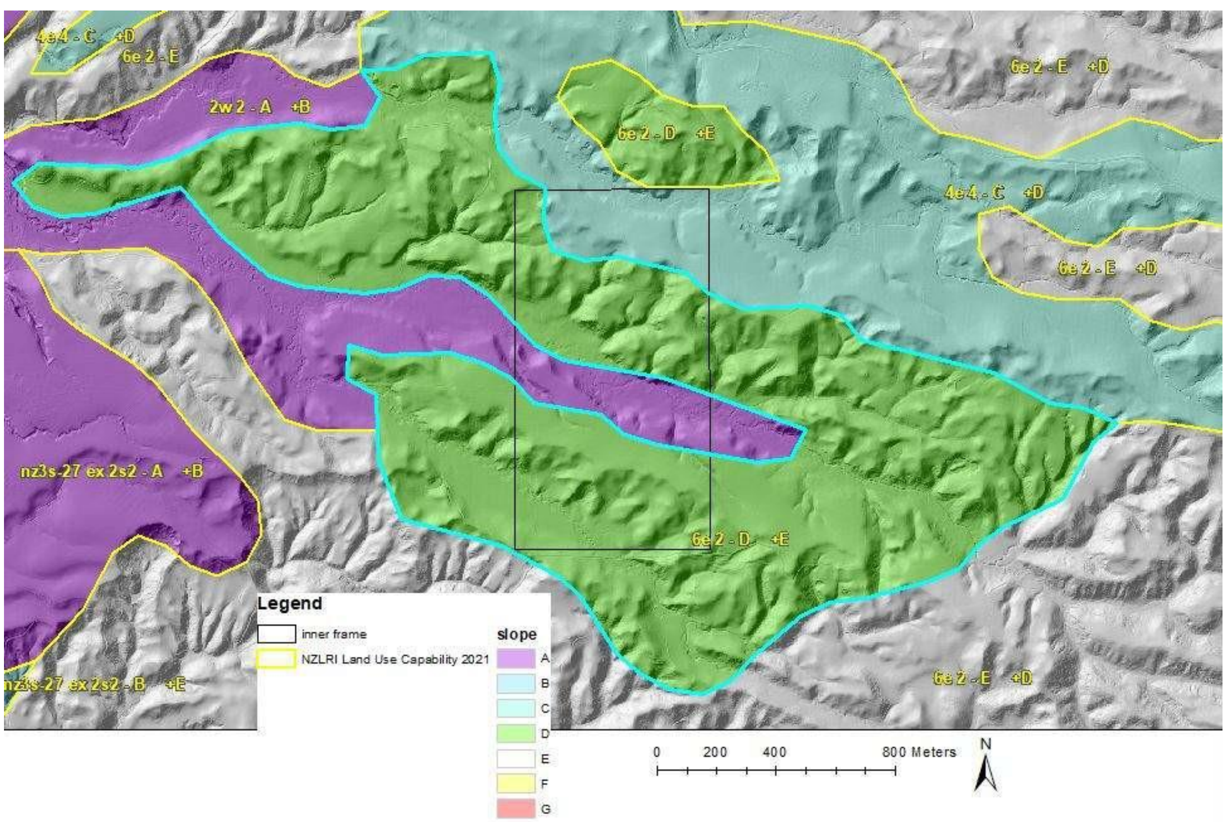
Sheet erosion is also covered in the Landforms document. Sheet erosion is widespread in hill country, and occurs on any bare ground surface, such as tracks, yards, cultivated land, creeks, slip scars, streambanks, and gullies. It also occurs when stock are trampling bare ground or saturated pasture.

Sheet erosion being exacerbated by trampling in saturated ground on jointed mudstone near Pongaroa

Use of scale for assessing erosion risk

The following two sets of images and explanatory texts illustrate the usefulness of different layers and scales of SLUI plan information when assessing erosion risk. These examples build on the learnings from the Regional Information document about the importance of understanding scale when using spatial information.

