Lake Waipopo

01/05/2024

NRC Lake Number: 103

- Habitat size
- Connectivity
- Buffering
- Water quality
- Aquatic vegetation diversity
- Aquatic vegetation integrity
- Endangered species
- Presence of key species
- LakeSPI score

ECOLOGICAL VALUE SCORE

5 /20

Overall Rank: Moderate to Low

Key impact	Management action
Eutrophication: There are signs of nutrient enrichment from the pasture dominant catchment.	Develop a farm environment plan and use the management tool box for immediate interventions.
Stock access: Stock have damaged the riparian margin through grazing and pugging.	Exclude stock and allow the riparian vegetation to regenerate.
Invasive Species: No invasive species are present but new introductions will cause significant damage.	Limit access to the lake and increase biosecurity awareness.

Did you know:
There in no submerged vegetation in this lake!

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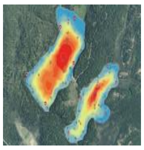
Report card glossary



Habitat size: This score is based on the size and depth of the lake. Large deep lakes are more stable because they have a greater dilution capacity and a larger area to support different habitat types.

Connectivity: This score considers the number of nearby lakes and wetlands. This connectivity is important as several threatened birds travel between waterbodies that form a network of habitats across the landscape.

Buffering: This score is based on the riparian vegetation around the lake and how much native vegetation and wetlands there are in the catchment. This vegetation filters pollutants entering the lake from the surrounding land.

Water quality: This score is based on the nutrient concentrations in the lake. Higher nutrient concentrations typically result in a poor level of ecological health and is often associated with murky water and algal blooms.

Aquatic vegetation diversity: This score is based on how many different species of aquatic plants live in the lake. Lakes with a high diversity of aquatic plants are usually in better ecological condition.

Aquatic vegetation integrity: This score is based on the extent, diversity and condition of native submerged plant. Fully vegetated lakes with a high species diversity are often in the best condition.

Endangered species: This score is based on how many endangered plants and fish live in this lake. Endangered species add value to the ecosystem and are an indicator of good ecological health.

Presence of key species: This score is based on the presence of freshwater mussels (kakahi or torewai). These mussels are important for lake health because they filter the lake and remove algae.

LakeSPI: This score is based on the health, density and extent of native and exotic submerged plants in the lake. This score also integrates the impact of invasive submerged plants.

General description

Lake Waipopo (Katavich) was assessed during the following years: 2005, 2019, and 2024.

Lake Waipopo (Katavich) (34°56'37"S 173°09'49"E) is a small (6.3 ha) shallow (<2 m) lake west of the larger Lake Waiparera. The lake is situated on private land and sits in a depression amongst grazed pasture with forestry along the outer catchment boundary.

