SOUTHLAND
PHYSIOGRAPHIC ZONES

WATER AND LAND 2020 & BEYOND

CENTRAL PLAINS
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.

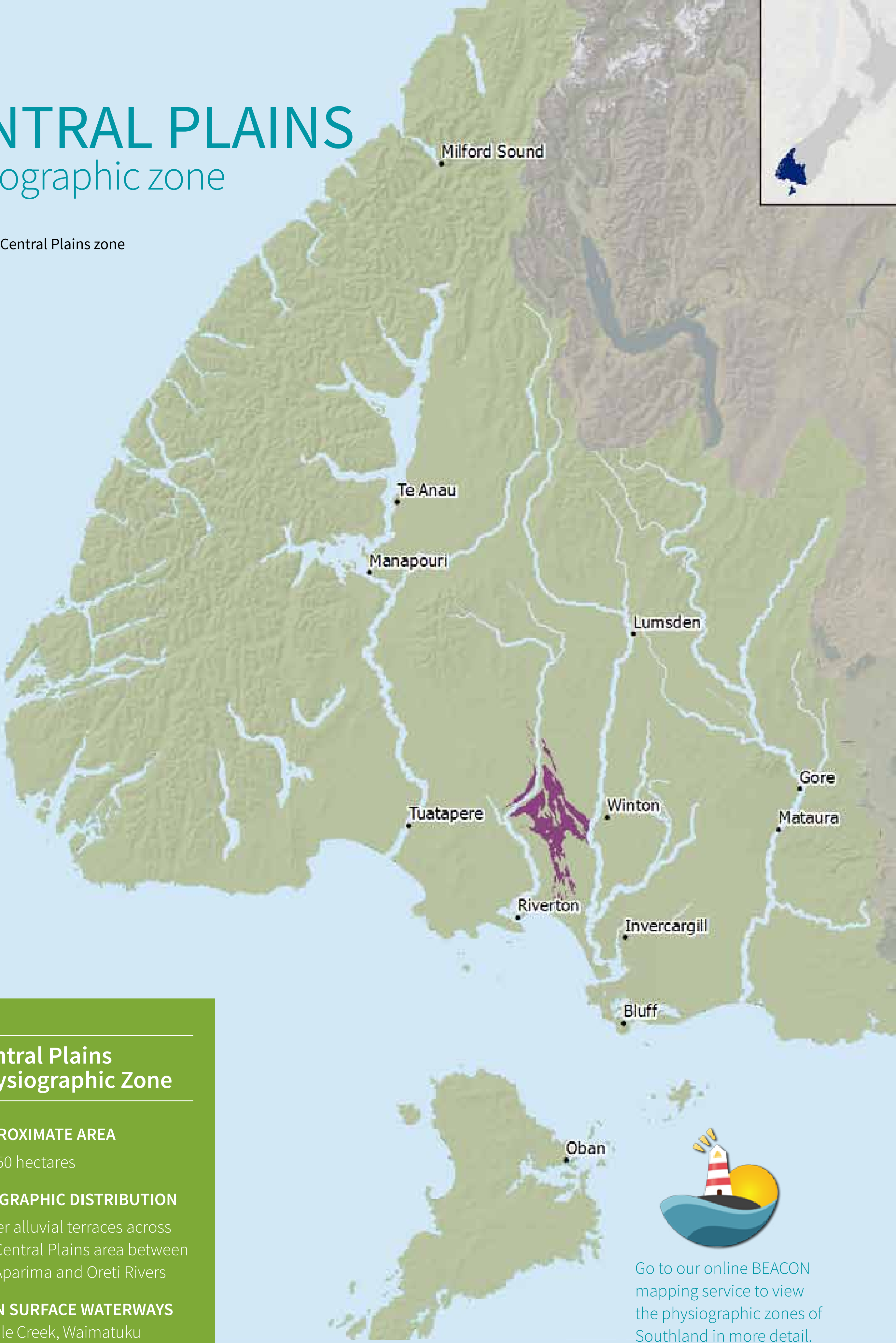
Physiographic zone technical information

