Farm Environmental Management Plan:

Glenmore Station

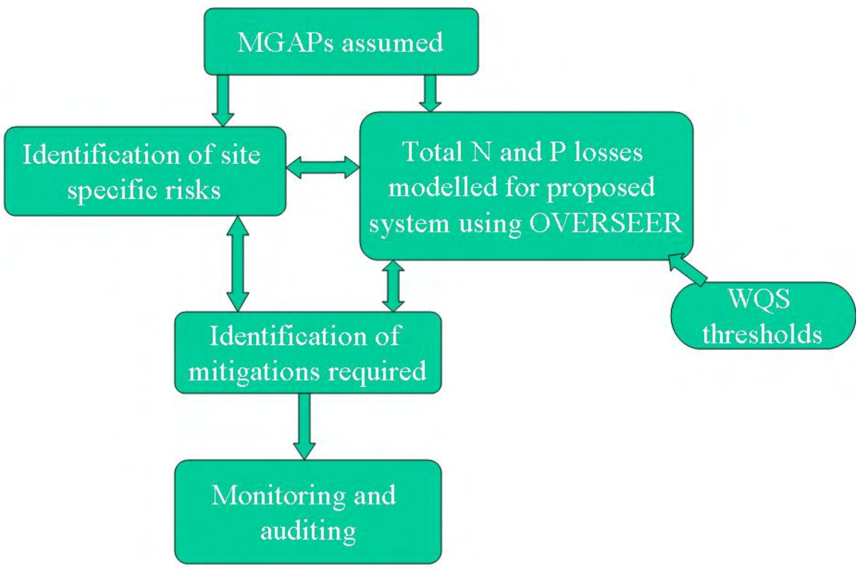
1. Introduction

The Water Quality Study ('WQS') funded by Mackenzie Water Research Limited ('MWRL'), found that the additional irrigation proposed in the catchment could take place without significant adverse effects on the environment providing that nutrient reduction occurred on the farms.

The process that was advocated for ensuring this on-farm nutrient reduction was through Farm Environmental Management Planing. A clear process for building a Farm Environmental Management Plan (FEMP) was laid out in the Water Quality Study and has been followed here. An overview schematic of the process of building a FEMP is shown in Figure 1.

The responsibility of the implementation, monitoring and auditing of the plan lies with the **farmer**.

Figure 1: Overview schematic of the process to build a Farm Environmental Management Plan



MGAP – Mandatory good agricultural practices

Please note:

This plan has 3 appendixes;

1. Glenmore Station Farm Management Plan (2008-2012)

2. Glenmore Station Environmental Report

3. Table showing all stocking movements, class and numbers

These documents are provided for your reference if you should require any further information on the principles that underlie the management of Glenmore Station and the broad environmental patterns that are present on the property.

2. Farm Description

2.1 General farm description

Glenmore Station (19,200 ha) is located on the western side of Lake Tekapo on the edge of the Mackenzie Basin, South Canterbury. It is a long relatively narrow property (Figure 1), extending 30 km northwest from Lake Tekapo to within c. 1.5 km of the boundary of Aoraki/Mount Cook National Park. The property is a predominantly pastoral lease (PT001), with a small area of freehold title. Some land is also leased from Mackenzie District Council. These different land tenures are all managed as one farming unit. Glenmore Station currently runs 10,000 merino sheep, 460 red deer and 400 angus cattle.

Glenmore Station is a part of the ARGOS (Agriculture Research Group on Sustainability) programme which includes an extensive environmental monitoring involving land-cover, aquatic and soil monitoring. Full details on the methods used are provided in Norton et al. (2006). The primary goal of the ARGOS high country monitoring programme is to assess the response of high country ecosystems to (1) management inputs and (2) external perturbations such as climate change or species invasion

For more information on Glenmore Station, refer to Appendix 1 (page 33)

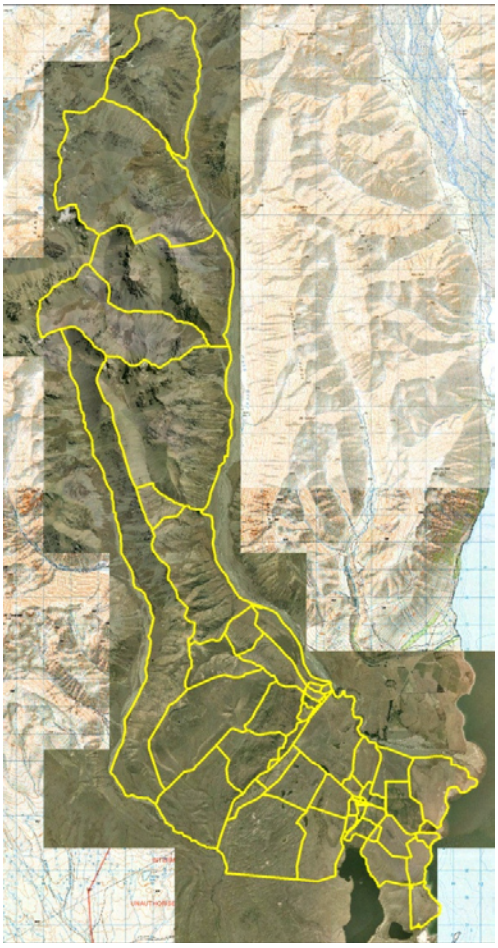


Figure 1: Aerial map of Glenmore Station

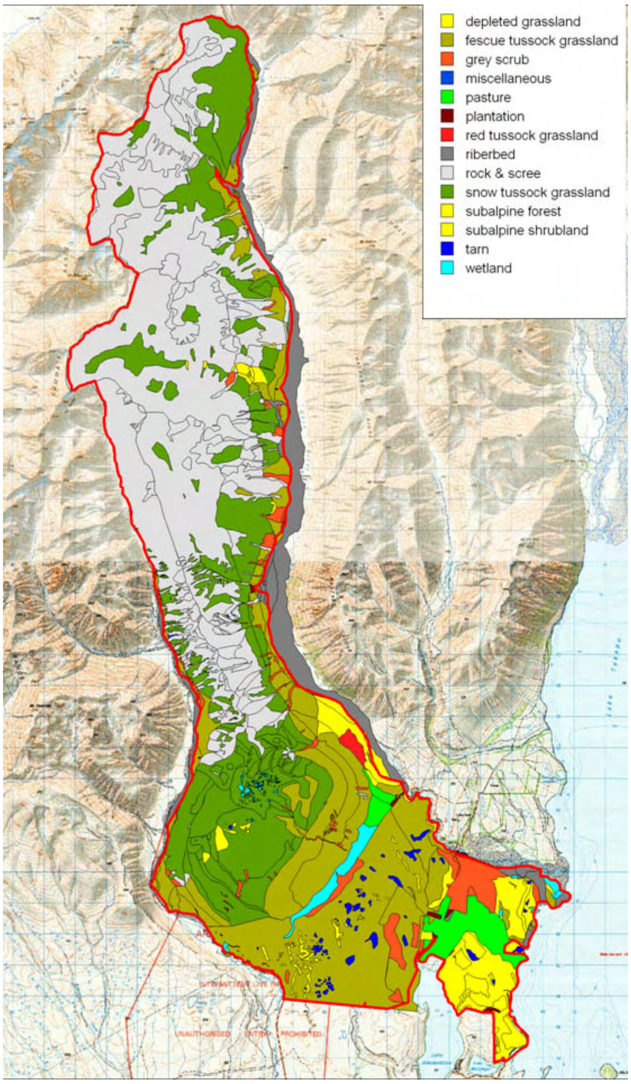


Figure 2: Vegetation map of Glenmore Station

(Refer to Appendix 2 (Page 108-113) for more detail on current vegetation.)