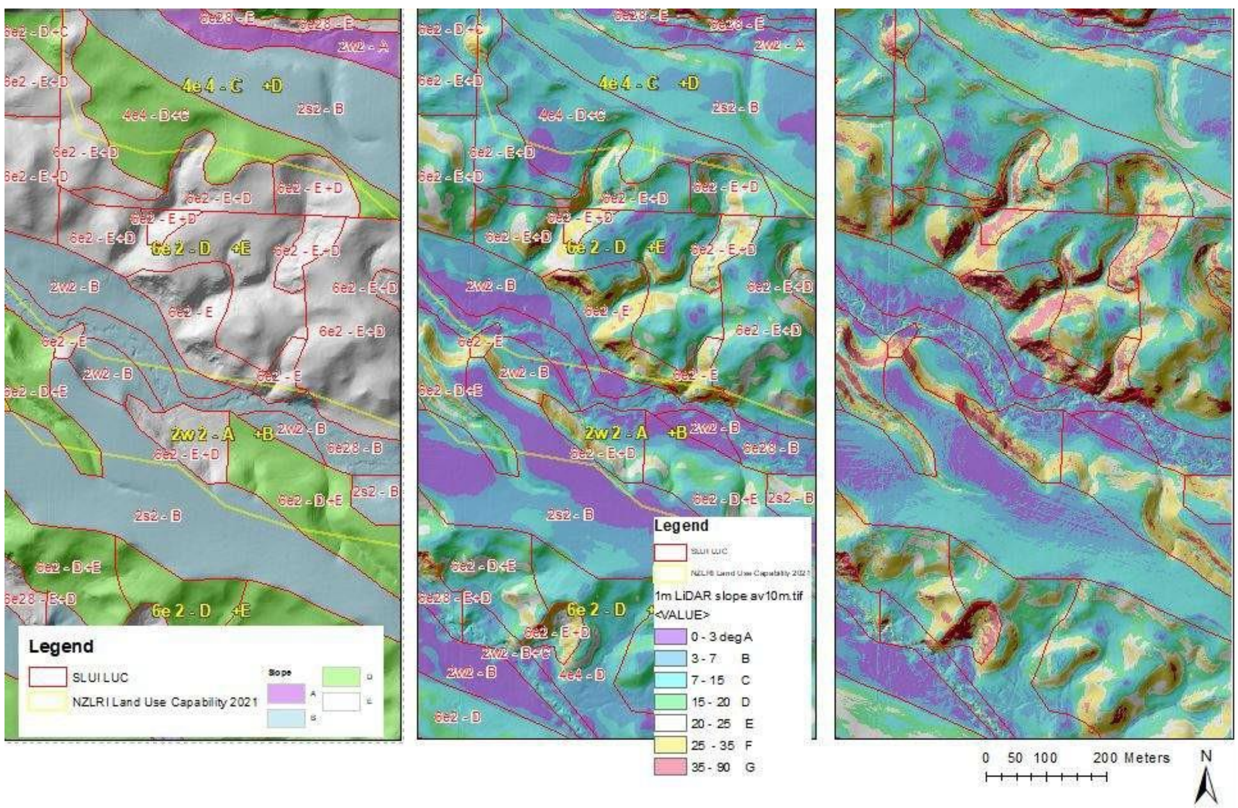
The image below shows a single NZLRI 6e2 unit, mapped as D+E (strongly rolling plus moderately steep). The regional scale NZLRI is useful for separating steeper from less steep farms, but the LiDAR hillshade background shows that there are also flats, gently rolling land, and steep parts of hills within that LUC unit.



The lower left image is zoomed in to show the farm-scale SLUI LUC units. The SLUI LUC units more accurately separate the flats from the rolling land from the hills, and also take out the stream in this case. It is useful for showing the types and rough quantities of works that should be done in each unit and the overall erosion risk of each unit.

The lower middle image shows the 10m averaged LiDAR slopes. The 10m averaged slope is accurate enough to judge erosion risk of individual hillsides within a paddock as it shows the overall slope.

The lower right image shows 1m LiDAR slope. This is a better product for judging the accuracy of unit boundaries, but is not better for estimating slope angle for erosion risk, because it over-estimates the amount of very steep land and therefore the erosion risk in this low elevation hill country.