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

CENTRAL PLAINS
physiographic zone



Central Plains Physiographic Zone

APPROXIMATE AREA

18,150 hectares

GEOGRAPHIC DISTRIBUTION

Lower alluvial terraces across the Central Plains area between the Aparima and Oreti Rivers

MAIN SURFACE WATERWAYS

Middle Creek, Waimatuku Stream

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

Overview

The Central Plains physiographic zone is characterised by clay-rich soils derived from mafic parent materials. The shrink-swell properties of these soils result in a bi-modal soil drainage pattern which has a significant influence over water quality.

Key features

- Clay-rich soils exhibit shrink-swell characteristics.
- Soils shrink and crack when dry allowing drainage to bypass the soil matrix to the underlying aquifer.
- Wet soils are prone to waterlogging, requiring an extensive artificial drainage network to maintain agricultural productivity.

WATER QUALITY RISK	CENTRAL PLAINS
Contaminant pathways	Deep drainage (including bypass flow) and artificial drainage
Dilution and attenuation processes	Reducing soils
Primary receiving environments	Aquifers and surface waterways
Water quality risk	Nitrogen, phosphorus, sediment, microbes

Water quality implications

Wet soil

- Contaminants (including nitrogen, phosphorus, sediment and microbes) are exported rapidly to surface waterways via mole-pipe drains.

Dry soil

* Cracks allow nitrate and other contaminants (phosphorus and microbes) to infiltrate rapidly through soil macropores (bypass flow) to underlying groundwater.

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 intermittently along alternate drainage pathways that have lower attenuation potential.

There are no variants identified for the Central Plains physiographic zone.

Associations

There are three physiographic zones commonly associated with the Central Plains zone (Figure 1).

Oxidising

Small areas of the Oxidising zone are interspersed within the Central Plains zone, where soils have lower base saturation and clay content.

Infiltration from the Oxidising zone contributes to baseflow in streams draining the Central Plains zone.

Gleyed

The Gleyed zone surrounds the Central Plains zone in areas where soils have high clay content. However, these clay minerals originate from different geological sources and therefore do not exhibit the characteristic shrink-swell behavior of soils in the Central Plains zone.

There is little hydrological interaction between the Central Plains and Gleyed zones due to the extent of surface water catchment boundaries.

Peat Wetlands

The Peat Wetlands zone occupies relatively small areas around the margins of the Central Plains zone. It occurs where groundwater drainage is impeded by the underlying geological materials (limestone or older alluvial deposits), particularly in lower elevation areas.

These areas are remnants of what was historically a wider peat wetland complex that once covered an extensive area of the Central Plains.

