SOUTHLAND
PHYSIOGRAPHIC ZONES

WATER AND LAND 2020 & BEYOND

BEDROCK/HILL COUNTRY
Technical information

Physiographic zones are part of the *Water and Land 2020 & Beyond* project that aims to maintain and improve water quality in the Southland region, and to help us as a community achieve our goals for water.

Understanding our water

The Physiographics of Southland project was developed to better understand the evolution of water across Southland. By understanding where water comes from and the processes it undergoes as it moves through drainage networks, we can better understand the reasons for different water quality outcomes across the region.

The findings of the Physiographics of Southland project have been published in two reports, which identify the key drivers of hydrochemistry and water quality variability in Southland (Rissmann *et al.*, 2016), and describe a classification system for managing land use effects on water quality (Hughes *et al.*, 2016).

Physiographic zones and water quality

Physiographic zones represent areas of the landscape that have a common influence over water quality. The proposed Southland Water and Land Plan identifies nine physiographic zones in Southland that can be used to manage land use effects on water quality.

Physiographic zone technical information

The purpose of this booklet is to describe generalised water quality risks associated with individual physiographic zones. A companion booklet titled *Guide for using the Southland physiographic zones technical information* explains the terms and source data used in this booklet.

What's inside

environment SOUTHLAND REGIONAL COUNCIL
Te Taiao Tonga

BEDROCK/HILL COUNTRY
physiographic zone

Bedrock/Hill Country zone

VARIANTS

Artificial drainage

Overland flow

Bedrock/Hill Country Physiographic Zone

APPROXIMATE AREA

1,516,340 hectares

GEOGRAPHIC DISTRIBUTION

Hokonui Hills, Stewart Island, Catlins, Taringatura Hills and foothills of the Garvie, Umbrella, Livingstone, Eyre, Takitimu and Fiordland Mountains

MAIN SURFACE WATERWAYS

Mokoreta River, Mimihau Stream, Dunsdale Stream, Wairaki River, Irthing Stream

Go to our online BEACON mapping service to view the physiographic zones of Southland in more detail.

Overview

The Bedrock/Hill Country physiographic zone comprises prominent landforms where soils overlie bedrock or glacial till, and where there is a history of dense vegetation cover. This zone is the largest, covering approximately half of the Southland region.

Key features

- Rolling to steep land below 800 metres elevation where soils overlie bedrock or glacial till.
- High precipitation volumes due to orographic enhancement at higher elevations.
- Currently or historically densely vegetated (e.g. native forest, tussock or plantation forestry).
- Dense dendritic stream network that comprise the headwaters of many lowland streams.
- Limited groundwater resource.

Water quality implications

Less developed land:

- Provides a source of high quality water and dilution for downstream areas.

More developed land:

- Potential source of contaminant losses (nitrogen, phosphorus, sediment and microbes) via overland and artificial drainage to surface waterways (event driven).
- Low water quality risk in flatter, more well drained areas where deep drainage predominates due to attenuation and denitrification in the soil zone.

WATER QUALITY RISK	BEDROCK/HILL COUNTRY	BEDROCK/HILL COUNTRY(a)	BEDROCK/HILL COUNTRY(o)
Contaminant pathways	Deep drainage	Artificial drainage	Overland flow
Dilution and attenuation processes	Reducing soils Lower contaminant concentrations due to high precipitation volumes	Reducing soils	Reducing soils
Primary receiving environments	Surface waterways	Surface waterways	Surface waterways
Water quality risk	Low	Nitrogen, phosphorus, sediment, microbes	Nitrogen, phosphorus, sediment, microbes

Variants and associations

Variants

Variants identify areas within physiographic zones where there is increased water quality risk when soils are wet. Contaminant losses from variants occur along alternate drainage pathways that have lower attenuation potential.

The Bedrock/Hill Country physiographic zone has two identified variants.

Bedrock/Hill Country(a) – artificial drainage variant

Areas that have an elevated potential for artificial drainage due to a combination of low slope and slow subsoil permeability. This variant is generally located along base of hillslopes where fine materials have accumulated and where land is developed. This variant occupies 2% of the total area of this zone.

Approximate area: 28,800 ha.

