7Th February 2024

Agricultural Land Use Assessment

144 and 170 Main North Road, Kaiapoi ("site")

Purpose of Report

The purpose of this report is to review and consider the potential agricultural uses of the site within the context of Waimakariri District Council Zoning (Rural) and National Policy Statement classification (Class 1 and 3 Highly Productive Land).

This report assesses the technical and economic feasibility of a range of agricultural options and their suitability on the site and viability in the long term for land based primary production purposes.

Author Expertise

I am a self-employed Registered (NZIPIM) Farm Management Consultant primarily working in Canterbury but with client base between Central Otago and Nelson, and including Central Plateau, with specialisation in pastoral and arable land use systems and development.

I hold the qualifications of Bachelor Agricultural Science, Lincoln University

I work with farmers, local and central government organisations, and industry interest groups.

I specialise in advising in farm and agribusiness management with particular expertise in grazing and stock management systems, arable farming, irrigation & farm development, financial management, and supervise and contract-manage development projects.

I am familiar and experienced with all the farming practises, soils, and climate of the Central and North Canterbury area in general including the site in question.

I have worked for MAF Advisory Services Division based in Nelson and North Canterbury prior to forming my own consultancy practice, Dunham Consulting Ltd, in 2002

I regularly research and undertake feasibility and financial viability analysis for potential farming options. This has included land development strategy options for unimproved and irrigated land and intensification of land use through conversion to more intensive land use policies. This work has been over a full range of land types and farming systems.

I have acted as an expert witness in relation to various issues including land use planning, land development, farm machinery development disputes and animal welfare prosecutions.

My qualifications as an expert are set out above. The matters addressed in this report are within my area of expertise, however where I make statements on issues that are not in my area of expertise, I have stated where information has been sourced from. I have not omitted to consider material facts known to me that might alter or detract from the opinions included in this report.

SCOPE

In this report I address the following issues:

(a) The land use capability of the site

(b) The range of pastoral, arable and horticultural options that could be physically operated on a long-term basis on the site.

(c) Consideration of the climate, soils, and water environments of the site

(d) The type and extent of support industries and resources, contractors, and expertise required for a sustainable and viable farming operation.

(e) The infrastructure on the site or required on site to support a viable farming business.

(f) The site's neighbouring land uses and the potential impact of viable land use activities onto the neighbours, including reverse sensitivities.

(g) The economic viability of operating a business on the Site while being compatible with the site's District Zoning and designation under the National Policy Statement.

Site

The land ("site") at 144 and 170 Main North Road, South Kaiapoi, is located east of and adjacent to Main North Road, between urban Kaiapoi (north), Main Trunk Railway Line (east), and Courtenay Stream (south). See Image 1.

Legal Description:

- Pt RS 37428 (CB701/7) limited to the land to the west of the Main Trunk Railway Line
  RS 39673 – approximately 9.6 hectares (170 Main North Road)

- Lot 1 DP 19366 – approximately 4.6ha and residence in southwest corner of the site (144 Main North Road)

Gross Area: 14.2 hectares

Image 1

Site Description

Topography

Ignoring the Kaikainui and Courtenay Stream embankment riparian margins which are permanently fenced off from use, the land lies between approximately 3.3m above sea level (pink in Image 2), and 0.5m above sea level (orange in the east and south).

The Site comprises essentially two terraces. A higher one running north-south on the western side of the site, at between 2.0 – 3.3m above sea level (see Image 2, pink, blue and green); and a lower terrace starting at about one-fifth down the eastern site boundary from the north, and widening to approximately 70m wide, running approximately parallel to the railway line, down to the south eastern corner at between 1.5m and 0.5m above sea level, but predominantly about 1.5m above sea level (see Image 2 orange colour on right hand side – ignoring Orange along the Kaikainui & Courtenay Stream margins).

Surface water and subsoil moisture flow from the upper terrace to the lower eastern terrace.

Drainage

There is one open drain running between the title boundaries of 144 and 170 Main North Road. It runs about 400m, west to east with outfall into Courtenay Stream. See Image 3.