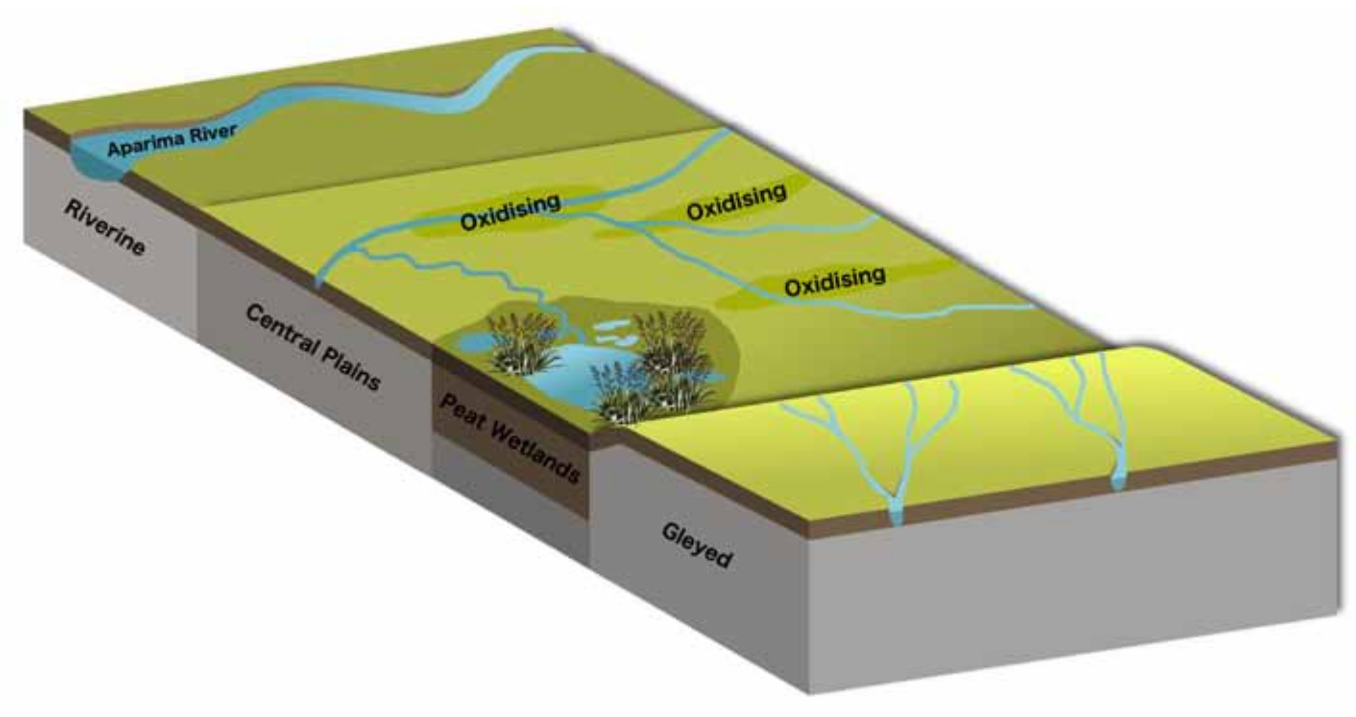
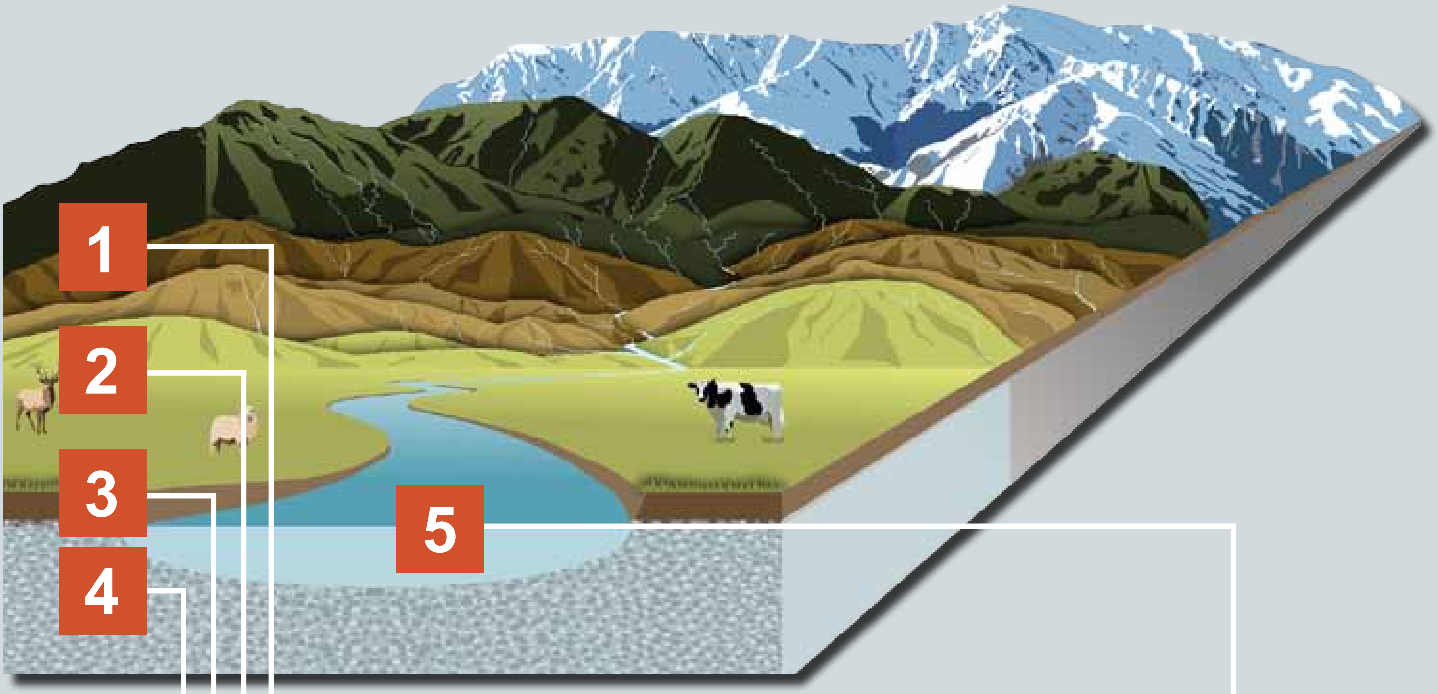