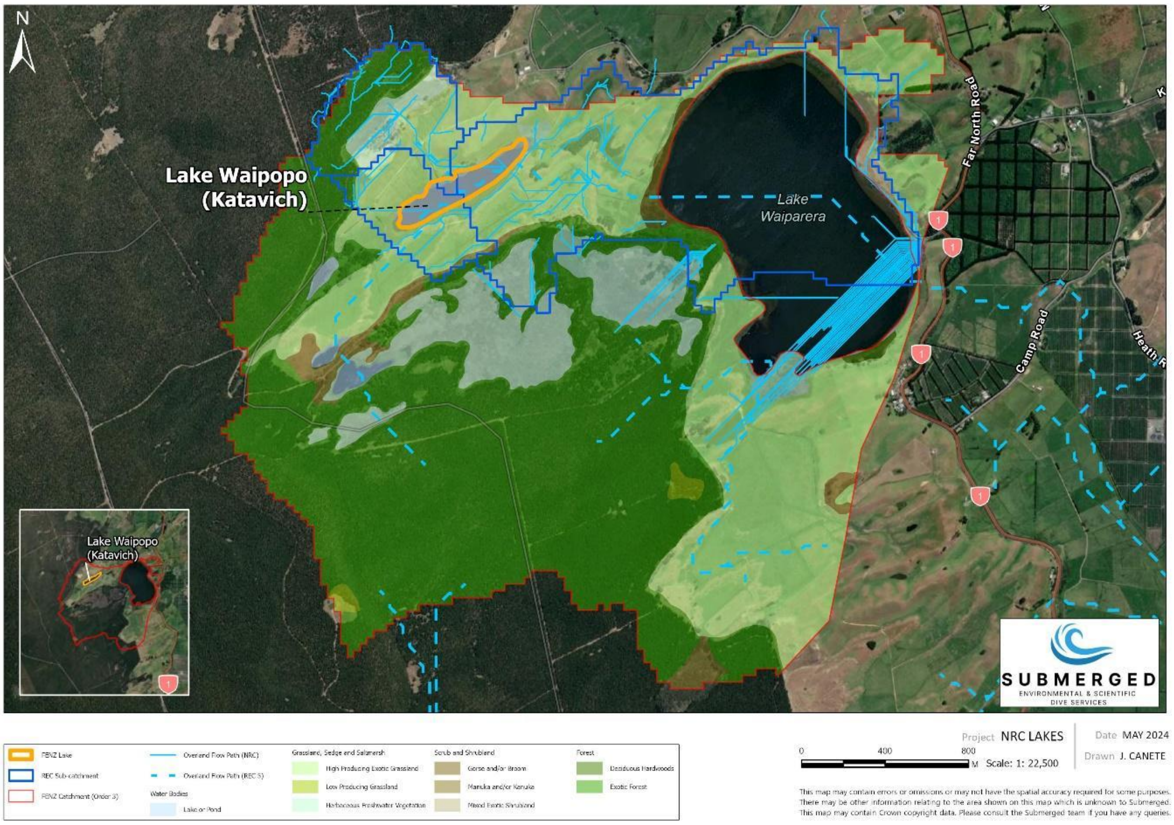
Lake Waipopo (Katavich) – Southeastern view showing the band of emergent vegetation that surrounds the lake and the pasture dominant land use

Catchment & sub-catchment description

The 596.62-hectare catchment largely consists of pasture (36%) and production forestry (48%). There are small pockets of manuka/kanuka scrub on the edge of the catchment and sub-catchment that equate to 2% of the total catchment area. The Waiparera wetlands make up 11% of the catchment area and are located south of the lake. This extensive wetland serves as a buffer between the lake and the southern forestry block.

The 225.39-hectare sub-catchment consists almost entirely of high-producing exotic pasture flanked by forestry. Seven percent of the sub-catchment is classified as wetlands, part of which is the outer edge of the Waiparera wetland, and the remainder is a large wetland northwest of the lake. This wetland buffers water flow from the surrounding forestry but is poor quality and is connected to the lake via a farm drain.

The lake itself has a wide continuous vegetated riparian margin that will attenuate incoming contaminants. However, the high-impact nature of the catchment and stream network that drains pastoral land into the lake means the level of land use related impact is likely to be high.



Lake Waipopo (Katavich) catchment land cover and overland flow path network

In-lake description

The lake exhibits pronounced ecological degradation, marked by the absence of vegetation and the prevalence of soft anoxic mud.

The water was a dark, black-stained hue and visibility was limited to less than 7 cm. The poor visibility is likely due to a combination of wind-induced sediment remobilisation, tannins from the emergent vegetation, and high suspended algal volumes.

There were thick layers of decomposing organic matter along the edge of the emergent vegetation that produced a distinctive sulphurous odour. Trapped sulphurous gas, resulting from decomposition processes, was also released as the lakebed was disturbed.

The majority of the survey area was shallow (< 1 m) and it appears that the combination of sediment deposition and encroaching emergent vegetation is driving the succession of this lake into a high-nutrient wetland.