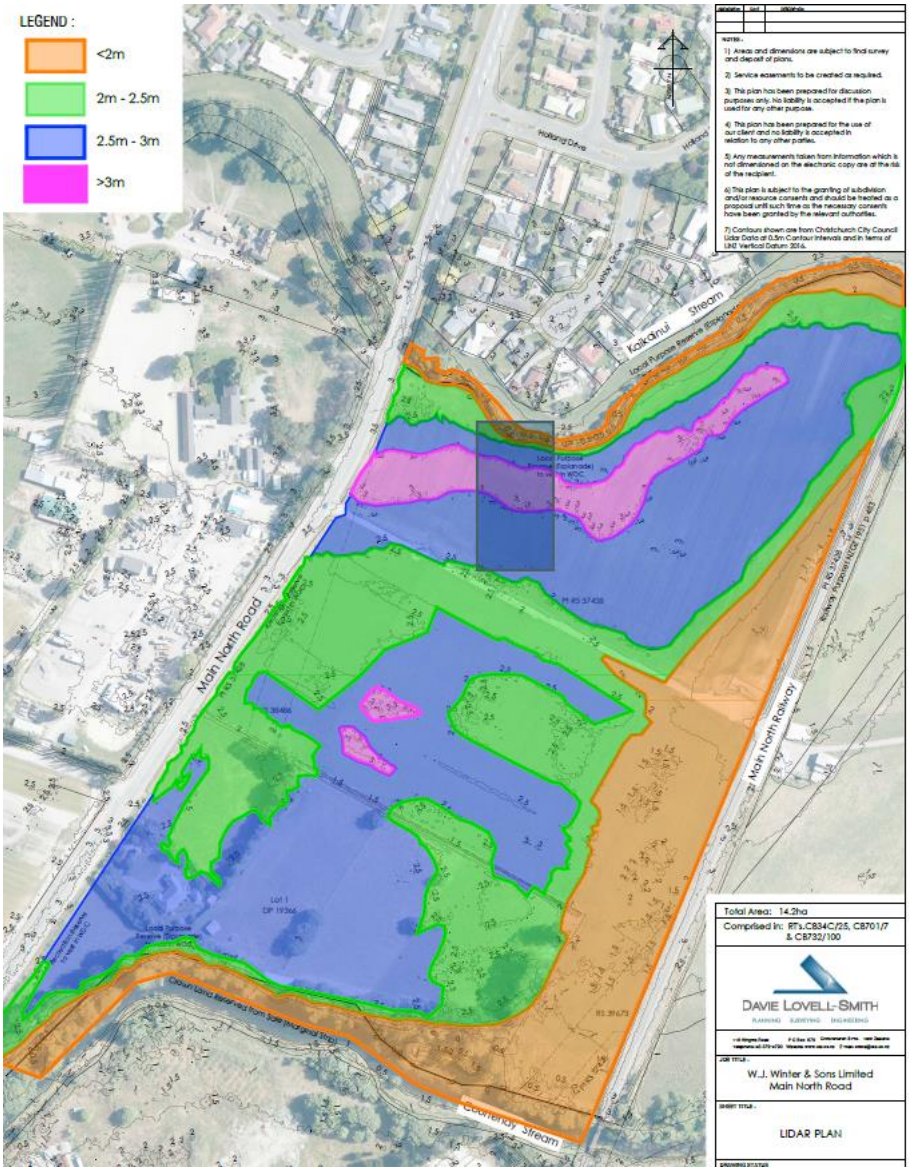

Image 2

Access onto the site (see Image 3)

There is one main access point off Main North Road at approximately mid-point along the boundary of the 170 Main North Road title. This feeds a vehicle access track across the site (west-east) and through to neighbouring land east of the Site. It is also the power pole electricity route.

There is also access off Main North Road to the residence at 144 Main North Road, which also provides access to the paddocks associated with the 4.6 ha title.

Houses, Buildings and Yards (see Image 3)

There is a residence at 144 Main North Road on the 4.6ha title in the southwest corner of the site. The house and curtilage occupy approximately 0.40 ha.