Bedrock/Hill Country(o) – overland flow variant

Areas that have an elevated potential for overland flow due to a combination of slope, soil drainage properties and higher volumes of precipitation. This variant is generally located at higher elevations where topography is steeper and precipitation volumes are higher or on sloping outwash where soils are less well drained due to silt accumulation from frequent flooding. This variant occupies 86% of the total area of this zone.

Approximate area: 1,303,770 ha.

Associations

The Bedrock/Hill Country physiographic zone is commonly associated with six physiographic zones in Southland (Figure 1).

Alpine

Occupies higher elevation areas (>800 m RSL) and provides pristine runoff to the headwaters of streams draining the Bedrock/Hill Country zone areas.

Gleyed

In places, the Gleyed zone receives discharge from streams draining the Bedrock/Hill Country zone around the margins of upland areas where poorly drained soils overlie alluvial deposits.

Lignite/Marine Terraces

Receives discharge from the Bedrock/Hill Country zone, particularly along the inland margin of marine terraces around the south coast.

Old Mataura

Aquifers underlying elevated alluvial terraces in the mid-Mataura catchment receive a minor component of recharge from adjacent Bedrock/Hill Country areas.

Oxidising

Streams and aquifers in the Oxidising zone receive discharge from the Bedrock/Hill Country zone where well drained, oxidising soils overlie alluvial deposits around the margins of inland basins.

Riverine

Many streams draining the Bedrock/Hill Country zone ultimately discharge to the main stem rivers of the Riverine zone.

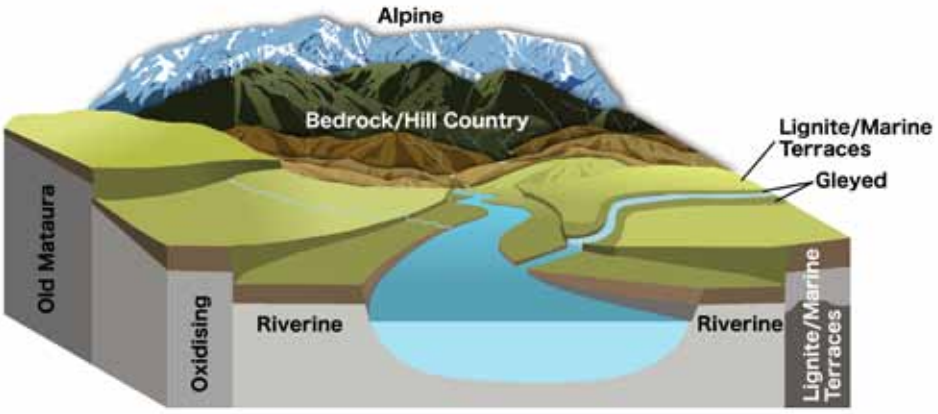


Figure 1: Landscape context image illustrating the relationship between the Bedrock/Hill Country zone and neighbouring physiographic zones. The Bedrock/Hill Country zone occurs at low to mid-elevations in hills and sub-alpine areas where rainfall is higher and more frequent. Some areas also receive runoff from the higher elevation Alpine zone. Runoff from these areas is the source of flow in the headwaters of many catchments draining lowland areas and makes a major contribution to cumulative discharge in downstream reaches of the main river systems. Runoff from the Bedrock/Hill Country zone may also recharge groundwater resource in lower-lying zones.

Dominant characteristics that affect water quality

Landscape characteristics

Surface zone characteristics

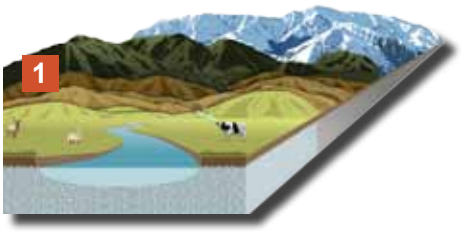
Soil zone characteristics

Saturated zone characteristics

Water quality implications

1 Landscape characteristics

The Bedrock/Hill Country physiographic zone occupies land that rises above the surrounding alluvial plains up to the approximate bush-line at 800 metres elevation. This includes areas that are, or were previously densely vegetated (e.g. native forest, tussock or plantation forestry).



Topography

Elevation

This zone is distributed relatively evenly across a wide range of elevations, predominately between 40 to 680 m elevation relative to sea level (m RSL).

The Overland Flow variant (Bedrock/Hill Country (o)) is generally located at higher elevations between 100 and 720 m RSL.