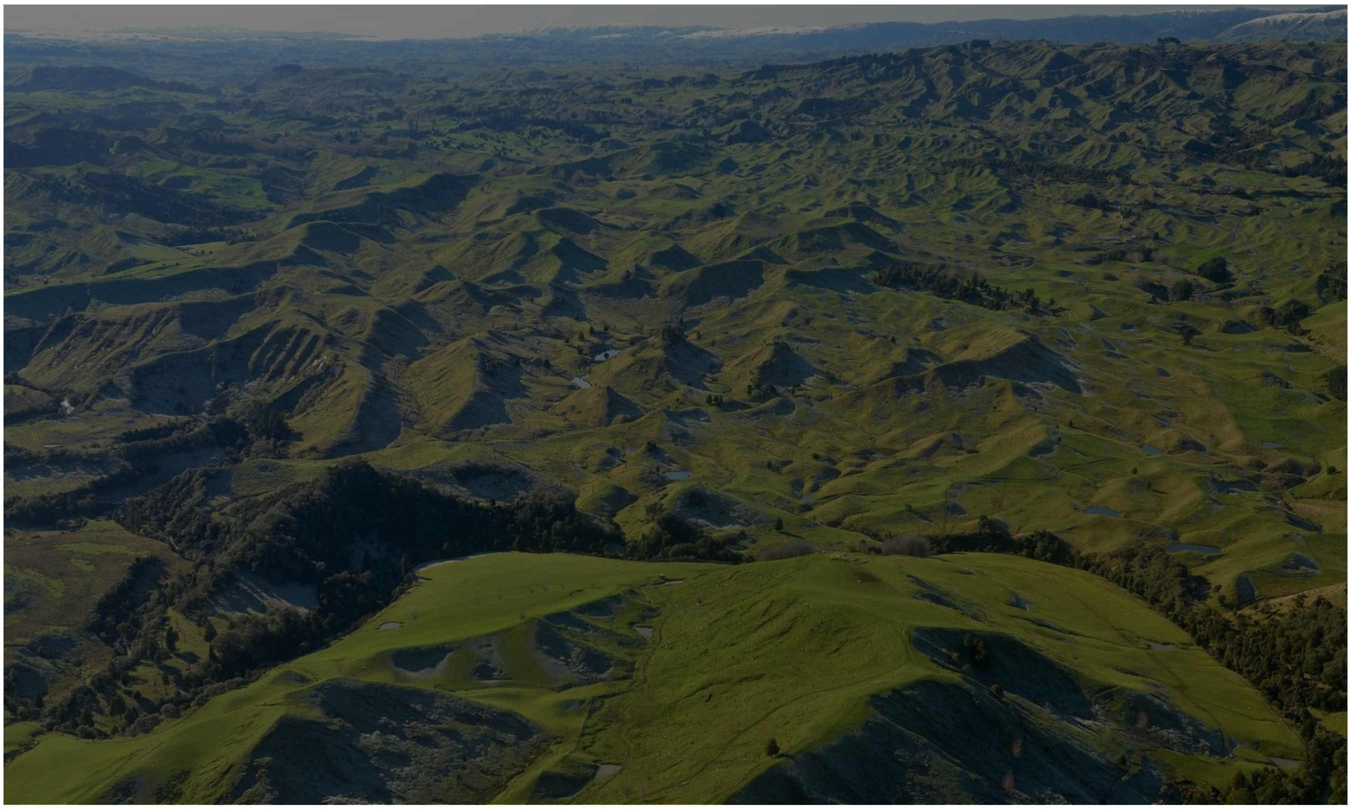
It is clear from the LiDAR slope and hillshade layers that neither the regional scale NZLRI mapping or the farm scale SLUI LUC are accurate enough to show where within a paddock to winter graze, plant poles or retire streams.

Guidance on extent of actions

While every farm is different, key factors to consider in determining what actions are fair and reasonable to include in a FWFP are:

- ☐ The specific freshwater issues (and their severity) within the catchment or sub-zone as outlined in the Catchment Context
- ☐ Actions at least meet accepted industry good management practices, and go further than that if indicated in the Catchment Context
- ☐ Actions are matched to the type and level of risk on farm
- ☐ Actions focus on the highest priority treatable risks as identified through the processes outlined in Document: Landforms, Document: Erosion and Document: Nutrient Management
- ☐ The extent to which historic or existing actions undertaken on the farm continue to mitigate risk
- ☐ The extent of work still required on that farm, and identification of which actions would have the greatest mitigation effect
- ☐ Opportunities for actions to align with existing farm operations or other desired outcomes (such as infrastructure resilience, soil conservation or crop productivity)
- ☐ What actions can be implemented within the 5-year timeframe?
- ☐ The cost of implementation and whether it is feasible (achievable for the farming system/business).