East of the house is a five-bay, three-sided barn, and small set of sheep yards.

On the larger title adjacent to the access track there is a set of cattle yards located on the eastern boundary, and a small pump shed located approximately 60m from the western end of the access track.

Key:
Cattle Yards
144 Main North Road - house & curtilage
Haybarn
Sheep yards
Open drain
Access track and power pole route ---------

Image 3

Subdivision, Fencing and Stock Water

170 Main North Road is subdivided into two paddocks of approximately 4.6 hectares each, and the land at 144 Main North Road is in five permanent paddocks at approximately 0.9 hectares each. All fences including the boundaries are permanent stock fencing, supplemented with electric wires on some fence lines. There is no access into either the Kaikainui Stream or Courtenay Stream.

Stock water to the larger 9.6 ha lot is supplied from a shallow ground bore (specific consent number unable to be confirmed), with water reticulated to permanent troughs in the two paddocks. Stock water to the smaller 4.6ha lot is from the house water supply (M35/5655) and reticulated to five paddocks.

Current Land Use

At 170 Main North Road, one paddock has been in barley grain production for three years and the other in permanent ryegrass pasture grazing dairy heifers spring to autumn. The heifers are not brought back onto pasture until after a spring silage cut (at about 3.0 t/ha dry matter, approximately end-October) plus 2-3 weeks regrowth. This strategy effectively allows pasture growth to be utilised while soils are wet in September and become dry enough to minimise soil pugging risk by mid-November when heifers are reintroduced. Stock leaves the land in late autumn, typically in May, before the paddocks get too wet underfoot.

The paddock usage of barley grain production and dairy heifer grazing respectively are swapped around after four years in pasture. Historically this land has been in the same barley – grass grazing rotation for about the last twelve years. When the land was purchased in 1967 the land was in sheep grazing, with some beef finishing. Then a mixed cropping rotation under irrigation was introduced through to about

2000 growing occasional cash crops including wheat, peas, barley and sometimes potatoes between 4-5 years of pasture.

The decline of a this more diverse range of crop options since 2000, coincided with high levels of bird predation of seed crops, neighbours' complaints about the noise of bird-scarer devices ("bangers"), higher prevalence of insect borne disease issues (aphids - potatoes), and failure to get crops certified due to risk of cross contamination by same species growing in the locality (failure to certify means failure to meet crop contract specifications, and financial loss). Soil drainage patterns and water table behaviour, also changed after the Christchurch earthquake (2011) which increased the crop yield variability and reduced average gross margin performance.

It is understood that the land at 140 Main North Road, has been in permanent pasture grazing sheep since at least the 1960's.

The barley paddocks are cultivated when soils dry out enough, usually late September, and drilled by mid-October [this is very late drilling with majority of Canterbury irrigated barley drilled in first week of September). The land is under moisture stress and being irrigated typically for about 6 weeks (mid-January to end February) but can be through to end March in about one year in five.

After barley harvest (typically February), the land either remains in fallow until the following spring drilling into another barley crop, or it is drilled into Italian ryegrass if it can be drilled early enough, and a viable yield grown and grazed before the land becomes too wet and must be destocked.

The dairy heifers are part of a larger herd that are grazed on the other parcels of land also owned by the 170 Main North Road owners.

Winter green feed crops are not grown due to wet winter soils with high soil pugging and subsequent soil structural damage risk.

Irrigation

There is a consent (CRC992605 – WJ Winter & Sons Limited) to take water for spray irrigation on land that includes the 9.6ha title on the site as well as land to the east of the railway line. The water is pumped from the Courtenay Stream at a point located downstream of the Site, with mainline pipe across to and over the Site. Hard-hose guns are used. The effective irrigation area is approximately 9.1 ha.

The smaller 4.6-hectare lot has no irrigation.

Electricity

Mains electricity is supplied to the site by power poles along the access track which also supplies land east of the site. There is a meter at the pump shed.