Slope

Most of the zone comprises rolling to steep land (slopes ≥8°) in sub-alpine areas.

The Artificial Drainage variant (Bedrock/Hill Country(a)) generally occurs on flatter areas along the base of hillslopes. The Overland Flow variant (Bedrock/Hill Country(o)) predominates in steeper, higher elevation areas.

Geology

The geology is comprised of a range of rock types, including sandstones, siltstones, mudstones, limestone, conglomerates, variously metamorphosed schist and ultra mafics.

These geological sediments typically comprise fault-bounded bedrock terranes of regional extent. In places the bedrock materials are extensively jointed and fractured, reflecting significant structural deformation. In areas such as the Te Anau Basin, basement rocks are overlain by thick deposits of glacial till.

Basement rocks and till deposits are mantled by a thin layer of loess and/or colluvial materials, which vary in thickness. The thickness of this layer reflects the relief of the underlying bedrock surface and the localised accumulation of slope debris.

Climate

Annual rainfall totals vary considerably across this zone, reflecting a pronounced west to east gradient across Southland, as well as orographic enhancement at higher elevations.

Average annual rainfall ranges from close to 10,000 mm in the Fiordland area to under 800 mm in lower elevation eastern and northern areas.

Average annual rainfall is appreciably lower in the Artificial Drainage variant due to its limited occurrence in the Fiordland area and occurrence at lower elevations.

Bedrock/Hill Country LANDSCAPE characteristics

ELEVATION
40 - 680 m RSL

SLOPE
Rolling to very steep

GEOLOGY
Hard rock

LANDFORM AGE
Pre-Quaternary

AVERAGE ANNUAL RAINFALL
2,655 mm per year

Bedrock/Hill Country(a) LANDSCAPE zone characteristics

ELEVATION
0 - 300 m RSL

SLOPE
Flat to undulating

GEOLOGY
Hard rock

LANDFORM AGE
Pre-Quaternary

AVERAGE ANNUAL RAINFALL
1,089 mm per year

Bedrock/Hill Country(o) LANDSCAPE zone characteristics

ELEVATION
100 - 720 m RSL

SLOPE
Rolling to very steep

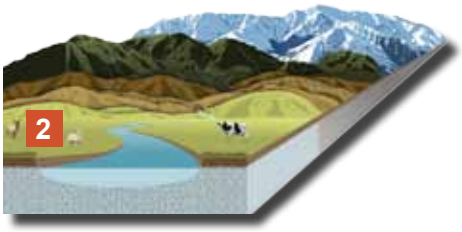
GEOLOGY
Hard rock

LANDFORM AGE
Pre-Quaternary

AVERAGE ANNUAL RAINFALL
2,772 mm per year

2 Surface zone characteristics

Recharge to the Bedrock/Hill Country physiographic zone occurs primarily via local precipitation with sub-alpine areas also receiving some pristine runoff from the higher elevation Alpine physiographic zone. Discharge from this zone predominately occurs via a dendritic stream network that is strongly influenced by topography.



Dilution

Due to orographic enhancement, elevated precipitation results in higher recharge volumes (and consequently reduced contaminant concentrations) compared to lowland areas.

Frequent high intensity precipitation events increase the potential for overland flow on rolling to steep topography (Overland Flow variant).

Less precipitation occurs in lower elevation areas with flatter slopes (Artificial Drainage variant). Where soils are well drained, land surface recharge predominates.

Surface waterways

Most streams have steep gradients and exhibit rapid flow velocities during high flows.

Many small streams draining this zone are observed to lose flow and dry up as they emerge from the foothills. Such flow loss may account for a significant component of the water balance in alluvial aquifer systems in inland basins.

Overland flow

Occurs in response to high intensity precipitation (infiltration excess) at any time of the year or as saturation excess during prolonged wet periods.

Steeper topography increases the potential for overland flow to occur (identified by the Overland Flow variant).

Overland flow comprises a major drainage pathway across the entire zone, however because this zone is so large there are significant areas where overland flow risk is low.