Figure 1: Landscape context image illustrating the relationship between the Bedrock/Hill country zone and neighbouring physiographic zones.   The Central Plains zone occurs on flat-lying alluvial terraces adjacent to the Aparima River and is interspersed with areas of the Oxidising zone reflecting erosion and deposition along historical channels of the Aparima River. Remnant areas of the Peat Wetland zone occur where drainage is impeded by the underlying geology. The Gleyed zone occurs on slightly elevated terraces further from the Aparima River. Little hydrological interaction occurs between the Central Plains and Gleyed 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 Central Plains zone extends from the Aparima River toward the Oreti River, across the northern portion of the Central Plains area. The zone also extends towards the south coast within the Waimatuku Stream catchment.

Topography

This zone occurs on flat to gently undulating (≤3° slope) alluvial terraces that are located predominately between 20 and 100 metres elevation.

Geology

Most of the Central Plains zone is comprised of alluvial gravel terrace deposits.

The subsurface geology comprises poorly sorted sandy gravels, with varying amounts of fine-grained material (sand and silt) vertically stratified within the gravel materials.

The texture of the alluvial deposits is inferred to reflect episodic deposition and reworking along a Late Pleistocene channel of the Aparima River.

Water chemistry generally indicates a carbonate influence, possibly reflecting incorporation of limestone sediments within the alluvial materials.

Climate

Average annual rainfall varies spatially between 838 and 1,125 mm, with rainfall increasing towards the base of the Taringatura Hills.

Central Plains LANDSCAPE zone characteristics

ELEVATION
20 – 100 m RSL

SLOPE
Flat to gently undulating

GEOLOGY
Quaternary sediments

LANDFORM AGE
Q2-Q4

AVERAGE ANNUAL RAINFALL
959 mm per year

2 Surface zone characteristics

Recharge to the Central Plains physiographic zone occurs exclusively via local precipitation infiltrating through the land surface.

Dilution

This zone is predominately recharged via land surface recharge (natural bypass flow) of local precipitation with little, if any, recharge from external sources (i.e. runoff from other zones). There is limited potential for dilution of contaminant concentrations associated with this recharge mechanism.

Surface waterways

Surface waters in this zone are characterised by a dense network of streams with a low gradient.

Surface drainage is augmented by an extensive artificial drainage network, including mole, tile and open channel drains.

Event driven flow (or quick flow) occurs in response to individual precipitation events during winter and spring when soils are wet for prolonged periods.