Net Effective Area

The net effective farming area after allowance for the Kaikainui and Courtenay Stream riparian margins, the farm track and cattle yards, and the residence (140 Main North Road) is 12.35 ha. See Image 4.

Image 4

Key:

- 144 Main North Road - house & curtilage
- Courtenay Stream riparian margin, bush, sheep yards, shed
- Access track and cattle yards
- Kaikainui Stream riparian margin

Site Zones and Classifications

District Zoning

Waimakariri District Council [WDC] Zones

Image 5

Under the Waimakariri Operative District Plan the Site lies within the Rural Zone (light green colour in Image 5) and is bounded by Residential Zone (dark red colour) to the north. Under the Waimakariri

Proposed District Plan the Site is zoned Rural Lifestyle Zone.

National Zoning

The Site includes land with National Environmental Standard (NES) classification:

Highly Productive Land: Class 1 and 3 National Policy Statement of 17th October 2022 (NPS-HPL)

The purpose of the NPS-HPL is to manage the subdivision, use and development of this non-renewable resource (soil), *providing a framework for Councils to enhance protection for highly productive land from inappropriate subdivision, use, and development and ensure it is available for growing vegetables, fruit, and other land-based primary production, now and into the future.*

This includes all land that is zoned General Rural or Rural Production and classed as Land Use Capability (LUC) 1, 2 or 3 which is considered as highly productive land for the purpose of the NPS-HPL.

Land Use Capability of the Site

The Land Use Capability of the Site is summarized in Image 6 & 7, compiled from individual LUC polygons in Images 8 and 9 [Images 8 to 9 Ref: LRIS Portal: NZLRI Land Use Capability 2021]