Bedrock/Hill Country SURFACE zone characteristics

DILUTION POTENTIAL
High to moderate recharge flux
DRAINAGE DENSITY
Low
STREAM ORDER
Predominately small
OVERLAND FLOW POTENTIAL
Moderate to high

Bedrock/Hill Country(a) SURFACE zone characteristics

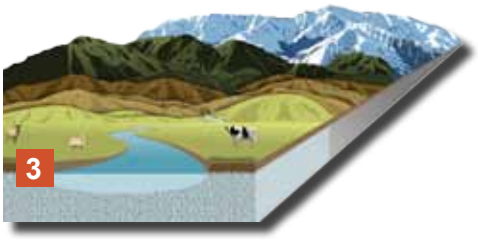
DILUTION POTENTIAL
High to low recharge flux
DRAINAGE DENSITY
Moderate
STREAM ORDER
Mixed
OVERLAND FLOW POTENTIAL
Very low to low

Bedrock/Hill Country(o) SURFACE zone characteristics

DILUTION POTENTIAL
High to moderate recharge flux
DRAINAGE DENSITY
Low
STREAM ORDER
Predominately small
OVERLAND FLOW POTENTIAL
Moderate to high

3 Soil zone characteristics

Soil pedology and chemical properties vary appreciably across the Bedrock/Hill Country physiographic zone. This variability is attributed to the diverse range of parent materials, vegetation cover, geomorphic surface age and climatic conditions that occur within this zone.



Soils

In general this zone contains:

- **Brown** and **Pallic** soils predominately in the Catlins, Hokonui Hills and foothills of the northern mountains.
- **Melanic** soils present near West Dome and to the south of the Takitimu Mountains.
- **Pallic** soils found on the lower slopes of the central and northern mountains.
- **Podzol** soils, which occur extensively across the Fiordland area.

Soil textures are typically coarse (stony silt loam and sandy loam) and soils are typically moderately well to well drained. However, the Artificial Drainage variant contains a significant proportion of finer textured silty loam soils that exhibit slow subsoil permeability.

Reduction potential

Soils in this zone are generally characterised as exhibiting high reduction potential due to abundant soil organic carbon associated with a history of dense forest and scrub cover.

Many soil types are thin and stony with variable (but generally elevated) organic carbon content and a friable consistency. As a result, denitrification may occur in soils that can also be vulnerable to physical erosion where vegetative cover is thin or absent.

Artificial drainage

Elevated artificial drainage potential occurs where land has been developed and soils have low subsoil permeability. This generally occurs along the base of hillslopes. Discharge via artificial drainage occurs on a seasonal basis when soils are wet or in response to large rainfall events.

Lateral drainage

Lateral flow through the soil profile occurs extensively across this zone. This form of drainage generally occurs when soils are wet for an extended period.

In well drained soils, lateral flow often occurs along the regolith/bedrock contact, particularly where the upper surface of the bedrock materials are weathered.

In soil types that have restricted drainage, lateral flow may occur above slowly permeable layers within the soil profile.

Bedrock/Hill Country SOIL zone characteristics

SOIL ORDER
Brown, Podzol

PROFILE DRAINAGE
Moderately to well drained*

PERMEABILITY
No data**

ANION STORAGE CAPACITY
No data**

REDUCTION POTENTIAL
High

ARTIFICIAL DRAINAGE DENSITY
None to low

LATERAL DRAINAGE POTENTIAL
Extensive

Bedrock/Hill Country(a) SOIL zone characteristics

SOIL ORDER
Podzol, Brown

PROFILE DRAINAGE
Poorly to moderately well drained

PERMEABILITY
Moderate over slow

ANION STORAGE CAPACITY
Moderate to high

REDUCTION POTENTIAL
Moderate

ARTIFICIAL DRAINAGE DENSITY
Moderate to high

LATERAL DRAINAGE POTENTIAL
Localised

Bedrock/Hill Country(o) SOIL zone characteristics

SOIL ORDER
Podzol, Brown

PROFILE DRAINAGE
Moderately well to well drained*

PERMEABILITY
No data**

ANION STORAGE CAPACITY
No data**

REDUCTION POTENTIAL
High

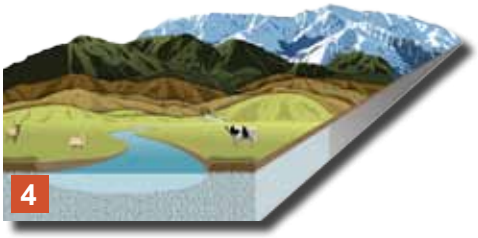
ARTIFICIAL DRAINAGE DENSITY
None to low

LATERAL DRAINAGE POTENTIAL
Extensive

* A significant proportion (>50%) of the zone does not have available data.
** A majority (>90%) of the zone does not have available data.