Higher soil infiltration rates during drier months (due to the potential for macropore flow) results in limited discharge to surface waterways in response to individual precipitation events. This is reflected in extended periods of stable baseflow during summer and autumn.

Overland flow

Overland flow is a minor flow pathway for this zone due to the predominantly flat topography.

Central Plains SURFACE zone characteristics

DILUTION POTENTIAL
Low recharge flux

DRAINAGE DENSITY
High

STREAM ORDER
Mixed

OVERLAND FLOW POTENTIAL
Low

3 Soil zone characteristics

A key feature of the Central Plains zone is the bi-modal drainage mechanism, which varies according to soil moisture status.

Soils

The Central Plains zone is comprised of Gley and Pallic soils. Over 94% of the zone consists of two soil series - Braxton and Pukemutu (Topoclimate South soil survey).

These soils are moderately deep to deep, with a silty clay to heavy silt loam texture. They are poorly drained with slow subsoil permeability, resulting in a high potential for waterlogging during wet periods.

Bi-modal drainage

Soils in the Central Plains zone are formed in a mixture of fine alluvium and loess sediments that are derived from tuffaceous greywacke and volcanic rocks sourced from the Takitimu Mountains. These mafic parent materials contain a high proportion of ferromagnesium minerals, which weather to form specific clay mineral types (e.g. smectites). These clay minerals are prone to shrink/swell behavior.

Shrinkage of these clay minerals when soil moisture is low causes extensive cracking. This allows rapid infiltration of recharge from the land surface through the soil zone (termed bypass flow) to underlying aquifers.

However, expansion of clay minerals as moisture increases causes these soils to revert to being poorly drained and prone to waterlogging when wet.

As a result, soil drainage in the Central Plains zone follows a seasonal pattern which tracks soil moisture.

Reduction potential

Soils in the Central Plains zone are classified as having a high reduction potential due to their poor drainage properties (when wet). Subsoils commonly exhibit redoximorphic features such as mottling, which indicate reducing conditions.

Therefore, significant nitrate removal via denitrification can occur in water infiltrating through the soil matrix.

However, the amount of denitrification that occurs is dependent on the residence time of water within the soil matrix, which is determined by soil hydraulic properties. As a result, water infiltrating rapidly through the soil zone via bypass flow may undergo limited denitrification.

Artificial drainage

When soils are wet, excess soil water drains rapidly to surface waterways via an extensive artificial drainage network. This discharge is typically episodic following rainfall events when soils are wet.

Lateral drainage

Lateral flow through the soil profile can occur in this zone when soils are wet.

In soil types that have restricted vertical drainage, lateral flow may occur along the top of slowly permeable layers within the soil profile.

However, the extent of lateral flow is localised due to the artificial drainage network.

Central Plains SOIL zone characteristics

SOIL ORDER
Gley, Pallic

PROFILE DRAINAGE
Poorly drained

PERMEABILITY
Moderate to slow

ANION STORAGE CAPACITY
Moderate

REDUCTION POTENTIAL
High

ARTIFICIAL DRAINAGE DENSITY
High

LATERAL DRAINAGE POTENTIAL
Localised

4 Saturated zone characteristics

Alluvial deposits underlying this zone host an extensive unconfined aquifer system that becomes increasing confined with depth. The alluvial deposits contain varying amounts of fine sediment and typically exhibit low aquifer permeability.

Groundwater

Groundwater recharge

The aquifer system is recharged by land surface recharge, which may occur rapidly when soils are dry and cracked.

Groundwater discharge

Groundwater discharge occurs via two separate mechanisms:

- Localised drainage of shallow groundwater to surface waterways is a major component of the overall water balance, which provides baseflow to numerous lower order streams and maintains groundwater levels within a well-defined range.
- Sub-regional circulation through deeper levels of the unconfined aquifer following the wider catchment drainage pattern is a relatively minor component of the water balance.