Wetland vegetation

Almost the entire lake perimeter has a wide band of emergent vegetation composed predominantly of *Typha orientalis, Eleocharis sphacelata, Schoenoplectus tabernaemontani* and *Machaerina articulata.*

The riparian margin provides buffering and habitat for wetland birds however, there was evidence of stock access. The surroundings consist of steep slopes with erosion issues and pasture which impacts the riparian and lake health.

Submerged vegetation

No submerged vegetation was seen during the 2024 survey. The poor substrate and extremely limited photic depth have created conditions that are unlikely to support the regeneration of native macrophytes. The eDNA analysis also did not detect any submerged plant species.

LakeSPI

No LakeSPI index could be generated as the lake is non-vegetated.

Lake Waipopo (Katavich) LakeSPI scores as a percentage of the maximum Potential LakeSPI score, Native Condition Index, and Invasive Impact Index

Survey Date	Status	LakeSPI %	Native Condition %	Invasive Impact %
2024	Non-vegetated	0	0	0
2019	Non-vegetated	0	0	0
2005	Non-vegetated	0	0	0

Wetland birds

Two At Risk – Declining mātātā (fernbird) (*Poodytes punctata vealeae*) were seen along the riparian margin of the lake. Mallards (*Anas platyrhynchus*), paradise shelduck (*Tardorna variegata*), black swan (*Cygnus atratus*) and Canada geese (*Branta canadensis*) were also seen during the 2024 survey. The tall emergent vegetation provides good habitat for many aquatic birds, with DoC SSBI survey in 1991 recording several At Risk - Declining spotless crake (*Porzana tabuensis tabuensis*). The following priority conservation species have been sighted near the lake; weweia (dabchick) (*Poliocephalus rufopectus*), matuku (Australasian bittern) (*Botaurus poiciloptilus*), black shag (*Phalacrocorax carbo novaehollandiae*), mātātā (fernbird) (*Poodytes punctatus*) and white heron (*Ardea alba*).

Matuku (bittern) were observed 5 km north of lake in 2000 and 9 km south of the lake in 2017 and 2019. Oother common species such as kingfishers, pukekos and swamp harriers were seen in 2019. Black shag and mātātā (fernbird) have been regularly sighted across the northern tip of the region since 2014. White heron have been sighted between 2013 - 2021 near Spirits Bay and Rangaunu Bay estuary so it is possible that they use wetlands/lakes across the Northern portion of the region. Weweia (dabchick) were sighted within 2 km east of the lake from 2013 – 2020 and black shags are commonly sighted across freshwater environments in the region.

Fish

No fish were sighted during the 2024 survey due to the exceptionally poor underwater visibility however, the eDNA analysis detected common bullies (*Gobiomorphus cotidianus*), shortfin eels (*Anguilla australis*), goldfish (*Carassius auratus*) and *Gambusia affinis.*

Aquatic invertebrates

No aquatic invertebrates were noted during the 2024 survey.

No freshwater mussels were found and there is no record of them in this lake. The substrate is not suitable, and the high concentration of suspended matter creates conditions that would prevent this species from establishing in the lake.

Endangered species

No endangered fish or plant species were recorded during the 2024 survey; however, the riparian margin provides habitat for wetland birds, including mātātā (fernbird), so it is possible that the lake is frequented by a variety of threatened avifauna.

Lake ecological value

Lake Waipopo (Katavich) was assessed as having a “Moderate to low” ecological value with a score of 5 out of 20. This score reflects the non-vegetated state of the lake however, the overall score is increased by the continuous band of mature riparian vegetation around the lake and the high degree of buffering it offers.

Lake Waipopo is a very shallow (<2 m) small (6.3 ha) lake, so it scores 0.5 out of 3 for the Habitat Size metric. It is adjacent to Lake Waiparera and a series of large wetlands, so it gets an additional point for connectivity to other waterbodies.