4 Saturated zone characteristics

The Bedrock/Hill Country physiographic zone has a limited groundwater resource hosted within fractured rock aquifers in bedrock.



Groundwater

Bedrock materials host small volumes of groundwater in joints and fractures (secondary porosity) within the rock mass. Such fractured rock aquifers typically exhibit low permeability.

In some areas, groundwater may also occur within the colluvial materials overlying bedrock.

Groundwater levels

Available data show the geometry of the piezometric surface is similar to the overlying topography.

Low-lying areas typically have water table depths of less than 5 metres below ground whereas the water table depth may exceed 30 metres in higher elevation areas.

Groundwater discharge

Baseflow in streams draining this zone tends to increase during winter and spring and reduce to low levels during summer months. This reflects the limited groundwater resource present in the basement rocks and overlying colluvial materials.

In some areas, springs and seeps occur extensively on hillslopes. This typically occurs where lateral flow is disrupted, due to changes in the thickness of the colluvial materials, slope or discontinuities on the underlying bedrock surface.

Reduction potential

Aquifers within this zone have low reduction potential due to their low organic carbon content.

Deep drainage

Deep drainage comprises a minor component of the water balance across the entire zone, however because this zone is so large it has significance on a local scale.

Bedrock/Hill Country SATURATED zone characteristics

WATER TABLE DEPTH
No data**
AQUIFER PERMEABILITY
Low
ACTIVE GROUNDWATER STORAGE
Minor
REDUCTION POTENTIAL
Low
DEEP DRAINAGE POTENTIAL
Low

Bedrock/Hill Country(a) SATURATED zone characteristics

WATER TABLE DEPTH
Shallow to moderate*
AQUIFER PERMEABILITY
Low
ACTIVE GROUNDWATER STORAGE
Moderate
REDUCTION POTENTIAL
Low
DEEP DRAINAGE POTENTIAL
Low to moderate

Bedrock/Hill Country(o) SATURATED zone characteristics

WATER TABLE DEPTH
No data**
AQUIFER PERMEABILITY
Low
ACTIVE GROUNDWATER STORAGE
Minor
REDUCTION POTENTIAL
Low
DEEP DRAINAGE POTENTIAL
Low

* A significant proportion (>50%) of the zone does not have available data.

** A majority (>90%) of the zone does not have available data.

5 Water quality implications

The main water quality issues for this zone are loss of nitrogen, phosphorus, sediment and microbial contaminants in developed areas via overland flow and artificial drainage.

Influencing factors

Factors that influence water quality in the Bedrock/Hill Country zone include:

- Rolling to steep topography which promotes overland flow
- Orographic enhancement of precipitation at higher elevations, with some areas also receiving runoff from adjacent alpine areas
- High intensity rainfall events
- High reduction potential in soils

Water quality issues

Overland flow can result in the rapid transport of particulate and dissolved contaminants to surface waters in response to individual precipitation events.

Contaminant losses via lateral flow are generally limited to dissolved nutrients due to filtration occurring within the soil profile.

Wet soils are more at risk from contaminant loss (see Figures 2, 3 and 4).

Groundwater

The overall risk to groundwater quality is low as denitrification potential within soils is generally high.

Surface water

The rapid export of nutrients (nitrogen and phosphorus), microbial contaminants and sediment can occur at any time of the year in response to heavy or sustained precipitation events.

Contaminant loss from this zone has the potential to impact the water quality of downgradient physiographic zones. Zones that receive a large proportion of recharge from this zone are particularly at risk.

Key HYDROCHEMICAL features

- Large volumes of dilute mid-altitude recharge waters reflecting orographic rainfall enhancement on elevated land.
- Water facies are mainly sodium bicarbonate dominated types although this can vary with geology (e.g. in limestone calcium is the dominant cation) and proximity to the coast.

What affects water quality in the Bedrock/Hill Country zone?