Lesson 4 - Horizons SLUI sediment priority classes



To aid prioritisation of the most important parts of a farm for reducing sediment entry to water, Horizons has a sediment priority class attached to the SLUI farm plan LUC mapping. SLUI is the Horizons Sustainable Land Use Initiative farm plan and works funding programme that started after the 2004 storm. If there is an existing SLUI farm plan for a farm where a FWFP is being developed or certified, the SLUI plan provides a useful guide to check the prioritisation of actions to achieve real water quality gains.

However, it is a guide only, and should always be checked against field evidence, such as photos of the erosion and delivery to water at the site. There is a layer showing the extent of SLUI farm plans available in the information Horizons is providing for farm plan for developers. Copies of the farm mapping and farm plan can be obtained from Horizons with landowner permission.

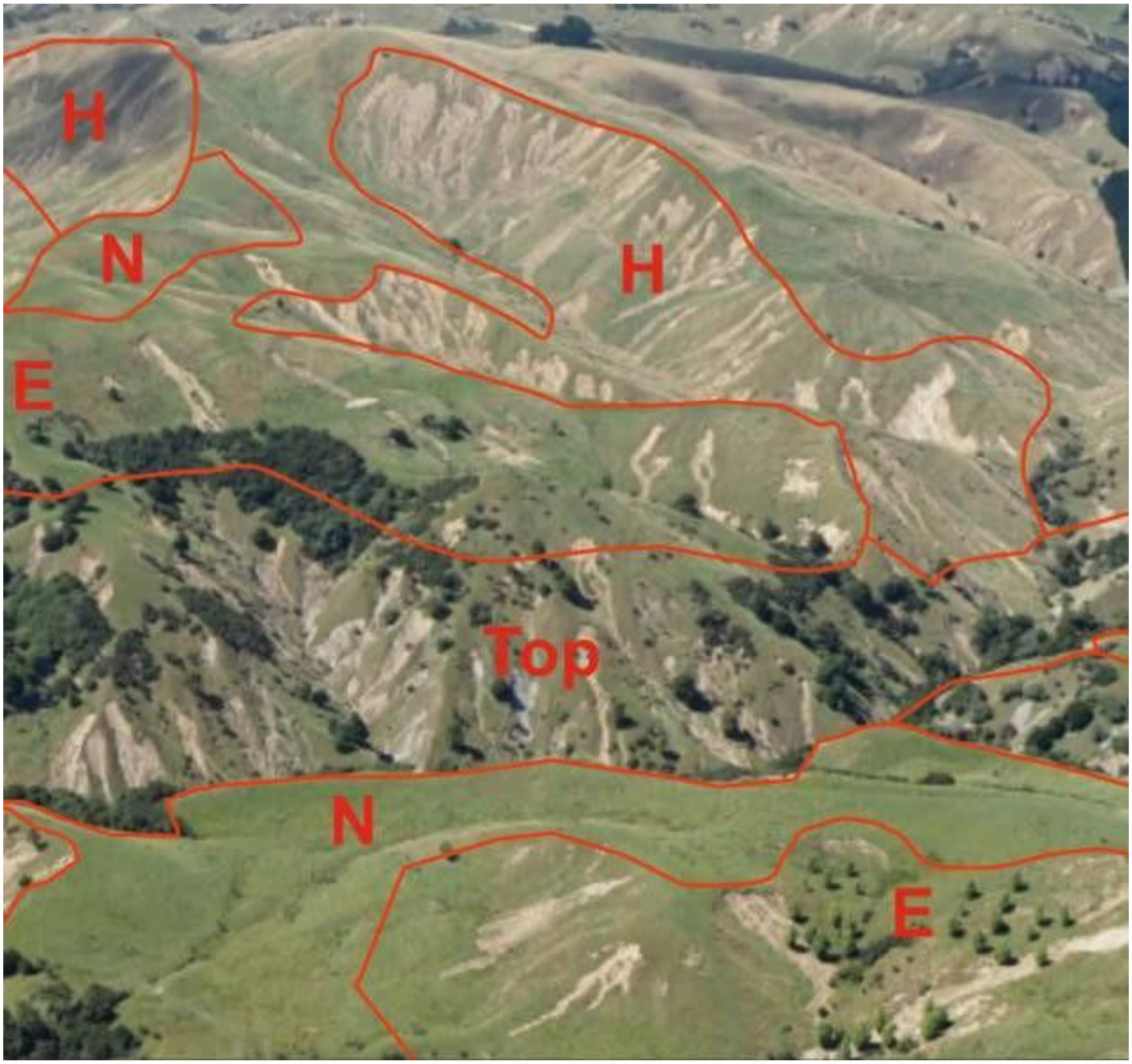
Prioritisation of actions to the right land units on a farm is very important, as land can deliver anywhere up to 80,000 tonnes of sediment per square kilometer. A very severe gullied earthflow can contribute over 1000 times as much sediment as would be expected from a river flat on the same farm, so prioritisation at the farm or paddock scale is important.