The lake scores a 2 out of 3 for the Buffering Metric. The entire lake perimeter (>95%) consists of a wide (>20 m) band of mature emergent vegetation and 11% of the wider catchment is classified as wetlands. The size of the lake and extensive wetlands in the adjacent areas means the relative percentage of wetlands to the lake area is high. The wider catchment has a low percentage of native vegetation (13%), and the sub-catchment has even less (7% of the sub-catchment area). This in combination with the extensive pasture brings down the overall score.

No water quality data is available for the lake, so it is automatically assigned a 0 out of 3. This is done to ensure a standardised approach when scoring unmonitored lakes and is representative of the worst-case scenario. In-lake observations indicate that the lake has likely been in a eutrophic state for some time and it is possible that it could reach a supertrophic state during hot summer temperatures.

Despite the wide continuous nature of the riparian margins, the species diversity is low and only 14 aquatic plant species were recorded and no submerged species were found. As a result, the lake scores a 1 out of 3 for the Aquatic Vegetation Diversity Metric.

The Aquatic Vegetation Integrity metric is taken from the LakeSPI Native Condition, the resulting score is 0 out of 3 which is reflective of the non-vegetated state.

No endangered plants or fish were seen during the survey, so the lake scores a 0 out of 3 for the Endangered Species Metric; however, records from the wider catchment indicate that the lake is likely used by a variety of threatened wetland birds.

No freshwater mussels were seen during the 2024 survey and the substrate conditions are not suitable for the establishment of this species.

Threats

Increasing eutrophication is the primary threat and will likely result in the continual degradation of the lake.

There were signs of recent pugging so stock may have intermittent access to parts of the lake. This contributes to the degradation of the riparian margin and has cascading effects on lake health.

The possible introduction of pest species is unlikely to have a significant impact as there is very limited in-lake ecological value.

The emergent vegetation buffers incoming contaminant loads and serves as habitat for wetland birds. However, the encroaching nature of the growth and sediment deposition could cause the lake to eventually transition into a high-nutrient wetland.

Management recommendations

The primary threats to Lake Waipopo (Katavich) are eutrophication and sedimentation. Interventions that minimise these issues will result in water quality improvements but it is unlikely to significantly increase the in-lake ecology. The following management actions are recommended:

Stock exclusion

There are signs of stock access along the lake margin and pugging has damaged sections of the riparian areas. Excluding stock will prevent erosion, stabilise the lake margin and allow riparian vegetation to establish.

Land/farm management plan

The impacts from the surrounding pasture can be managed through an effective land/farm management plan. An initial assessment should be done to identify waterways entering the lake, key areas of diffuse overland flow, critical source areas for contaminants and land use activities that do not follow best practices. Management interventions can then be selected from the Management tool box section to minimise the impacts from the catchment. The management interventions are primarily for water quality objectives and will unlikely result in significant in-lake ecological enhancement.

Routine monitoring

The lake has submerged vegetation and poor water quality so routine monitoring is not recommended. A brief 5 - 10 yearly assessment can be done to confirm the non-vegetated state and if significant changes occur, a new monitoring regime can be implemented.

Management tool box

The interventions are grouped in tables (tool box) according to the contaminant they manage. Phosphorus, nitrogen, sediment, and *E. coli* were identified as the primary contaminants that drive deteriorating lake health.

The management interventions in the tool boxes are listed in order of efficacy and cost effectiveness e.g., the first option in the table is the most efficient and/or cost-effective way to manage that specific contaminant whereas, the last option is the least efficient and/or most costly intervention. The actual costs and efficiency will differ between farms as it depends on the specific land use activity, scale of the activity/issue, level of existing infrastructure, existing interventions, underlying topography and expected outcomes. For this reason, all interventions should be considered when drafting an environmental management plan.