Image 6

Site Land Use Classes

Hectares	LUC class	LUC Description
5.20	1	1w 1
9.00	3	3s 5

14.20

Image 7

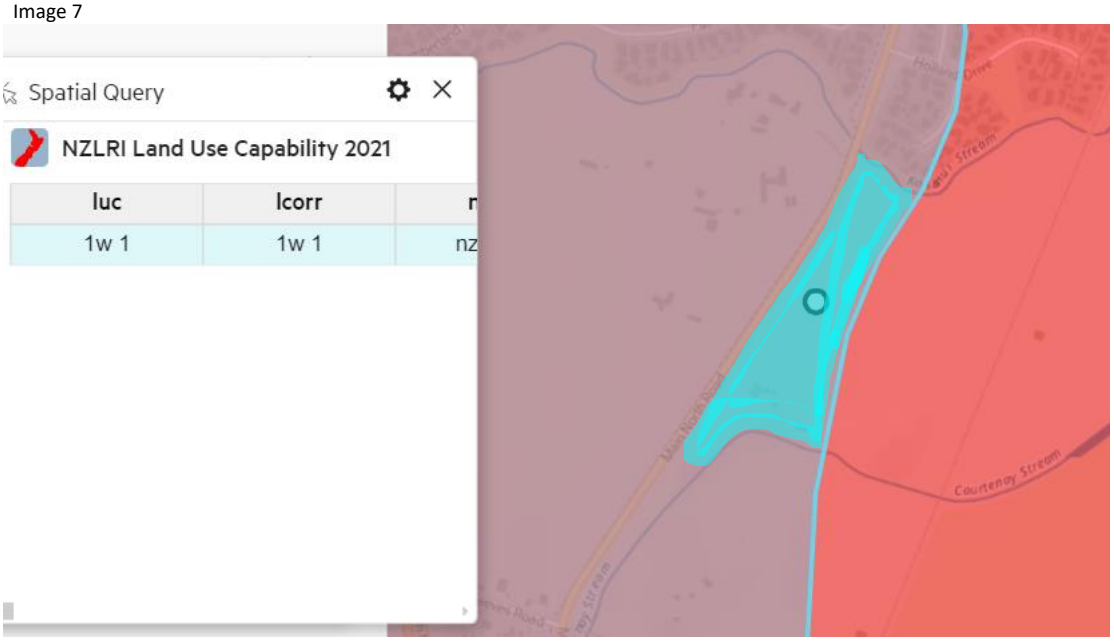

Image 8 - Site coverage of Land Use Class 1

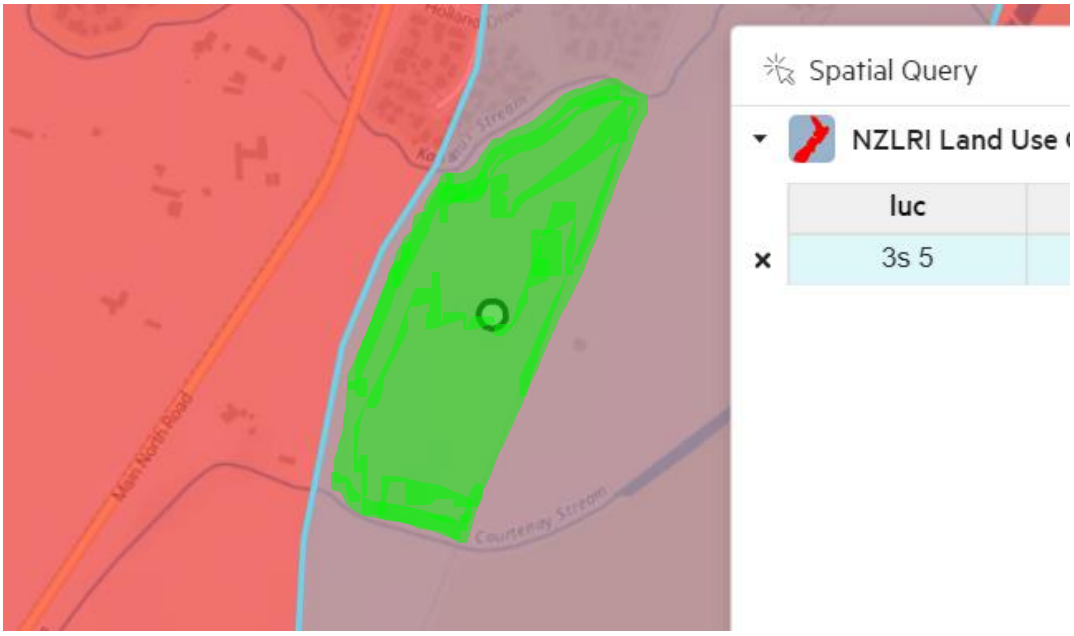

Image 9 Site coverage of Land Use Class 3

All of the Site land meets the NPS-HPL definitions.

Details of western LUC [Image 8]

For the purposes of the NPS-HPL the specific LUC rating is **'1w 1'**.

Interpretation of land Use Class Descriptions

Land Class	**1**	[versatility class]
Land Class Unit	**1w**	[restrictions to versatility]
Land Class Units	**1w 1**	[degree of versatility restriction compared to other 1w polygons]

The **Land Class** of the Site is '1' meaning:

'Land with virtually no limitations for arable use and suitable for cultivated crops, pasture, or forestry'

The **Land Class Unit** is '1w' meaning:

- *'w' wetness – where soil wetness resulting from poor drainage or a high-water table, or from frequent overflow from streams or coastal waters **first** limits production*

The **Land Class Units** is '1w 1' meaning:
The third numeral associates and orders polygons below the level of LUC subclass and can be disregarded as it simply allows location of land polygons with similar restriction characteristics and ranks them according to increasing degree of limitation to use.

Details of eastern LUC [Image 9]

For the purposes of the NPS-HPL the specific LUC rating is **'3s 5'**.

Interpretation of land Use Class Descriptions

Land Class	**3**	[versatility class]
Land Class Unit	**3s**	[restrictions to versatility]
Land Class Units	**3s 5**	[degree of versatility restriction compared to other 3s polygons]

The **Land Class** of the Site is '3' meaning:

'Land with moderate limitations for arable use and suitable for cultivated crops, pasture, or forestry'

The **Land Class Unit** is '3s' meaning:

- *'s' soil – where soil physical or chemical properties in the rooting zone such as shallowness, stoniness, low moisture holding capacity, low fertility (which is difficult to correct), salinity, or toxicity **first** limits production.*

The **Land Class Units** is '3s 5' meaning:
The third numeral associates and orders polygons below the level of LUC subclass and can be disregarded as it simply allows location of land polygons with similar restriction characteristics and ranks them according to increasing degree of limitation to use.