An extreme piece of top priority land near Taihape. Very severe earthflow and streambank erosion in mudstone has been found to deliver 60,000 tonnes of sediment per year to the river over a three-year period.

Priority for sediment or nutrient control is only partly predicted by the LUC system. Firstly LUC class is not predictive of erosion risk on units with a w (wetness), s (soil), or c (climate) limitation, only e (erosion). Secondly the LUC system was designed with emphasis on managing land for erosion but not sediment necessarily. For example; class 6e land usually has potential for moderate erosion.

However, some of it has very little sediment impact on water, due to erosion debris being caught on the lower slope, swale, dams or flats. Most 6e has a moderate impact, with around a third to a quarter of slip debris being able to enter streams. Meanwhile, while other 6e can deliver more than half of its erosion into a waterway powerful enough to carry the sediment downstream.

SLUI sediment priority class simplifies the situation into 4 classes. It remains a useful guide; and can be used as a flag or alert to check for field photos or other evidence to confirm or reject the assessment. For example, Horizons thought this was high priority and photos confirm moderate gully erosion cutting the base of an earthflow with fresh cracks.



Classes 6e and 7e land in jointed mudstone near Pongaroa showing slip and gully erosion, including from cyclone Gabrielle
Top = top priority land for addressing sediment (7e1 mudstone with potential for severe erosion and high delivery to water is shown),
H = highly erodible land (7e1 mudstone with potential for severe erosion and less than half delivery to water is shown. This image shows slip tails as well as slips on the H land, with most of the bare ground being tail, and it is clear that although some will be reaching the waterway most of it is remaining on slope).
E = other erodible land (6e3 with potential for moderate erosion and slight deliver to water is shown, in the foreground the slip tail is being contained in swale or lower slopes).
N = not a priority for sediment (4e and 6e land with negligible sediment visible after the recent severe rainfall).

Top priority land

Top priority land has severe to very severe risk of erosion, or high sediment delivery to waterway.

Example landforms are:

- Deep seated earthflow units with current (or potential over the life of the farm plan) severe erosion. Signs to look for are:
    - Visible cracks on surface – may be impossible to drive over
    - The side crack of the earthflow or slump is visible
    - Back scarp bare ground is visible
    - Toe (or base) erosion by a gully of stream is visible
    - The earthflow is pushing the stream towards the opposite bank creating so much streambank erosion that a cliff forms
    - Breakage of fencing, tracks, and trees tipped over or on an angle.
- 7e steep hill country (steep land) with over half of the sediment likely to reach a waterway: Signs to look for are:
    - Steep; 26 to 35 degrees to very steep over 35 degrees – means:
        - Potential for severe to very severe erosion, and has:
        - High sediment delivery to a stream. Examples are cliffs or steep slopes all the way to the water with little lower slope and no flats below.

Highly erodible land

Highly erodible land has a severe risk of erosion, OR medium sediment delivery to waterway.

Example landforms are:

- Other 7e steep hill country with less than half of the sediment reaching waterway.
- 6e hill country (which has potential for moderate erosion) with over half of sediment reaching the waterway. This land is typified by moderately steep slopes, averaging out to 21 to 25 degrees.
- Streams and their banks.

  High sediment loss tracks, crossings, or yards.