Management Interventions for Phosphorus			
Intervention	**Description**	**Co-benefit**	**Comments**
Stock exclusion/ Fencing	Preventing livestock access to the lake, decreases bank damage, reduces sediment inputs via bank erosion and prevents direct deposition of faces. All of which reduce *E. coli*, N and P loads.	Allows riparian vegetation to establish which provides filtration capacity, shading, habitat, and organic matter input.	Excluding stock from the stream network reduces impacts to the downstream receiving environment. Most cost-effective intervention considering the wide range of co-benefits.
Tile drain amendments	Use of P-sorbing Ca, Al and Fe materials as backfill for artificial drainage systems. This reduces the nutrient load entering the lake.	Additional filtration of sediment and faecal bacteria.	This is a potentially costly intervention but is very effective. It should be considered if there is a lot of overland flow paths draining into the lake.
Controlled release fertiliser	Use low-water-soluble P fertiliser. Less fertiliser-P is lost in runoff due to the low water solubility of products such as reactive phosphate rock resulting in increased P use efficiency.	Increases efficiency and P retention which lowers the overall amount of fertiliser required, resulting in large cost savings.	These types of fertilisers are not appropriate for soil pH < 6.0 or rainfall > 800 mm. Also, cannot be used for capital applications and must gradually replace highly-water soluble P applications at a rate of one-third per year.
Dams and water recycling	Recycling systems that divert irrigation outwash for use in others part of the farm reduces nutrient loads/discharges to the lake.	More efficient use of flood irrigation water and increased nutrient recycling.	Could require a change in irrigation infrastructure so should only be considered if water loss/discharges are a significant impact.
Precision/variable rate application of fertiliser	Precision fertiliser application using remote sensing of the nutrient status of the land to determine where & what nutrients should be targeted. This reduces the overall mobile nutrient load in the catchment and prevents excess nutrient loads entering the lake.	Reduction in the amount of fertiliser required, resulting in large cost saving.	Requires a change to the fertiliser application strategy and can present a higher initial implementation cost. Costs should reduce once the system is in place as less fertiliser will be required.
Precision irrigation	Use sensors to automate irrigation and nutrient inputs and optimises crop utilisation at fine scale.	Reduces the overall water and nutrient requirements, optimised applications result in better yields.	The initial infrastructure can be costly and requires active monitoring to ensure the process is optimised effectively.

Strategic grazing of pasture/crops within critical source areas	Identify the critical source areas of phosphorus and avoid grazing those areas during wet seasons.	Allows high P areas to be utilised for arable crops and allows a maximum yield from the land.	Requires more regular stock movement and an assessment of critical source areas.
Refurbish and widen flood irrigation bays	Water exiting flood irrigation bays as outwash represents about 20-50% of that applied. Re-contouring irrigation bays, and/or preventing outwash/wipe-off from accessing the stream network decreases P loads to the lake.	Recycling the water for use elsewhere on the farm reduces overall water consumption and nutrient requirements.	Recontouring can be costly and may result in a minor loss in yield.
Apply aluminium sulphate to pasture, forage cropland or crops in critical source areas	P-sorbing aluminium sulphate (alum) sprayed onto a winter forage crop just after grazing, or sprayed onto pasture a week before grazing, will prevent surface runoff losses of P and reduce nutrient loads to the lake.	Reduces overall catchment phosphorus load.	Presents an additional annual cost.
Restrict grazing of winter forage crops	Restrict grazing of forage crops in winter to reduce deposition of faeces and surface erosion. This limits the amount of phosphorus entering the lake during the wet season.	Better conditions for stock and less pasture damage.	Requires active stock movement and planning. Must be accompanied by a stand-off area that has no connection to a waterway.
Cover/ catch crop	Grow cover/catch crops on the same field in the same year, often used after the main crop or grass has been grazed or machinery has exposed the soil. This reduces nutrient and sediment loads to the lake.	Enhances soil health, prevents erosion, reduces nutrient leaching, and improves yield.	This will improve the year-round use of the pasture and can be designed in a way to maximise yields.
In-stream sorbents	Use of P sorbing material textile bags and place them on the stream bed to remove P from baseflow. This reduces the amount of P entering the lake from overland flow paths.	Additional filtration of other contaminants and reduces the catchment contaminant load.	Installation might require in-stream works. The focus should be on streams that flow into the lake and/or drain high impact land use.
Phosphorus matching to crop requirements	Matching soil Olsen P concentrations to pasture and forage crop requirements avoids	An agronomic optimum phosphorus dosing reduces the amount of	Will require targeted soil investigations but the analysis is low cost and