Reduction potential

While soils in this zone are highly reducing, underlying groundwater generally exhibits an oxidising or mixed redox state. This unusual situation reflects the limited influence of soil zone redox processes on a significant proportion of aquifer recharge (i.e. that which occurs rapidly as bypass flow).

Within the saturated zone, reduction potential is low reflecting the lack of sediments containing organic carbon.

Deep drainage

Deep drainage occurs at a slow rate through poorly drained wet soils but occurs rapidly via bypass flow through macropore structures (cracks, fissures) when dry soils experience heavy precipitation events.

Central Plains SATURATED zone characteristics

WATER TABLE DEPTH
Shallow

AQUIFER PERMEABILITY
Low

ACTIVE GROUNDWATER STORAGE
Moderate

REDUCTION POTENTIAL
Low

DEEP DRAINAGE POTENTIAL
Low

5 Water quality implications

Water quality risks in the Central Plains physiographic zone vary seasonally, depending on whether soils are wet or dry. When soils are wet, contaminants are rapidly exported to streams via artificial drains. When soils are dry, excess nitrate is leached to underlying groundwater in response to precipitation events.

Influencing factors

Water quality is strongly influenced by bi-modal soil drainage (see Figures 2 and 3).

Water quality issues

A significant proportion of drainage water bypasses the reducing soil matrix via artificial drainage or macropore flow. As a result, a majority of soil drainage undergoes limited denitrification (despite soils having a high reduction potential).

Groundwater

Nitrogen that accumulates in the soil during summer and autumn is prone to rapid leaching via bypass flow during the late autumn/early winter period. Depending on land use, this can result in elevated nitrate concentrations in underlying groundwater.

In turn, shallow groundwater containing elevated nitrate concentrations provides baseflow discharge to surface waterways draining the Central Plains zone.

Microbial contamination of groundwater is limited by filtration, adsorption and natural die-off of microbes within underlying areas of fine-grained alluvium.

Surface water

Rapid export of contaminants via artificial drainage occurs during sustained wet periods.

Nitrate concentrations in streams may increase during periods of baseflow reflecting drainage of groundwater containing elevated nitrate concentrations.

Elevated *E.coli* concentrations in surface waters reflect mole-tile drains intersecting soil cracks (when soils are dry) and rapid discharge via artificial drainage (when soils are wet).

Key HYDROCHEMICAL features

- Water facies are mainly calcium-bicarbonate (Ca-HCO_3) reflecting base rich soils formed in mafic parent materials
- Groundwater and surface water exhibit elevated pH due to the buffering capacity of limestone incorporated in the alluvial materials
- High alkalinity occurs due to pH buffering in the soil zone

What affects water quality in the Central Plains zone?

WHERE	KEY CHARACTERISTICS	CONTAMINANT PATHWAYS	ATTENUATION PROCESSES	WATER QUALITY RISK
All areas (wet soils)	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
		Lateral flow	Filtration, adsorption and denitrification in the soil matrix	Low water quality risk due to extent of physical attenuation and denitrification
		Overland flow	Limited attenuation of soluble and particulate contaminants	Low water quality risk due to limited extent of overland flow except in response to extreme precipitation events
		Deep drainage to groundwater (via soil matrix)	Filtration, adsorption and denitrification in the soil matrix	Low water quality risk
All areas (dry soils)	Extensive cracking due to shrink/swell behavior of soils Rapid infiltration of soil drainage via bypass flow	Deep drainage to groundwater (natural bypass flow) allowing rapid infiltration of recharge from the land surface to underlying groundwater	Limited denitrification with some attenuation of particulate contaminants in groundwater recharge	Nitrogen Elevated nitrate concentrations leached to underlying groundwater
		Discharge via artificial drainage network (where soil cracks intercept mole-pipe drains)	Limited attenuation of soluble and particulate contaminants	Nitrogen Phosphorus Microbes Sediment Contaminants discharged rapidly to surface water

CONTAMINANT PATHWAY	MITIGATION OBJECTIVES
Deep drainage	Reduce the accumulation of surplus nitrogen in the soil, particularly over autumn and winter
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