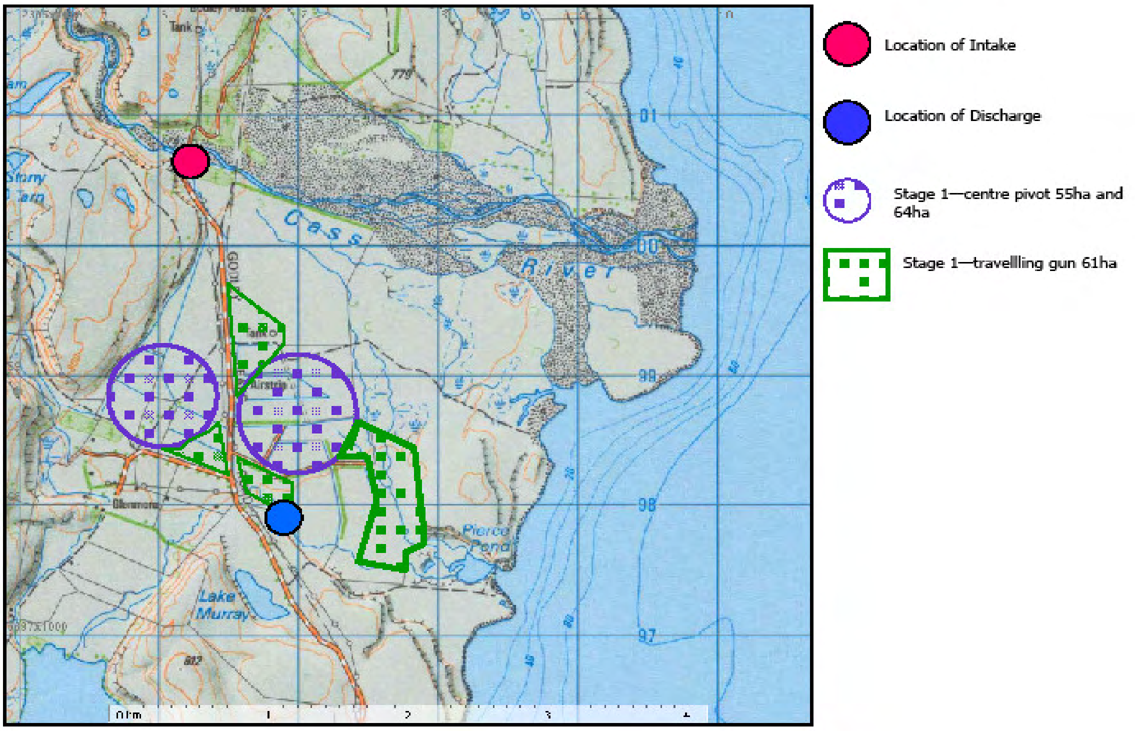


Figure 3: Irrigation Area

Table 1. Cover utilisation by season and stock class for current system

	Cover utilisation by season and stock class - CURRENT			
Class of stock	**Spring**	**Summer**	**Autumn**	**Winter**
Ewes	Oversown hill	Oversown hill	Native	Fed out on Oversown hill
Hoggets	Grass flats	Grass flats	Oversown hill	Fed out on Oversown hill
Breeding cows	Grass flats	Native	Native	Native
Deer	Grass flats	Grass flats	Oversown hill	Fed out on Oversown hill

For full stocking class, movements and numbers, refer to Appendix 3 on page 133.

2.2 Proposed farming system

Glenmore Station's application is to renew their existing consent; therefore the irrigated area is not changing. However, in order to become more efficient users of water, Glenmore is proposing to convert to spray irrigation over a 5 year period. This conversion will see stock numbers possibly increasing by 50 cattle and wintering another 500 hoggets. However, stock movements in general will not change.

2.3 Soils

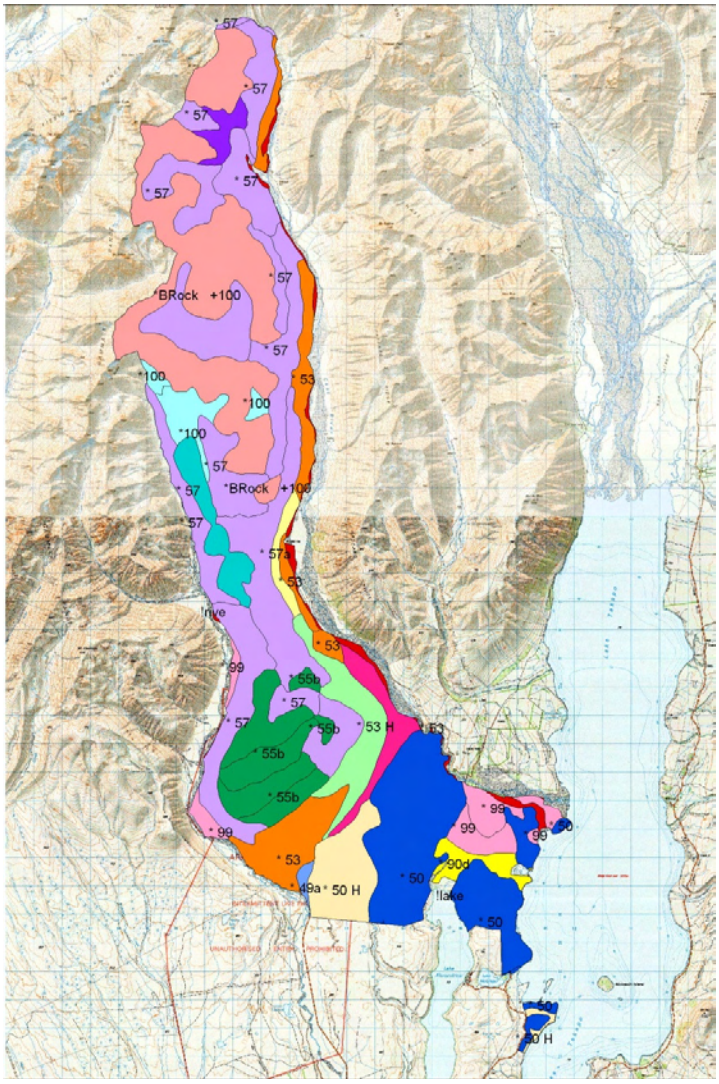


Figure 4: soils

Glenmore soils

Upland and high country yellow brown earths		
49a	Acheron	Flat terraces & gently sloping fans
50	Tekapo	Undulating to easy rolling; small areas rolling; few tarns in hollows
50H	Tekapo Hill	Moderately steep & including short steep slopes; small areas of rolling
53	Cass	Rolling moraines & easy rolling fans
53H	Cass Hill	Moderately steep with patches of flat and rolling
55b	Puketeraki	Moderately steep with some steep bluffs; also patches of rolling
57	Kaikoura Steepland	Steep to very steep, mainly graded slope deposits (27-38°) with rock outcrops, also rocky bluffs; narrow rolling ridge crests & some razorback ridges with crumbling rock; numerous small cirques & few cols rolling to hilly
57a	Tekoa Steepland	Moderately steep
Gley Recent Soils		
90d	Dobson	Flat low-lying land on valley floors
Recent Soils		
99	Tasman	Flat to gently sloping floodplains & terraces, & gently to moderately sloping fans (up to 15°)
Alpine Steepland Soils		
100	Alpine Steepland	Mostly steep to very steep; small area rolling to hilly