Refer to Appendix A for Land Use Capability Definitions.

Wetness limitations of the Class 1 land

The Class 1 land has virtually no limitations to use, apart from wetness limitations that derive from a high water-table and slow subsoil drainage on approximately 5.2 hectares; the key point is that the wetness limitations override the broad versatility that the Versatility designation (Land Class 1) implies.

The Class 1 land on the Site has imperfect drainage (see Image 11) as a result of a moderately permeable soil layer beneath a more rapidly permeable upper soil layer (see Image 10). This land also has a high water-table typically late May to late September.

This means that high rainfall or a close sequence of rainfall events, or during extended periods of high water-table saturating the soil typically winter to mid spring, water perches above the slower draining moderate permeability layer until it is able to drain away. The high water-table means that the lower horizons are saturated, so the water has nowhere to drain to until surrounding land starts to dry out and water-tables fall, typically about mid-spring).

This causes roots to be waterlogged and poorly oxygenated resulting in poor productivity typically for up to 14 weeks (early June to mid-spring).

LUC Class 1 - Permability		
Soil depth	Permability	Rate
0-20cm	Rapid	>72 mm/hr
20- 50cm	Moderate	18-72 mm/hr
50-100cm	Rapid	>72 mm/hr

Image 10 Ref: S-Maps Landcare Research

Soil Drainage

Class	Description	Area
	Poorly drained	< 1ha
	Imperfectly drained	6ha
	Unclassified Land	0ha
	Water	< 1ha

Disclaimer - Report statistics are estimated from all

Image 11 Ref: S-Maps

Soil limitations of the Class 3 land

The Class 3 land (9.0 ha) has moderate limitations to use, resulting from soil limitations that derive from soil moisture deficit for typically approximately 6-7-weeks (mid-January to early March) but can be 10-11-weeks (mid-January to mid-April) in approximately 1 year in five, which significantly impacts on pasture productivity and pasture feed quality especially during January to late March.

Rainfall is estimated at 568mm/yr. with annual evapotranspiration (PET) at 853mm [reference: Overseer version: 6.5.4], indicating a significant summer soil moisture deficit of approximately 294mm, over 50% of the annual rainfall.

Without irrigation or precipitation, the Class 1 & 3 land is expected to take between 15 days and 24 days to go from fully moist soil to wilting point depending on the particular soil type. See Image 12.

Site Soils Physical Characteristics

Approx hectares		ratio	Texture	Depth	PAW (100cm)	Approx. Soil Moisture Deficit mm	Approx. Days to Wilting Point
14.20	Kaiapoi_3a.1	49%	silt over sand	deep	163	-294	15
	Kaiapoi_1a.1	31%	silt	deep	213	-294	19
	Kaiapoi_2a.1	12%	silt	mod. deep	168	-294	15
	Matapihi_4a.1	9%	silt	deep	259	-294	24
		100%			187		

Image 12

The Class 3 land also has wetness limitations that are similar to the Class 1 land (proportionally similar area of 'poorly' drained land - see Image 13), but the wetness limitations are a secondary limitation compared to the primary limitation of soil moisture deficit.

Similarly, the Class 1 land has soil moisture deficits similar to the Class 3 land (see Image 12) but are prioritised as a secondary limitation to the wetness limitations.

Soil Drainage

Class	Description	Area
	Poorly drained	1ha
	Imperfectly drained	8ha
	Well drained	< 1ha
	Unclassified Land	0ha

Disclaimer - Report statistics are estimated from all siblings in the selected area - including the non-

Image 13

Soils on the Site

There are two types of soil identified on the Site, Kaiapoi silt loams and Matapihi silt loams, including three different types (siblings) of Kaiapoi silt loams. [reference: Landcare Research S-Maps].