WHERE	KEY CHARACTERISTICS	CONTAMINANT PATHWAYS	ATTENUATION PROCESSES	WATER QUALITY RISK
All areas	Localised precipitation Land surface recharge Well-drained soil	Lateral flow through the soil matrix when soils are wet Deep drainage through soil and saturated zone when soils are wet	Filtration and adsorption removes virtually all particulate and microbial contaminants. Significant denitrification potential in the soil zone	Low
Artificial drainage variant	Low subsoil permeability Flat topography	Artificial drainage in response to sustained or heavy precipitation events	Limited filtration, adsorption and denitrification may occur in water moving through the soil matrix	Nitrogen Phosphorus Microbes Sediment Contaminants discharged rapidly to surface water
Overland flow variant	Sloping topography Higher volumes of precipitation	Overland flow in response to sustained or heavy precipitation events	Some reduction in contaminant concentrations (although loads are unchanged) may occur where there are higher precipitation volumes	Nitrogen, phosphorus and microbes in developed areas and sediment in all areas Contaminants discharged rapidly to surface water

CONTAMINANT PATHWAY	MITIGATION OBJECTIVES
Overland flow	Protect soil structure, particularly in gullies and near stream areas Manage critical source areas Reduce phosphorus use or loss
Artificial drainage	Protect soil structure, particularly in gullies and near stream areas Reduce phosphorus use or loss Reduce the accumulation of surplus nitrogen in the soil, particularly over autumn and winter Avoid preferential flow of effluent through drains Capture contaminants at drainage outflows

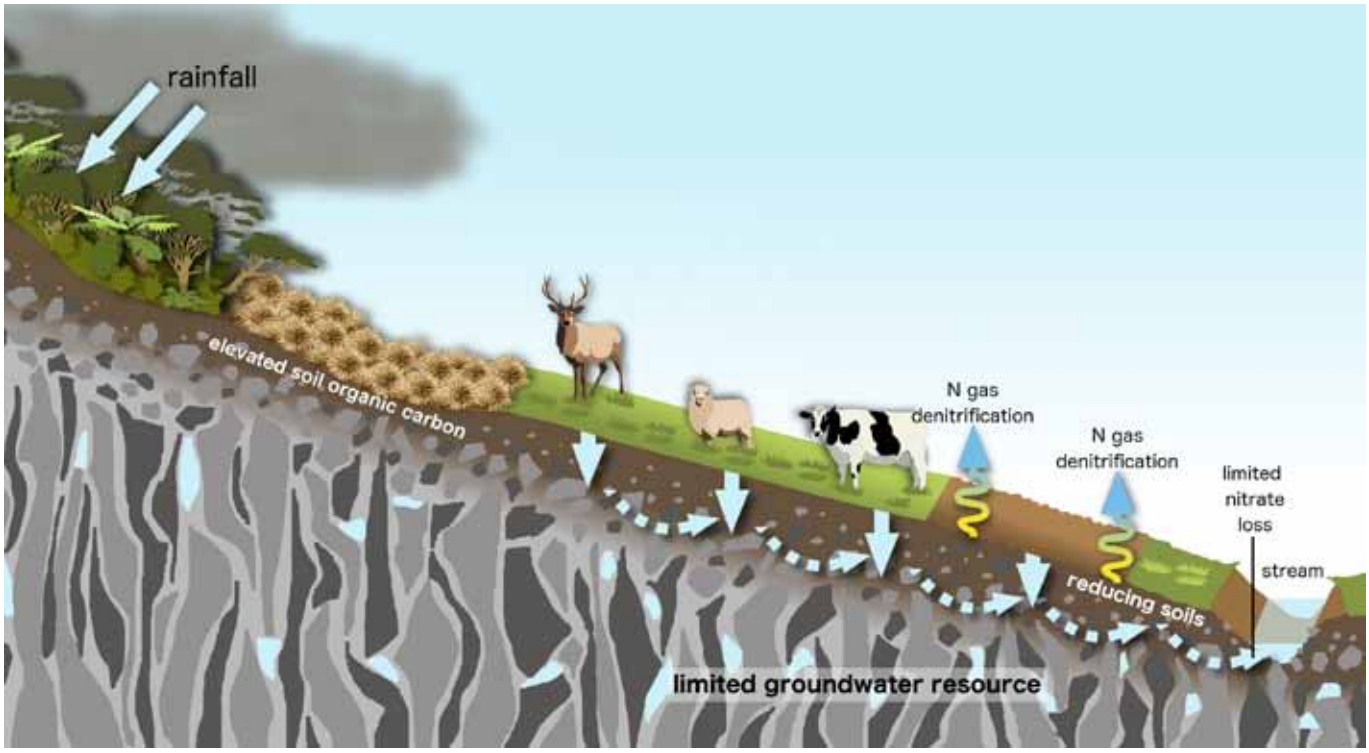


Figure 2: **Main Zone** – Deep drainage to groundwater typically contains low nitrate concentrations due to denitrification within the soil zone.