2.4 Topography

Block	**Management unit**	**Area (ha)**	**Landscape values**	**Recreation values**	**Biodiversity values**
Irrigated Paddocks	Paddocks	259.7			
Dryland Paddocks	Paddocks	243.1			
Old Glenmore	Downs	126.9	freehold	freehold	freehold
Lake	Downs	113.8	Yes (part)	Yes (part)	Yes (part)
Larches	Downs	185.3	Yes (part)	Yes (part)	
Lake Murray	Downs	127.4	Yes (part)	Yes (part)	Yes (part)
Clover Hill*	Downs	367.4	Yes (part)		Yes (part)
Single Hill	Downs	34.9			
Feed Pad	Feed Pad	159.4			Yes
Fishing Hut	Developed moraine	368.9			Yes (part)
Hartleys	Developed moraine	148.1	Yes (part)	Yes (part)	Yes (part)
Stud	Developed moraine	133.2			Yes (part)
Little Downs	Developed moraine	504.8		Yes	Yes (part)
Peters Patch	Developed moraine	248.0	Yes		Yes
Bruce's	Joseph Swamp	70.9			Yes
Joseph Creek	Joseph Swamp	83.8			Yes
Joseph Swamp	Joseph Swamp	53.4			Yes

Block	**Management unit**	**Area (ha)**	**Landscape values**	**Recreation values**	**Biodiversity values**
Cass Flat	Cass Flat	204.8		Yes	Yes (part)
McPhersons	Lower hill slopes	347.9	Yes (part)	Yes	Yes (part)
Bottom Joseph	Lower hill slopes	276.2	Yes (part)		Yes (part)
Cass Face	Lower hill slopes	211	Yes (part)		Yes (part)
Lower Ribbonwood	Lower hill slopes	150.0	Yes (part)		Yes (part)
Bottom Block	Lower hill slopes	922.5	Yes (part)	Yes	Yes (part)
Sunday	Undeveloped moraine	746.7	Yes	Yes	Yes
Sardine	Undeveloped moraine	648.7	Yes (part)	Yes	Yes
Fork	Mountains	2,097.8	Yes	Yes	Yes
Top Joseph	Mountains	974.9	Yes	Yes	Yes
Upper Ribbonwood	Mountains	285.3	Yes	Yes	Yes
Waterfall Creek	Mountains	146.2	Yes	Yes	Yes
Waterfall	Mountains	2,088.7	Yes	Yes	Yes
Tin Hut Creek	Mountains	1,086.4	Yes	Yes	Yes
Tin Hut	Mountains	1,448.9	Yes	Yes	Yes
Twin Basin	Mountains	2,006.8	Yes	Yes	Yes
Top Block	Mountains	1,146.1	Yes	Yes	Yes

*part freehold block

2.5 Climate

The climate of Glenmore Station is dominated by the rain shadow effect of the Southern Alps, with a rapid decrease in precipitation from northwest to southeast. The climate is semi-continental, with warm dry summers and cold winters. Snow normally lies above c. 1000 m for several months during winter and can extend down to Lake Tekapo at times. No detailed climate data is available for Glenmore Station, but data from adjacent stations indicates the likely range of conditions that occur.

2.5.1 Rainfall

The average rainfall at the Glenmore Station homestead over the past 5 years has been 670 mls. The main sources of rainfall in the Mackenzie Basin are associated with west to northwest airflows bringing rain east across the main divide and south to southeast airflows bringing rain in from the lower Waitaki Valley. A strong west-east rainfall gradient occurs across the Mackenzie Basin reflecting the decreasing influence of west-northwest rain further east in the basin (Table 1). Rainfall at Glenmore Station spans some of this gradient, with annual rainfall at the head of the property likely to be less than that received at the Hermitage (3985 mm), perhaps c. 3-3500 mm per annum, while rainfall along the shores of Lake Tekapo is likely to be slightly less than that received at Godley Peaks (762 mm), perhaps c. 700 mm per annum. Data from adjacent stations shows considerable year-to-year variation in rainfall. At Lake Tekapo, total annual rainfall has varied between 324 and 874 mm over the period 1927-2004 (Fig. 3a), while summer (December-March) rainfall also shows marked dry periods such as in the 1970s, especially 1970/71 and 1972/73 which are the two driest summers on record (Fig. 3b). Low rainfalls coupled with high day-time temperatures are likely to lead to marked soil moisture deficits during the summer months. Strong winds will further increase this effect.