	excessive soil P concentrations and reduces the P load to the lakes and stream network.	fertiliser required and the overall annual cost.	can be coupled with other soil health tests.
Vegetated buffers/planting below critical source areas	Vegetated buffer below critical source areas and at the base of steep sloped pastures work to decrease contaminant loss in surface runoff by a combination of filtration, deposition, and improving infiltration.	Stabilises land, provides habitat for fauna and helps create wildlife corridors across the landscape.	Choose vegetation types based on the outcomes and site details. Use different planting mixes for erosion protection than for nutrient attenuation.
Constructed/natural seepage wetlands	Modification of landscape features such as depressions and gullies to form wetlands creates additional catchment buffering. Restoring natural seepage wetlands at the heads and sides of streams will reduce the contaminant load entering the stream/lake network.	Enhanced flood attenuation and increased habitat and biodiversity values.	These wetland features need to be fenced and restored to a good ecological condition for them to provide a high level of ecosystem services.
Sediment traps/retention ponds/bunds	In-stream sediment traps and retention ponds will allow coarse sized sediment and associated N and P to settle out. Bunds constructed along paddock edges creates ponds of water at the bottom of fields where sediment settles out which prevent excess contaminants from entering the lake.	Potential to buffer storm events and downstream flooding.	Typically, only effective on cropping land with slope greater than 3 degrees.

Management Interventions for Nitrogen			
Intervention	**Description**	**Co-benefit**	**Comments**
Stock exclusion/ Fencing	Preventing livestock access to the lake, decreases bank damage, reduces sediment inputs via bank erosion and prevents direct deposition of faces. All of which reduce *E. coli*, N and P loads.	Allows riparian vegetation to establish which provides filtration capacity, shading, habitat, and organic matter input.	Excluding stock from the stream network reduces impacts to the downstream receiving environment. Most cost-effective intervention considering the wide range of co-benefits.

Change animal type	Animal type influences nitrogen leaching due to differences in the spread of urinary nitrogen. Nitrogen leaching from sheep and deer is approximately half that from beef cows at the same level of feed intake.	Also leads to decreased N2O emissions.	Careful consideration of the animal type is required as some species exacerbate other contaminant issues e.g., a change to deer may lead to greater sediment and P loss.
Constructed/natural seepage wetlands	Modification of landscape features such as depressions and gullies to form wetlands creates additional catchment buffering. Restoring natural seepage wetlands at the heads and sides of streams will reduce the contaminant load entering the stream/lake network.	Enhanced flood attenuation and increased habitat and biodiversity values.	These wetland features need to be fenced and restored to a good ecological condition for them to provide a high level of ecosystem services.
Cover/ catch crop	Grow cover/catch crops on the same field in the same year, often used after the main crop or grass has been grazed or machinery has exposed the soil. This reduces nutrient and sediment loads to the lake.	Enhances soil health, prevents erosion, reduces nutrient leaching, and improves yield.	This will improve the year-round use of the pasture and can be designed in a way to maximise yields.
Reduce nitrogen in critical source areas	Reduced use of nitrogen fertiliser on winter forage crops coming out of long-term pasture and avoid excessive nitrogen inputs to effluent blocks. This reduces the nitrogen load entering the lakes during high rainfall events.	Decrease emissions of greenhouse gases, reduce overall fertiliser requirements and an improvement in energy use.	Will require targeted soil investigations to ensure an accurate soil nitrogen profile.
Strategic grazing of pasture/crops within critical source areas	Identify the critical source areas of nitrogen and avoid grazing those areas during wet seasons.	Allows high nitrogen areas to be utilised for arable crops and allows a maximum yield from the land.	Requires more regular stock movement and an assessment of critical source areas.
Precision/variable rate application of fertiliser	Precision fertiliser application using remote sensing of the nutrient status of the land to determine where & what nutrients should be targeted. This reduces the overall mobile	Reduction in the amount of fertiliser required, resulting in large cost saving.	Requires a change to the fertiliser application strategy and can present a higher initial implementation cost. Costs should reduce once the system is in