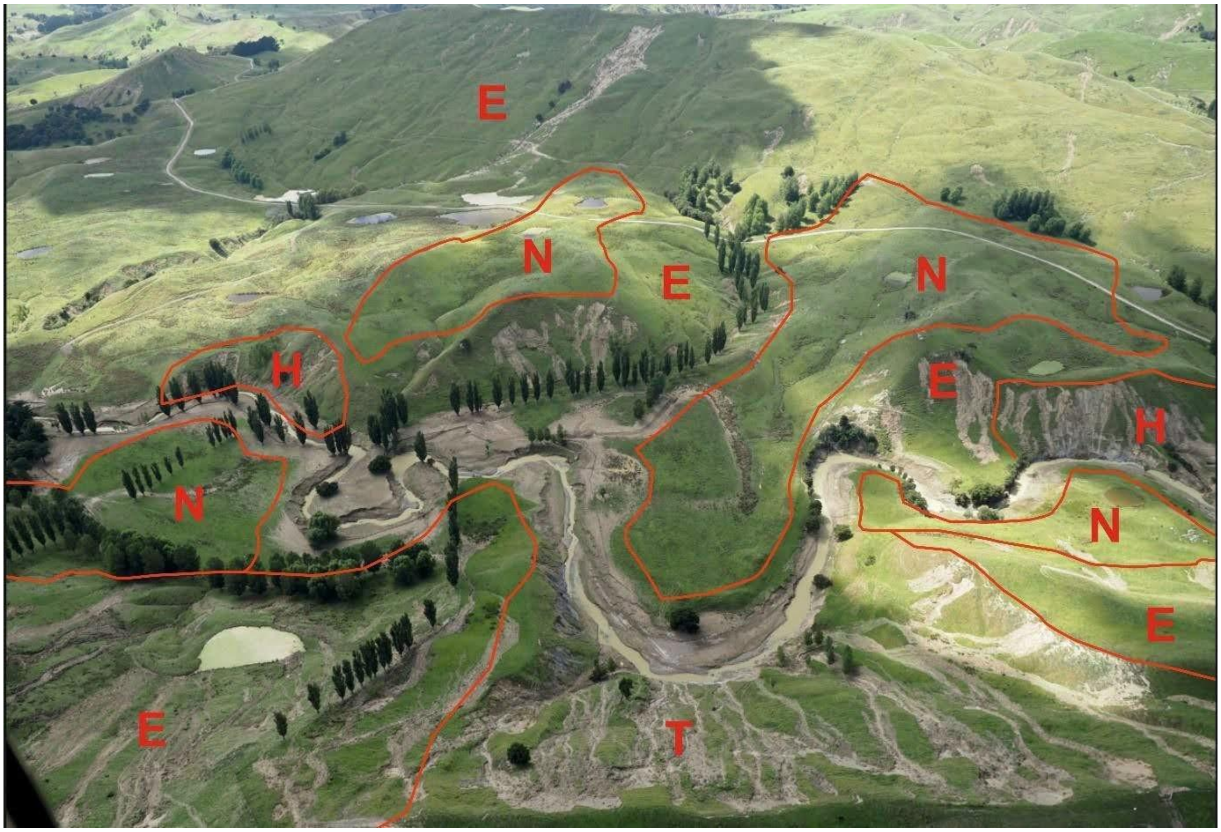
Erodible land

Erodible land has moderate (or less) risk of erosion and slight delivery to waterway.

Example landforms:

- Other 6e steep hill country with potential for moderate erosion but with less than half of sediment reaching waterway. Slope angles are typical of 6e land - mainly 16-25 degrees, but with a run-out for slips onto low angle land that catches most of the sediment.
- Swales, ditches, and wet puggy areas in the water flow line, typically in LUC classes 1-4.

- Low to medium sediment loss tracks, crossings, or yards., where there is typically low stock pressure and low connection to waterways.



Sandstone and mudstone hill country near Pongaroa, showing Cyclone Gabrielle slip erosion on mainly Erodible land.
T = top priority land for addressing sediment, H = highly erodible land,
E = other erodible land,
N = not a priority for sediment.

High sediment loss track, credit Sarah Nicholson Horizons Regional Council

Not priority land

Not priority land has negligible to slight risk of erosion and negligible sediment delivery to waterway.

Example landforms are:

- Other 6e or 5e steep hill country with potential for only slight erosion and negligible sediment reaching waterway.
- Any other LUC units with negligible sediment reaching waterway.

If you would like to provide feedback on this document, please email:

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