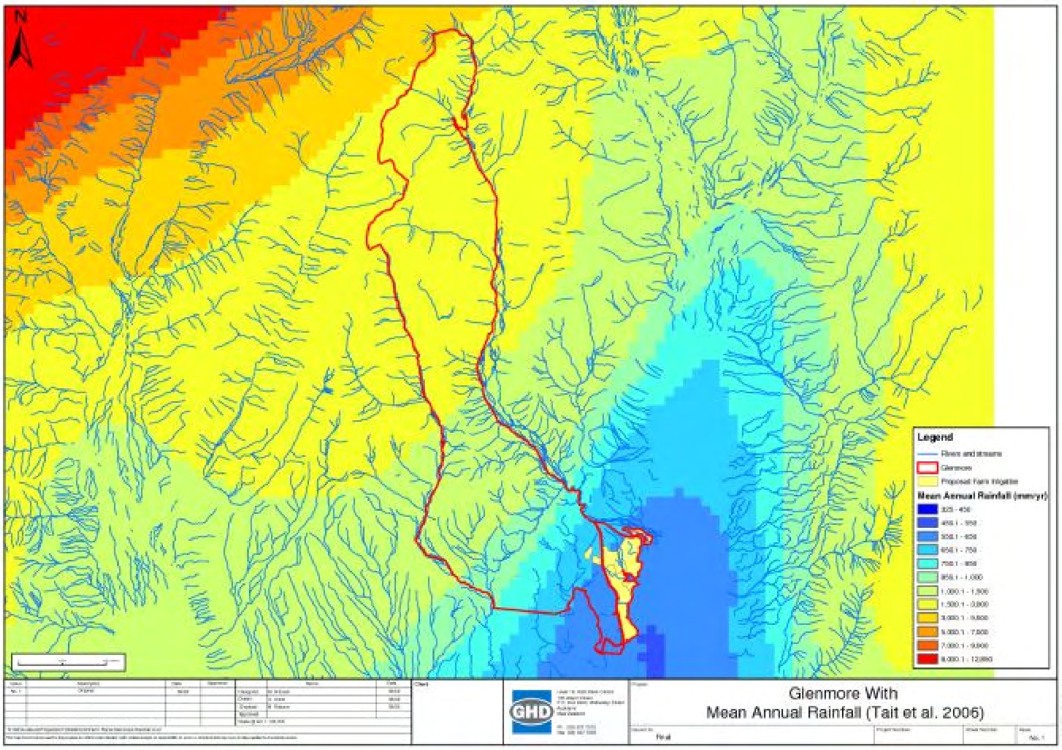


Figure 5: Rainfall

2.5.2 Temperatures

There are again no specific temperature data for Glenmore Station, but data from Godley Peaks (762 m; 1951-1980 normals), 5 km to the north of the Glenmore homestead, provides an indication of the likely conditions experienced across the lower part of Glenmore Station (Table 2). Mean annual temperature at Godley Peaks is 8.5 °C, with a January mean daily maximum temperature of 21.0 °C and mean daily minimum of 8.3 °C, while the comparable figures for July are 6.0 °C and -3.3 °C (Anon 1983). There are few stations to compare the more inland conditions at Glenmore, although temperature data from the Hooker valley in Aoraki/Mt Cook National Park is perhaps more indicative of valley floor conditions in the Upper Cass Valley where temperatures will be cooler than those close to Lake Tekapo (Table 2). Obviously there will be marked reductions in temperature with increasing altitude, comparable to the differences found in the Craigieburn Range in North Canterbury where mean annual temperature decreased from 7.9 °C at 914 m to 3.7 °C at 1554 m elevation. Frosts are frequent in winter in the Glenmore area (annual mean of 154 days at Lake Tekapo: Scott, 1999).

Table 2. Temperature data from Godley Peaks and the Hooker Valley (1951-1980 normals, Anon 1980).

	Godley Peaks temperatures (°C)			Hooker Valley temperatures (°C)		
	Mean min	Average	Mean max	Mean min	Average	Mean max
January	8.3	14.7	21.0	6.6	13.4	20.1
February	7.6	14.6	21.5	6.0	13.3	20.6
March	5.9	12.5	19.0	5.2	11.8	18.3
April	3.3	9.2	15.1	2.1	8.4	14.6

May	0.7	5.6	10.4	0.0	5.1	10.2
June	-2.2	2.5	7.1	-3.2	2.2	7.5
July	-3.3	1.4	6.0	-5.2	0.8	6.8
August	-2.4	3.1	8.6	-3.0	2.3	7.5
September	-0.1	6.2	12.5	-1.0	5.1	11.2
October	2.5	8.7	14.8	1.7	8.0	14.3
November	4.3	10.2	16.1	3.9	10.0	16.0
December	6.5	12.8	19.0	4.6	11.3	18.0
Annual	3.2	8.5	14.3	1.5	7.6	13.8

3. Environmental Context

The environmental context of the farm is a reference both to local and wider receiving environments.

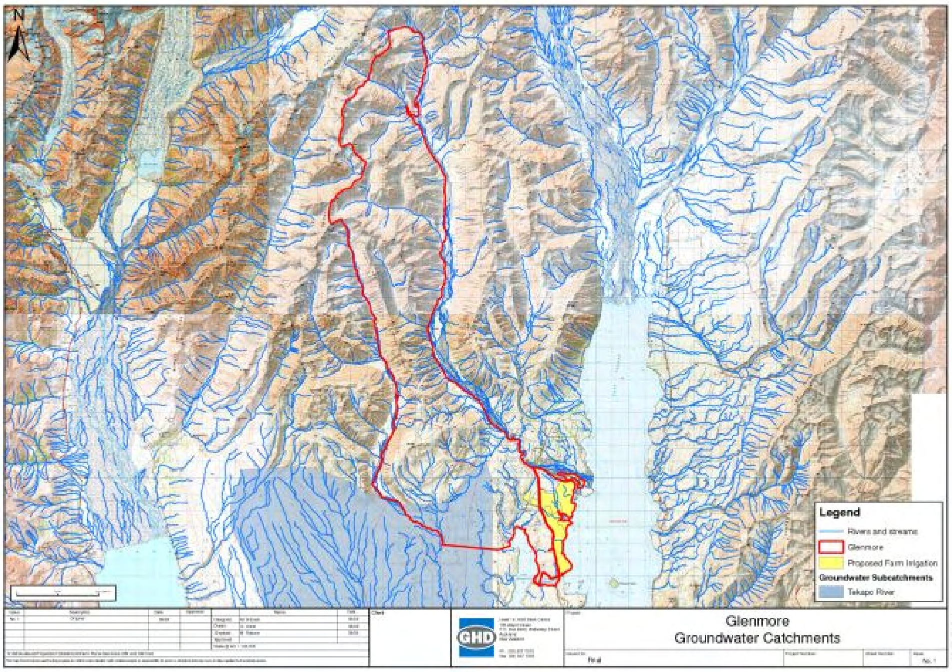


Figure 6: Groundwater Receiving Environment

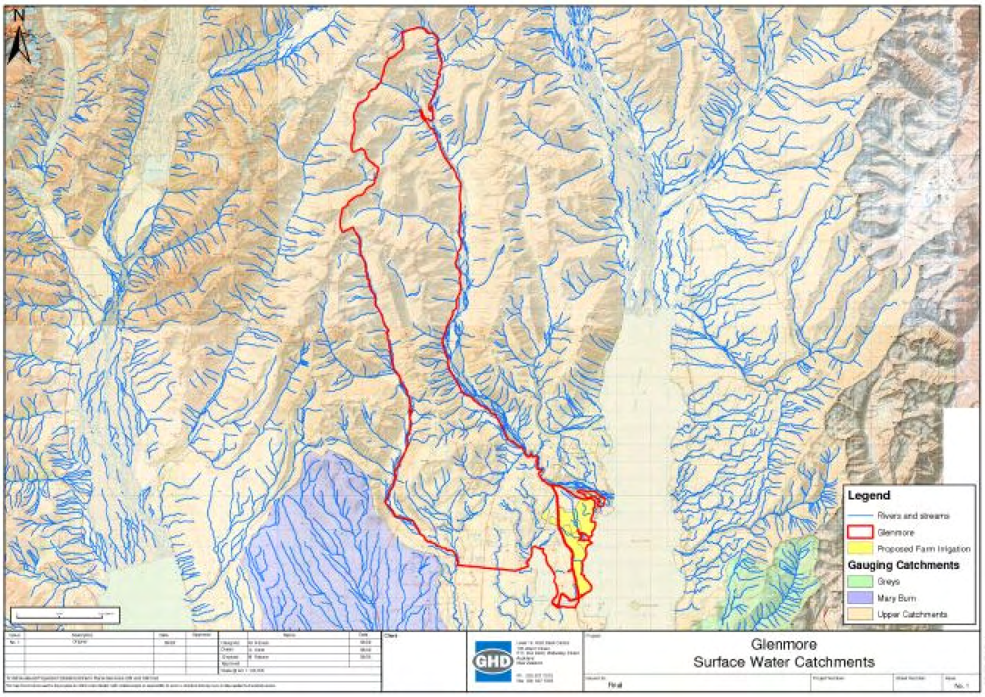


Figure seven: Surface Water Receiving Environment

3.1 Water Quality Study receiving environments and mitigation requirements

Glenmore Station, according to the WQS, has a small area of Tekapo River groundwater catchment, but lies in the "Upper Catchments" surface water catchment.