	nutrient load in the catchment and prevents excess nutrient loads entering the lake.		place as less fertiliser will be required.
Precision irrigation	Use sensors to automate irrigation and nutrient inputs and optimises crop utilisation at fine scale.	Reduces the overall water and nutrient requirements, optimised applications result in better yields.	The initial infrastructure can be costly and requires active monitoring to ensure the process is optimised effectively.
Controlled release fertiliser	Use slow-release nitrogen fertiliser. Less mobile nitrogen is lost in runoff due to the low water solubility and slow release resulting in increased nitrogen use efficiency.	Increases efficiency and nitrogen retention which lowers the overall amount of fertiliser required, resulting in large cost savings.	These types of fertilisers may result in a lower initial yield and might not be as effective in cold dry soil.
Denitrification beds	Large containers filled with woodchips that intercept drain flow and denitrify nitrate in water to nitrogen gas which is released to the atmosphere. These reduce the concentrations of bioavailable nitrogen entering the lake.	Provides additional filtration of other contaminants.	Suitable for tile/sub-surface drains or small surface drains. Can create hydrological blockages in larger channels.
Restrict grazing of winter forage crops	Restrict grazing of forage crops in winter to reduce deposition of faeces and surface erosion. This limits the amount of phosphorus entering the lake during the wet season.	Better conditions for stock and less pasture damage.	Requires active stock movement and planning. Must be accompanied by a stand-off area that has no connection to a waterway.

Management Interventions for Sediment			
Intervention	**Description**	**Co-benefit**	**Comments**
Stock exclusion/ Fencing	Preventing livestock access to the lake, decreases bank damage, reduces sediment inputs via bank erosion, and stabilises the stream network.	Allows riparian vegetation to establish which provides filtration capacity, shading, habitat, and organic matter input. Prevents direct deposition of faces and reduces *E. coli*, N and P loads.	Excluding stock from the stream network reduces impacts to the downstream receiving environment. Most cost-effective intervention considering the wide range of co-benefits.
Cover/ catch crop	Grow cover/catch crops on the same field in the same year, often used	Enhances soil health, prevents erosion, reduces nutrient	This will improve the year-round use of the pasture and can be

	after the main crop or grass has been grazed or machinery has exposed the soil. This reduces nutrient and sediment loads to the lake.	leaching, and improves yield.	designed in a way to maximise yields.
Contour cultivation	Cultivation along contours of cropping land with slopes greater than 3 degrees reduces the speed and eroding power of runoff water.	Stabilises slopes and prevents slips. Increases yield by farming steep areas. Reduces nutrient loads from highly mobile soils during high rainfall events.	Requires new techniques and earthworks. This practice should be combined with detention ponds/bunds at the base of the slopes to further enhance contaminant attenuation.
Restrict grazing of winter forage crops	Restrict grazing of forage crops in winter to reduce surface erosion. This limits the amount of sediment entering the lake during the wet season.	Better conditions for stock and less pasture damage.	Requires active stock movement and planning. Must be accompanied by a stand-off area that has no connection to a waterway.
Sediment traps/retention ponds/bunds	In-stream sediment traps and retention ponds will allow coarse sized sediment to settle out. Bunds constructed along paddock edges creates ponds of water at the bottom of fields where sediment settles out which prevent excess contaminants from entering the lake.	Potential to buffer storm events and downstream flooding.	Typically, only effective on cropping land with slope greater than 3 degrees.
Constructed/natural seepage wetlands	Modification of landscape features such as depressions and gullies to form wetlands creates additional catchment sediment buffering. Restoring natural seepage wetlands at the heads and sides of streams will reduce the sediment load entering the stream/lake network.	Enhanced flood attenuation and increased habitat and biodiversity values.	These wetland features need to be fenced and restored to a good ecological condition for them to provide a high level of ecosystem services.
Vegetated buffers/planting below critical source areas	Vegetated buffer below critical source areas and at the base of steep sloped pastures work to decrease sediment loss in surface runoff by a combination of filtration, deposition, and improving infiltration.	Stabilises land, provides habitat for fauna and helps create wildlife corridors across the landscape.	Choose vegetation types based on the outcomes and site details. Use different planting mixes for erosion protection than for nutrient attenuation.