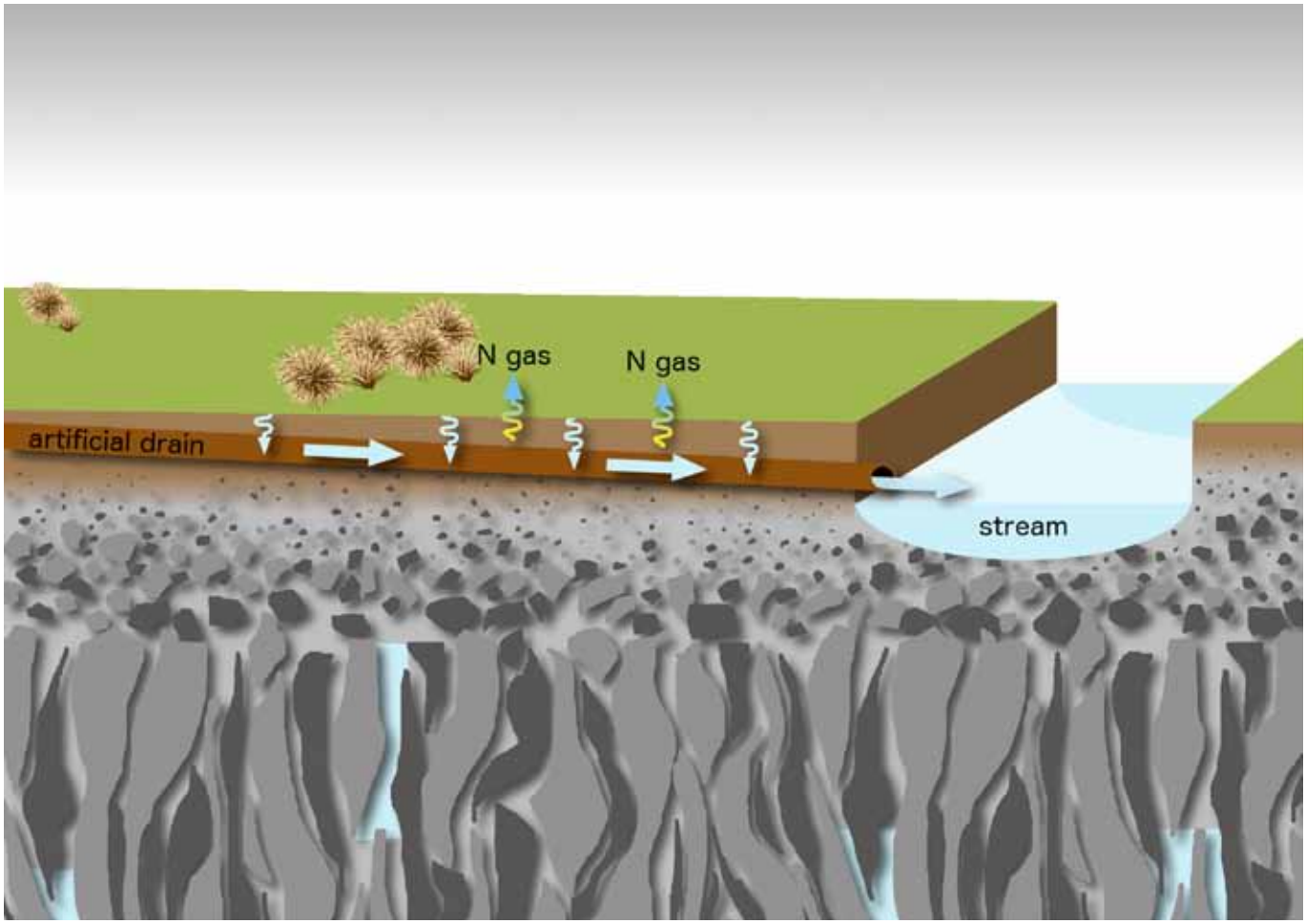


Figure 3: **Artificial Drainage variant** – Episodic losses of nitrogen (N), phosphorus (P), sediment (S) and microbes (M) to surface waterways occurs in developed areas in response to heavy or sustained precipitation events due to slow subsoil permeability on flatter slopes.