For this farm, there are no thresholds.

3.2 Local receiving environments

The local receiving environment is Mailbox Swamp Stream and Lake Tekapo. This is existing irrigation, and at present, excess water diverted but not taken, and some border dyke tail gate water is discharged into Mailbox Swamp Stream. This all ultimately ends up in Lake Tekapo.

Mailbox Swamp Lagoon is an important wetland and provides habitat and breeding sites for gamebirds.

4. Farm Environmental Management Plan development

4.1 Stage 1 – Mandatory good agricultural practices

The table below shows the mandatory good agricultural practices that will be adopted. These include the base assumptions of OVERSEER and therefore help validate the use of the model on the farm.

Table 5. Mandatory good agricultural practices

Mandatory good agricultural practices	**What these practices mean on farm**
Fertilisers applied according to code of practice for fertiliser use	The fertiliser users' code of practice aims to ensure that where fertilisers are used that they are used safely, responsibly and effectively and in a way that avoids, remedies or mitigates any adverse environmental effects. The code of practice includes guidance on fertiliser use, application, storage, transport, handling and disposal.
Use a fertiliser recommendation system (nutrient budget) and account for all sources of nutrients including applied effluents and soil reservoirs accounted for	Planning fertiliser applications to all crops, determining crop requirement and accounting for soil nutrients and organic nutrient supplies, all reduce the risks of applying excessive fertiliser above the crop requirement. This maximises the economic return from the use of fertilisers and reduces the risk of causing nutrient pollution of the environment Accounting for all sources of nutrients including imported sources and soil reservoirs is an important management measure in all farming systems and become especially important on farms where manure is produced and applied to the land. The re-application of organic manures to land is often thought of as a disposal of a waste product, and the available nutrients within the organic manures are not accounted for. The use of an integrated nutrient budgeting tool such as OVERSEER automatically accounts for nutrients supplied in organic manures.
Fertiliser application applied evenly	The even application of fertiliser is an assumption of the OVERSEER model as included in the fertiliser code of practice. Fertiliser spreaders should be tested and calibrated in-house at least annually and every 5 years by an independent auditor.
Irrigation and effluent applied evenly	The even application of water and or effluent is an assumption of the OVERSEER model. Irrigators should be tested and calibrated in-house at least annually and then every 5 years in accordance with the code of practice for irrigation evaluation by a qualified irrigation auditor.
Crop, cultivation, nutrient inputs and yield records kept per farm management unit	Maintaining good crop input records is important for: • The calculation of cumulative annual organic fertiliser applications and also their contribution to long term nutrient supply; • The prediction of realistic crop yields that are used to

	determine crop requirements; • Providing accurate inputs to the OVERSEER nutrient budgeting model that is being used here as a proxy for measuring diffuse nutrient losses.
Good design of irrigation systems	Design will match soil properties and low application amounts on shallower soil to prevent summer drainage.
Robust irrigation scheduling	Good irrigation scheduling to prevent summer drainage.
Supplement and feeding out management	To be addressed in the Farm Environmental Risk Assessment.
Winter grazing management	To be addressed in the Farm Environmental Risk Assessment.

4.2 Stage 2 – OVERSEER and meeting WQS mitigation requirements

There are no WQS thresholds set for Glenmore Station. The table below shows the output from OVERSEER for the modelled proposed farming system at Glenmore Station. The table below shows the output from OVERSEER for the modelled proposed farming system at Glenmore. The results illustrate that the proposed farm system losses as modelled by OVERSEER are within the thresholds set out by the WQS. Management or mitigation strategies that have been used to meet this threshold are detailed in Section 5.

Total N and P losses modelled by OVERSEER for the proposed farming system on Glenmore Station and WQS thresholds

	Nitrogen Threshold (kg/farm)	Phosphorous Threshold (kg/farm)
MWRL Water Quality Study Property Thresholds	14000	300
OVERSEER® outputs	11239	218

Note: The MWRL WQS when determining the threshold for Glenmore excluded extreme slopes, therefore when modelling in Overseer these same extreme slopes have been excluded. Modelling in Overseer was undertaken for only 3002ha.

4.3 Stage 3 – Identification and mitigation of site specific environmental risks

The Farm Environmental Risk Assessment FERA has been undertaken on the existing farming system at Glenmore and has highlighted potential water risks. These risks are described below. The full FERA is attached as Appendix A.

The FERA focused on the irrigation areas; existing or proposed and any intensively farmed areas in the farming system.

4.3.1 Soil Risk

The risks associated with soil are that although wind erosion wasn't evident there is a potential vulnerability to wind erosion. The continuation of irrigation will ensure that ground cover levels are upheld and will reduce the risks associated with bare ground and wind erosion

4.3.2 Water Risk

The risk associated with water is that stock are not restricted from entering all of the head races of the border dykes. Glenmore has a proposed conversion plan to convert to spray irrigation whereby the water flow in the headraces will cease.

4.3.3 Site specific management measures and existing mitigation measures in place

1. Glenmore Station is committed to conversion to spray irrigation as can be seen in Figure 3. This will alleviate the ability for stock to access the water in the border dyke head races.
2. Riparian fencing and planting

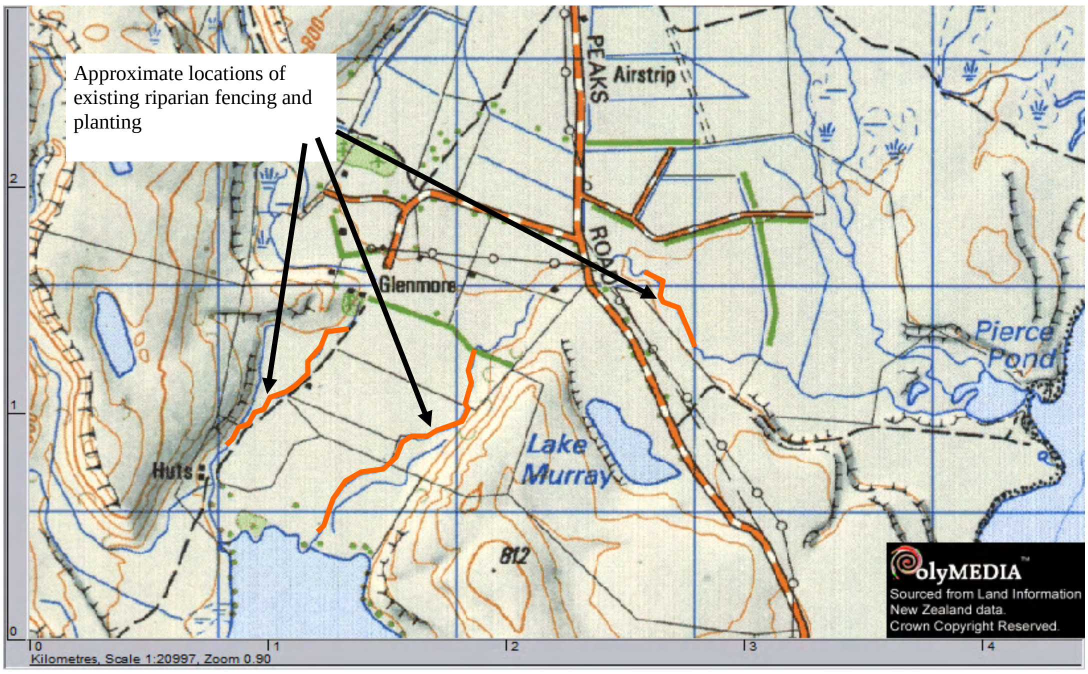
Three areas of riparian fencing and planting have already been undertaken on Glenmore.