Strategic grazing of pasture/crops within critical source areas	Identify the critical source areas of sediment and avoid grazing those areas during wet seasons.	Allows high sediment areas to be utilised for arable crops and allows a maximum yield from the land.	Requires more regular stock movement and an assessment of critical source areas.
Minimum tillage/ direct drilling of seed	Direct drilling of seed into stubble or pasture reduces the proportion of time that land is bare and erodible during the growing cycle. This greatly reduces the sediment loads entering the lakes/streams.	Enhanced soil condition and stability. Less erosional issues and increased productivity.	May not be suitable for all crop types.
Increasing forested area/ windbreaks	Combination of retirement and pole planting on highly erodible land. Introduction of tree roots to soil regolith protects soil on steep slopes from mass movement erosion.	Stabilises slopes and prevents slips. Increases yield by farming steep areas. Reduces nutrient loads from highly mobile soils during high rainfall events.	This intervention should be planed with other re-vegetation interventions to create blue-green networks and wildlife corridors across the landscape.

Management Interventions for *E. coli*			
Intervention	**Description**	**Co-benefit**	**Comments**
Stock exclusion/ Fencing	Preventing livestock access to stream and lake banks reduce stream bank damage and stops the direct deposition of excreta (*E. coli*) into the waterways.	Allows riparian vegetation to establish which provides filtration capacity, shading, habitat, and organic matter input. Prevents direct deposition of faces and reduces *E. coli*, N and P loads.	Excluding stock from the stream network reduces impacts to the downstream receiving environment. Most cost-effective intervention considering the wide range of co-benefits.
Strategic grazing of pasture/crops within critical source areas	Identify the critical source areas near waterways and avoid grazing those areas during wet seasons.	Allows these areas to be utilised for arable crops and allows a maximum yield from the land.	Requires more regular stock movement and an assessment of critical source areas.
Restrict grazing of winter forage crops	Restrict grazing of forage crops in winter to reduce the amount of deposited excreta during the wet season. This limits the amount of *E. coli* entering the lake during high rainfall events.	Better conditions for stock and less pasture damage.	Requires active stock movement and planning. Must be accompanied by a stand-off area that has no connection to a waterway.
Sediment traps/retention ponds/bunds	In-stream sediment traps and retention ponds will allow faeces settle out. Bunds constructed along paddock edges creates	Potential to buffer storm events and downstream flooding.	Typically, only effective on cropping land with slope greater than 3 degrees.

	ponds of water at the bottom of fields where excreta accumulate. This prevents excess *E. coli* from entering the lake.		
Vegetated buffers/planting below critical source areas	Vegetated buffer below critical source areas and at the base of steep sloped pastures work to decrease excreta (*E. coli*) loss in surface runoff by a combination of filtration, deposition, and improving infiltration.	Stabilises land, provides habitat for fauna and helps create wildlife corridors across the landscape.	Choose vegetation types based on the outcomes and site details. Use different planting mixes for erosion protection than for nutrient attenuation.