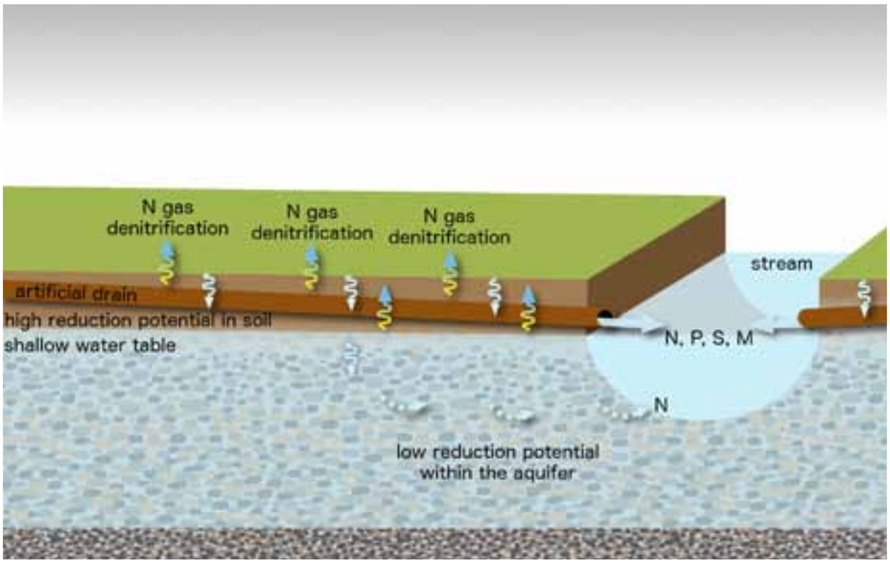


Figure 2: **Wet soils** – When soils are wet, artificial drainage provides a pathway for episodic export of dissolved nitrogen (N), phosphorus (P) sediment (S) and microbes (M) to surface water

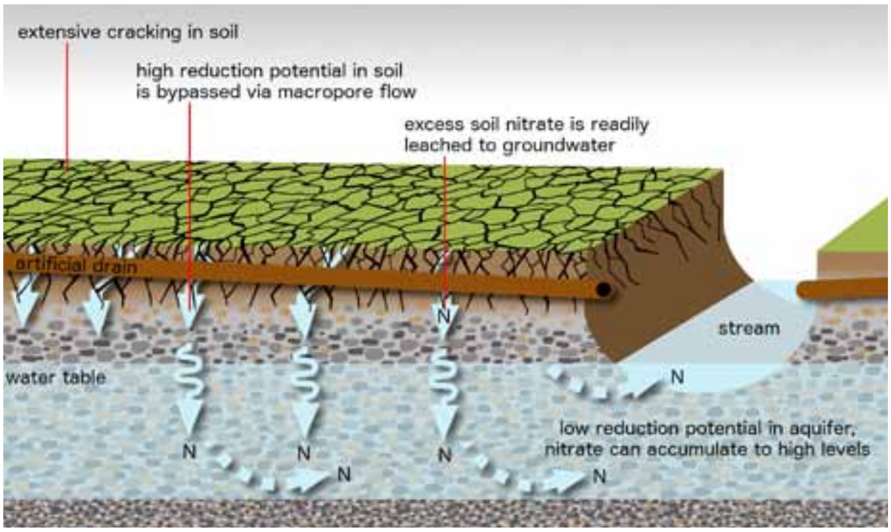


Figure 3: **Dry soils** – When soils are dry, macropore flow through soil cracks allows rapid leaching of excess nitrate from the soil zone to underlying groundwater. Where soil cracks intercept mole-pipe drains, contaminants may be loss via artificial drainage. Nitrate concentrations in aquifers can be elevated due to low aquifer denitrification potential. Groundwater discharges as baseflow to streams, influencing surface water quality.