Photo A: showing fenced off Mailbox creek

Photo B: showing fenced off Scotts Creek

Photo C: showing fenced off buffer zone at head of Lake Alexandrina

Figure 8: Map showing the approximate locations of existing riparian planting and fencing as in photos above.



3. Fodder crops are grown as part of the pasture renewal process, ensuring that organic matter levels are not depleted in only a few paddocks. Regrassing after winter grazed fodder crops will be at the earliest opportunity.
4. A contractor or approved handler if required is used to apply chemicals at Glenmore.
5. Deer farm

All of the deer fencing at Glenmore has an electric wire mid way up the fence to reduce the deer's ability to fence walk. There was no visual compaction evident within the deer farm. This will be monitored during the annual compaction survey.

6. Cultivation and Trafficking

Direct drilling is the primary method for renewing pasture. Inversion tillage is used if required to break in (cultivate for the first time) any new pastures and occasionally soil can be left bare over winter. Inversion tillage is used at the most appropriate time to reduce the potential effects of wind erosion. Reestablishment of pastures does not involve inversion tillage.

Stock are grazed over winter and trafficking of soils when wet does occur. Annual monitoring and identification of soil compaction and documented remedial actions taken will ensure any soil compaction due to stock grazing over winter is identified.

7. Compaction

Soil around water troughs is not compacted nor does pugging occur at present. If compaction does occur then this will be assessed during the annual soil compaction survey and remedial action taken if required.

8. Runoff

There is no evidence of track runoff entering a watercourse. This will be monitored as part of the annual track survey. Annual monitoring and identification of track runoff and documented remedial actions taken will ensure any track runoff entering a watercourse is identified.

4.3.4 General issues on extensive high country farming systems

In extensive high country farming systems there are a number of issues that on more intensive farming systems would be assessed as being a risk to water quality but on extensive high country farming systems they have not been defined as a risk due to the extensive nature of the farming systems and the lower stocking rate per hectare. Some of these general issues have been identified below:

1. There will be areas within the farming system where tracks will cross waterways; these are tracks that are used irregularly, in extensive areas of the farm.
2. There are also areas within a high country farming system where stock will have unrestricted access to streams for crossings and stock water. This is essential access for stock movement and stock

water. On most farms there are a number of small creeks/streams that flow within the hill country and it would be logistically impossible to place stock crossings on all of these. There is also the need for stock to move across streams/creeks within a block (paddock) for grazing access. A reticulated water system would be unsustainable in the hill country as troughs would freeze solid in the winter months, preventing access to fresh drinking water.

3. Swamps/heavy grounds are an integral area in a high country farming system; they provide a water source and good grazing for stock in dry years. In undertaking the FERA it has been identified that all swamps/heavy ground need to be monitored to ensure that bank erosion, compaction and pugging does not occur.

4. Wind erosion is a significant issue in the upper Waitaki Catchment. The sparse vegetation on large areas of land in the Mackenzie Basin gives little protection to the shallow, friable soils which continue to be eroded by frost heave and westerly winds. A mean soil loss of 0.22 mm/year or 2.2 tonnes of soil lost per hectare across a number of sites within the Mackenzie Basin has been reported. While it cannot be assumed from this information that erosion rates will continue at this level in the future, the results do confirm a strong relationship between the percentage of vegetation cover and erosion risk. The problem of bare ground and exposure to wind erosion has been compounded since the early 1990s by the rapid spread of hieracium particularly on the poorest soils. One of the most significant impacts of further irrigation in this area would be a reduction in the amount of bare ground and corresponding reduction in wind erosion risk. (***Environmental, Economic and social impacts of irrigation in the Mackenzie Basin. Ministry for the Environment, February 2005.)***

5. Monitoring and identification of any problems arising for the above issues has been included in Table 8.

5. Farm Environmental Management Plan for Glenmore Station

5.1 Mitigation measures and management options adopted on Glenmore Station

The table below shows the all the mitigation and management tools that are proposed to be undertaken on Glenmore Station. Measures indicated as **FEMP stage 1 are those identified as Mandatory Good Agricultural Practice**, **measures identified as FEMP stage 2 are those changes that have been modelled in OVERSEER to meet the WQS mitigation requirement (if required)**, and those indicated as **FEMP stage 3 are mitigation measures chosen to ameliorate site specific environmental risks on the farm**.

Table 7 indicates in brief how the measures are to be monitored and audited.

Table 7. Table of mitigation options, monitoring and auditing for Glenmore Station

FEMP stage	Measure	Monitoring	Auditing
1	Fertilisers applied according to code of practice for fertiliser use		Self certification
1	Accounting for all sources of nutrients including applied effluents and soil reservoirs	Soil and effluent testing and cumulative effluent inputs per management unit	Reconciliation of fertiliser, effluent and soil records with nutrient budget for example blocks. Submission of examples soil and effluent tests
1	Even fertiliser application	Calibrate and optimise fertiliser spreaders annually and every 5 years by an external auditor	Submission of testing and calibration
1	Even irrigation and effluent application	Calibrate and optimise irrigators annually in house and every 5 years by an external auditor	Submission of testing and calibration
1	Record crop, cultivation, nutrient inputs and yields per farm management unit	Upkeep of records	Submission of example block records
1	Good design of irrigation systems	Design of irrigation system by a certified professional	Irrigation system audited by a certified auditor every 5 years
1	Robust irrigation scheduling	Calculation of annual % effective water use	Submission of annual % effective water use
2	No winter application of fertiliser on the irrigation area	Field records	Signed field records
2	N fertiliser applications split to under 50 kg N/application	Field records	Signed field records
2	No P fertiliser within three weeks of irrigation	Field records	Signed field records
2	Olsen P of below 30 maintained	Regular soil testing (every 3 years)	Submission of soil tests
3	Exclude lower border dykes from watering due to the proximity to the Lake and stony shallow soil nature	Photos and location plan	Annual audit report prior to conversion to spray (conversion area does not include the lower borders)

FEMP stage	Measure	Monitoring	Auditing
3	Monitor and manage stock access, stock type and stock number from all permanently flowing waterways within other non irrigated intensively farmed areas	Location Plan and details	Location plan first annual audit
3	20 metre layback from any water way when applying fertiliser by land based application e.g. bulk spreader	Field records	Annual Audit report

5.2 Monitoring and Auditing

5.2.1 Baseline monitoring

There are a number of existing environmental monitoring projects being undertaken on Glenmore Station. Below is a brief description of these, for further information please see Glenmore Station Environmental Report.

Table 1: Nitrate and Phosphate water test results for samples taken from both the intake and discharge points of the Glenmore irrigation scheme.