The Kaiapoi soils, including all siblings, make up approximately 89% of the Site and the Matapihi soils 8.0% of the Site. Small quantities of other soil types combine to make up the remaining 3% of the area. See Image 15.

The Site is located on slightly undulating to flat alluvial floodplains formed from repeated layering of silt from the Waimakariri River. Predominantly silt loams (Kaiapoi silt, or silt over sand loams) with some Matapihi silt on the lower terrace, the soils have clay contents that reduce the rate of soil drainage in lower soil horizons, resulting in imperfect drainage forming over geological time. See description Image 14. The Matapihi soil is on a lower terrace than the Kaiapoi soils, with a higher average annual water table, and are wetter for longer through the year.

Site soils general descriptions

LUC Class 1 polygon	LUC Class 3 polygon
Flat to undulating recent floodplains developed from alluvium from various sources near sea level, with deep (>100 cm) fine textured silt loam to sandy loam, fertile Recent soils in low rainfall (< 800mm) areas. The depth to low chroma colours, gleying or mottling is greater than 100 cm and there is a very slight wetness limitation after drainage.	Flat to undulating alluvial plains and terraces below 400 m asl with moderately shallow and/or stony Brown and Recent (yellow grey earth and recent) soils in low (<800 mm) rainfall areas with a marked summer moisture deficit.
Deep slightly wet soils on floodplains in summer moisture-deficient districts	Moderately shallow and/or stony soils on plains and terraces, in summer moisture-deficient eastern districts.

Image 14 - Table Ref: LRIS Portal: NZLRI Land Use Capability 2021

Soil Siblings

Sibling	Area	Proportion
Kaia_3a.1	6 ha	46.4%
Kaia_1a.1	4 ha	29.2%
Kaia_2a.1	2 ha	11.5%
Matpi_4a.1	1 ha	6.8%
Kaia_4a.1	< 1 ha	3.1%
Waim_42a.1	< 1 ha	3.1%

Image 15

These soils typically experience significant summer moisture deficit (-294mm) as described on Page 11 & 12, impacting on pasture and crop production unless irrigated.

The key points are -

- Recent (geological age) soils
- Derived from river floodplains & fans
- High winter water tables
- Impeded subsoil drainage
- Marked summer moisture deficit
- Deep, fertile soils

For the purposes of this report the **S-Maps Summary** [reference: Landcare Research S-Maps] of the Site is used to define main soil types (which only includes significant areas of soil siblings) and areas of each type. (see Image 16 & 17).

The Soils Summary will be used in discussing land use options.

Image 17

Site Soils Summary

	Hectares	%
Kaiapoi_3a.1	8.24	58%
Kaiapoi_1a.1	4.12	29%
Matapihi_4a.1	1.84	13%
	14.2	

Image 16

Discussion

The Matapihi soils overlie almost exactly the area of poor drainage in the south-east corner, (see Images 13, 15 and 17), while the Kaiapoi soils are where the soil is imperfectly drained.

87% of the area consists of mottled Kaiapoi soils (spots or blotches of colour often rusty red in colour, showing the presence of iron oxides) indicating that there are periods of restricted profile drainage, usually early winter to mid-spring.

The remaining 13% of the area (Matapihi soil) are gley soils which are more extreme in the degree of mottling or more usually have the iron and manganese oxides segregated out into layers in the subsoil and restrict rooting depth at the point of the chemical segregation.

The key point is that both soils are formed from high groundwater tables, are imperfectly to poorly drained, and consequently trafficability (livestock and machinery) is very limited when soils are wet, typically early winter to mid spring, hence the high structural vulnerability rating (e.g. from livestock pugging - see Image 18). Likewise, pasture productivity is reduced when roots lie in very wet soil particularly during early to mid-spring.