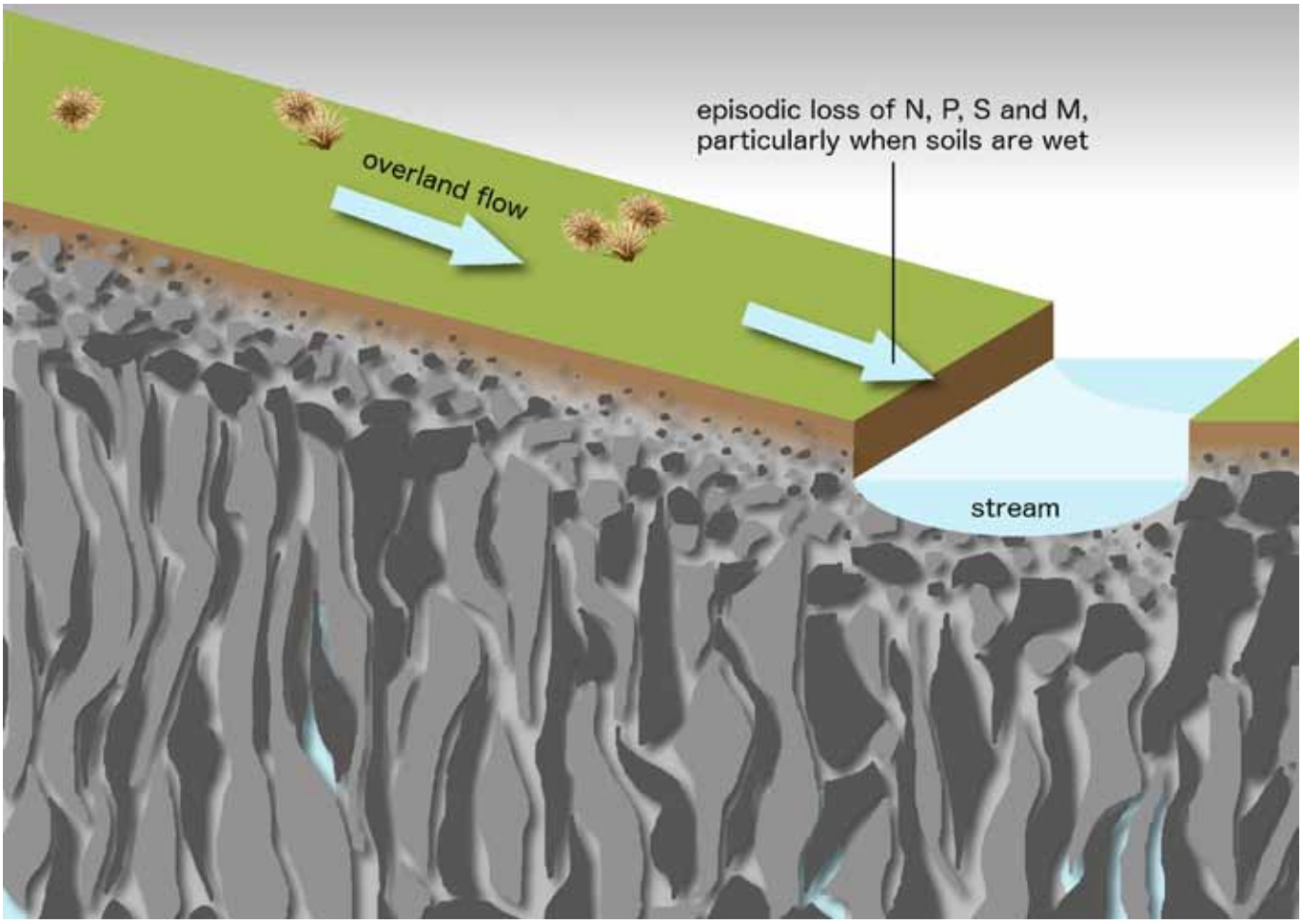


Figure 4: **Overland Flow variant** – Episodic losses of nitrogen (N), phosphorus (P), sediment (S) and microbes (M) to surface waterways occurs in developed areas in response to heavy or sustained precipitation events due to steep topography.