	Intake at Cass River 16 Dec 2007	**Discharge at Mailbox Creek 16 Dec 2007**
Nitrite-N g/m3	<0.0020	0.0038
Nitrate-N g/m3	0.027	0.42
Nitrate-N + Nitrite-N g/m3	0.027	0.42
Total Phosphorus g/m3	0.040	0.043
Total Phosphate g/m3	0.12	0.13
	Intake at Cass River 18 Feb 2008	**Discharge at Mailbox Creek 18 Feb 2008**
Nitrite-N g/m3	<0.0020	0.0020
Nitrate-N g/m3	0.013	0.28
Nitrate-N + Nitrite-N g/m3	0.013	0.28
Total Phosphorus g/m3	<0.0040	0.016
Total Phosphate g/m3	0.020	0.050

This table illustrates that samples taken in December 2007and February 2008, show a negliable change in water test results.

	Discharge at Mailbox Creek 18 Feb 2008	Pearce's Pond (DOC Black Stilt enclosure) discharge into Lake Tekapo 18 Feb 2008
Nitrite-N g/m3	<0.0020	0.0020
Nitrate-N g/m3	0.023	0.038
Nitrate-N + Nitrite-N g/m3	0.023	0.039
Total Phosphorus g/m3	<0.0040	0.0040
Total Phosphate g/m3	0.020	0.020

This table again illustrates that samples taken from where the water leaves the irrigation system and enters Pearce's Pond and then where it leaves the pond to enter Lake Tekapo show a negliable change in water test results.

5.2.2 Environmental monitoring, Glenmore Station

Environmental monitoring at Glenmore has been established as part of the ARGOS (Agriculture Research Group on Sustainability) programme and involves land-cover, aquatic and soil monitoring. Full details on the methods used are provided in Norton et al. (2006). The primary goal of the ARGOS high country monitoring programme is to assess the response of high country ecosystems to (1) management inputs and (2) external perturbations such as climate change or species invasion.

Three types of monitoring have and continue to be undertaken; Land cover, aquatic and soil monitoring. Further information relating to this monitoring can be found in Glenmore Station Environmental Report.

5.2.3 Additional Baseline monitoring

		Location	Frequency	Measured parameters to include
Soil	Soil nutrient testing	Further details in Environment Report	Further details in Environment Report	Standard suite of soil nutrients
Water	Surface water quality	Further details in Environment Report	Further details in Environment Report	Total Nitrogen, nitrate, ammonia, total Kjeldahl nitrogen, total phosphorus, dissolved reactive phosphorus, suspended solids.
Pasture	Ground cover and species	All blocks	Annually	% Ground cover, species
Weeds and Pest Monitoring	Weed and pest infestation	Whole Farm	Annually	Done as part of an annual survey from Ecan

5.2.4 On-going monitoring

On going monitoring and auditing of FEMP are as important as the plan itself.

Table 7 above shows the current monitoring undertaken for Glenmore Station and Table 8 below shows the proposed monitoring plan, frequency, location for the monitoring along with the triggers and contingency plans if triggers are exceeded.

Table 8. Example monitoring plan for Glenmore Station showing location, frequency and parameters for monitoring

		Location	Frequency	Measured parameters to include	Triggers	Contingency plan if triggers are exceeded
Soil	To include: Soil nutrient testing	Further details in Environment Report	Further details in Environment Report	Standard suite of soil nutrients	Olsen P >30	Reduce or stop the application of P fertiliser to the area and monitor
Soil	Soil compaction testing	All irrigation blocks in rotation	Annually for soil compaction testing.	Soil compaction	Compaction, surface capping	Remove compaction with the appropriate tool
Soil	Visually monitor swamps/heavy ground	Joseph Swamp area	Annually	Visual compaction, pugging or stock induced bank erosion	Any visual sign of compaction, pugging or stock induced bank erosion	Remove stock from the area and rectify
Soil	Compaction	Deer winter feed pad	Annually	Compaction or pugging	Compaction surface capping	Remove compaction with the appropriate tool
Runoff	Wet weather survey	All blocks	Annually	Runoff	Runoff occurring	Introduce runoff removal infrastructure where appropriate.
Water	Surface water quality	As per consent conditions	As per consent conditions	As per consent conditions	No significant decrease in water quality	If comparative surface water analysis indicates a decrease in surface water quality then the particular contaminant should be identified while a full root cause analysis is undertaken
Water	Irrigation application	Irrigation area	Annually in house and 1 in 5 years by an independent	Application uniformity	>80 %	Optimisation of the irrigator performance will be performed at the time of testing
Tracks that cross waterways	Visual assessment of bank/track erosion	All tracks that cross creek/stream within extensively farmed areas	Annually	Visual assessment of bank/stream erosion caused by vehicle crossing or stock	Any sign of extensive visual erosion	Restrict vehicle and stock access until an assessment of the damage and cause can be made
Fertiliser	Fertiliser application	All Farm	Annually in house and 1 in 5 years by an independent	Application uniformity	>80 %	Optimisation of the spreader performance will be performed at the

		Location	Frequency	Measured parameters to include	Triggers	Contingency plan if triggers are exceeded
						time of testing
Weed and pest pressures	Weed and pest populations	Relevant blocks	Annually	% or magnitude of infestation	ECAN monitor and communicate if their triggers have been exceeded	Legislative compliance with notice of direction issued by ECAN

NB: Where triggers are exceeded, the immediate contingency plans in Table 9 should be implemented while a 'root cause' analysis is carried out. Any further mitigation measures to be adopted as a result of monitoring should be added to Tables 7, 9 and 10.

1) Is the current mitigation option implemented correctly?

No – Implement and monitor

Yes – to 2)

2) Has anything changed in the farm system?

Yes – remodel and monitor

No – to 3)

3) Have there been abnormal conditions at the time of trigger breach?

Yes – continue monitoring to see if trigger breach continues

No – Seek advice if suitably qualified person to investigate root cause and suggest appropriate mitigation.

If emergency conditions occur that risk a pollution event, such as a catastrophic failure of the irrigation system that is resulting in overland flow to a watercourse, seek immediate guidance from you regional council:

Environment Canterbury 0800 76 55 88

5.2.5 Auditing

The auditing process allows both the farm operator to illustrate, and other interested parties to have confidence that the management practices and mitigations planned for the farm are being implemented. In addition, the audit shows that there is a mechanism for the adaptive management of the property should the chosen mitigation or management not perform to expectations.

An annual audit is proposed, and requires both external and in-house input. The annual audit should be completed and submitted to ECan by end of July each year.

The audit measures and actions in case of non-compliance will be finalised once the FERA is completed. Those pertaining to FEMP stages 1 and 2 are included here.

Table 10 below shows an example of an annual audit report for Glenmore Station.

Table 10. Table showing proposed contents of an annual audit report for Glenmore Station

Mitigation Measure	Audit Measures	Action in case of non compliance
	Annual audit of OVERSEER nutrient budget and report based on previous 3 years. Submission of compliance with thresholds	Should the OVERSEER report show losses exceeding the threshold, further mitigations should be adopted to effect a reduction in nutrient loss to below thresholds.
	Submission and brief interpretation of water quality analysis	Where triggers have been exceeded, immediate contingency plans should have been carried out and a root cause analysis conducted. The results of which should be presented here.
	Submission and brief of annual wet weather survey	Any remedial actions proposed after the annual survey should be undertaken.
	Submission and brief of annual tracks that cross waterways survey	Any remedial actions proposed after the annual survey should be undertaken
	Submission and brief of annual compaction survey of the irrigation area	Any remedial actions proposed after the annual survey should be undertaken
	Annual pest and weed survey undertaken by Ecan should be submitted	Legislative compliance
Even irrigation application	Calibrate and optimise irrigators annually in house and every 5 years by an external auditor	Submission of testing and calibration
Record crop, cultivation, nutrient inputs and yields per farm management unit	Verification of records	If records have not been produced then this should be rectified for next audit
Good design of irrigation systems by a certified professional and audited every 5 years	Irrigation system audited by a certified auditor every 5 years and any changes recommended should be implemented	If changes recommended not implemented then this should be rectified by next audit
Robust irrigation scheduling	Verification of records	If records not received then this should be rectified by next audit
No June/July application of fertiliser on the irrigated area	Field records	If records not received this should be rectified for next audit.
N fertiliser applications split to under 50 kg N/application	Field records	If records not received this should be rectified for next audit
No P fertiliser within three weeks of irrigation	Field records	If records not received this should be rectified for next audit
Olsen P of below 30 maintained	Submission and brief interpretation of soil test results	Where triggers have been exceeded, immediate contingency plans should have been carried out and a root cause analysis conducted. The results of which should be presented here.

Exclude lower border dykes from watering due to the proximity to the Lake and stony shallow soil nature	Map and photos	If obvious watering has occurred then this should be rectified prior to the next audit
20 metre layback from any water way when applying fertiliser by land based application e.g. bulk spreader	Field records and maps	If maps not received with annual audit this should be rectified by the next audit.

6. Summary

This FEMP has been written to serve two purposes; to ensure the existing farm system can meet the nutrient mitigation requirements set out by the MWRL Water Quality Study, and to set out the process for identification of farm specific environmental risks that arise from the inherent characteristics of the farm and from the existing farm system and its management.

The WQS thresholds and modelled outputs from OVERSEER detailed in Section 4.2 illustrate that this proposed system meets the WQS thresholds identified.

A full on-farm risk assessment was completed in December 2009 with a commitment to address the risks identified. Section 4.3 sets out the risks identified for this property and those issues common to all high country farming systems, along with existing mitigation measures.

The mitigation and management measures detailed in Table 6 set out the measures that have been adopted to mitigate and manage the risks that were identified in the risk assessment along with mandatory good agricultural practices and those measures that have been modelled in OVERSEER.

Baseline monitoring and any additional monitoring proposed for this property are identified and set out in Section 5.2, Tables 7 and 8 allows the performance of the measures chosen to be monitored and where they are performing sub-optimally, these can be addressed through the root cause analysis process.

The auditing of this plan, addressed in Section 5.2.3, Table 9 ensures that the relevant mitigation measures outlined in Table 6 are audited annually either internally or externally and communicated to ECAN by the end of July each year.

It must be noted that Glenmore Station has undertaken a large amount of mitigation and monitoring within the last 5 years primarily through the ARGOS program. Further details can be found in the Glenmore Station Farm Management Plan (2008-2012) and the Glenmore Station Environmental Report.

7. References

Ministry for the Environment. 2005. Environmental, Economic and social impacts of irrigation in the Mackenzie Basin

GHD (2009a). Cumulative Water Quality Effects of Nutrients from Agricultural Intensification in the Upper Waitaki Basin – Mitigation Toolkit.

Webb, T. H. (1992). Soils of the Upper Waitaki Basin, South Island, New Zealand, DSIR.

APPENDIX A: Farm Environmental Risk Assessment

GUIDELINES QUESTIONS FOR THE COMPLETION OF A FERA   November/December 2009

The plan is to focus on those existing/proposed irrigation areas along with any intensive areas surrounding. We also need to keep in mind that this is a whole farm environmental risk assessment and hence other areas of the farm may also be applicable at times. Take notes on wetland areas, swamps, major streams/rivers, location of the yards in relation to watercourses

Some guideline questions for track management and runoff		**Notes/description**
1	Do any regularly used tracks run through streams?	No. In extensive high country properties there are areas within the farm where tracks will cross streams, these will be tracks that are used irregularly
2	Do any tracks directly runoff to a water course	No
3	Stock crossings?	Culverts are installed in intensively farmed areas. In extensive high country properties there are areas within the farm where stock will cross streams and use streams for stock water.
4	Any evidence of previous runoff, soil wash or erosion?	No but a potential vulnerability to wind erosion
6	Do you have a silage pit located near a permanent watercourse?	No
Some guideline questions for stock management		
1	Are measures taken to control dietary intakes of N and P? (Intensive beef and dairy)	N/A
2	Are stock restricted from entering watercourses in intensively farmed areas?	Yes, by riparian fencing and planting of Scots Creek, Muddy Creek and Mailbox Creek
3	Do you graze stock in paddocks that have a hydraulic connection to a watercourse in winter months?	No
4	Yards - do you use water? If yes, details (e.g is it collected, discharged, what is it used for…?)	Yes dipping, no runoff into waterways

Some guideline questions for biodiversity		
1	Are there any special areas or species of interest or conservation on the farm?	Kettle tarns, DOC lagoon for black stilt breeding
2	Are there any water or wetland features on the farm?	Kettle tarns
3	Are these features actively protected?	QE2 covenant over 1000ha of land that has kettle tarns, water quality monitoring of tarns
Some guideline questions for chemical usage	***Chemical storage and handling is dealt with under the Hazardous Substances and New Organisms Act***	
1	Are those handling chemicals of 'approved handler status'?	Yes, contractor used for spraying pasture
Some guideline questions for water		
1	Do you use border dyke irrigation?	Yes
2	Do you collect wipeoff losses?	NO
3	Are these wipeoff losses discharged to a watercourse	????? Check discharge location
4	Is there evidence of bankside erosion in any permanent flowing watercourses?	No, shallow stony streams. All main waterways within intensively farmed areas are fenced
Some example questions on cropping		
1	Is inversion tillage used? Describe	Yes, disc/plough if required otherwise direct drill
2	Are soils left bare over winter?	no
3	If arable or fodder crops are grown, are measures taken to conserve or build soil organic matter on arable land?	Yes

4	Are remedial measures in place after winter grazed crops?	Yes, ryecorn is grown also rape. Ryecorn will regrow in the spring, a 2nd crop of rape is sown in early spring to utilise the depsoited nutrients
5	Is there a possibility of run off from winter grazed areas reaching a water course?	No
6	Other cropping issues or incidences? Please describe	No
Some example questions on soil health		
1	Are there compacted, consolidated or capped soils?	Thatch has been evident in older pastures, these are being cultivated to remove the presense of thatch. There is the potential for compaction along the fence lines within the deer unit this has been mitigated by installing a hot wire around the fence line.
Some example questions on pest and weed management		
1	Do you undertake any current pest or weed control? E.g rabbits, gorse	Yes, wilding pines, rabbits - poison and shooting