All the soils have rapid permeability of water in the top 20cm, lying over moderate permeability of varying depths. This means that excess water (high rainfall events and high rainfall event frequency) will move down through the “A” horizon and perch on top of the moderate permeability layers and only drain away at the rate of the moderate layer. In practise the perching of groundwater can result in roots in the topsoil layer being slightly dry to dry, while roots below approximately 20cm are impacted by being too wet. This will also negatively impact on pasture yield and seasonality.

Waterlogged conditions also result in many soil organisms being restricted because of anaerobic conditions, negatively impacting on pasture health and growth.

Plant available water (PAW) is rated as high on the site at 187 mm of water. In practise this means that the soils dry out and pastures come under moisture stress later (e.g. January) than in free draining, lower PAW soils (e.g. late November) but will still experience significant periods of

moisture stress mid-January to March (-294mm soil moisture deficit on average).

In summary, all soils on the site, with Matapihi soil being more extreme than the Kaiapoi soil, are limited in plant and crop production (and therefore in livestock stocking rates, and range of crop options and performance) while waterlogged (typically June to September, but can be May to October), and while under soil moisture stress (typically mid-January to March, but can be mid-December to April).

Site Soils Physical Characteristics

Approx hectares		ratio	Texture	Depth	PAW (100cm)	Structural Vulnerability
14.20	Kaiapoi_3a.1	46%	silt over sand	deep	163	high
	Kaiapoi_1a.1	29%	silt	deep	213	high
	Kaiapoi_2a.1	11%	silt	mod. deep	168	high
	Matapihi_4a.1	8%	silt	deep	259	high
		94%			187	

		ratio	Drainage Class	Water Logging Vulnerability	Permeability Profile
14.20	Kaiapoi_3a.1	46%	imperfectly	moderate	moderate over rapid
	Kaiapoi_1a.1	29%	imperfectly	moderate	moderate
	Kaiapoi_2a.1	11%	imperfectly	moderate	moderate over rapid
	Matapihi_4a.1	8%	poorly	high	moderate

		ratio	
14.20	Kaiapoi_3a.1	46%	Deep, imperfectly drained, mottled, weakly developed silt over sand loams
	Kaiapoi_1a.1	29%	Mod. deep, imperfectly drained, mottled, weakly developed silt loams
	Kaiapoi_2a.1	11%	Mod. deep, imperfectly drained, mottled, weakly developed silt loams
	Matapihi_4a.1	8%	Deep, poorly drained, gley, weakly developed silt loams

		ratio	Diggability Depth	Topsoil Clay%	Topsoil
14.20	Kaiapoi_3a.1	46%	Deep >1.0m	12 - 25%	stoneless
	Kaiapoi_1a.1	29%	Deep >1.0m	13 - 25%	stoneless
	Kaiapoi_2a.1	11%	Mod. Deep 45-90cm	12 - 25%	stoneless
	Matapihi_4a.1	8%	Deep >1.0m	12 - 25%	stoneless

Image 18

Practical land-use considerations

On winter wet soils, green feed crops are more difficult to consume efficiently with higher wastage and more potential topsoil structure damage from pugging (and machinery if required for feeding out supplement). Soil damage from compaction requires significantly longer pasture rotation intervals (more years in pasture between green feed crops) to restore soil structure, or alternative winter feed strategies are required such as silage instead of green feed crop (typically a more expensive option) to minimise pugging damage.

Therefore, animal feed crops grazed in situ, are constrained by winter soil wetness limitations, which limits the range of livestock policies available. Consequently, best practise is to not grow winter green feed crops.

This means that the range of arable crops for grain & seed production will be significantly limited or infeasible due to the late planting dates and fewer growing-degree days to bring crop to maturity, resulting in lower subsequent yields when not irrigated. Similarly, horticulture ground crop options are very limited by late sowing dates and summer moisture deficits. Wet winter soils rule out tree crops and viticulture as well.

In summary, primary production policies on the Site are limited to livestock policies with horticulture options being ruled infeasible by winter wet soils, late spring growth, and dry summer to late-autumn soil moisture deficits. Arable crop options are limited to late spring sown feed cereal (barley).

Productivity

Average land productivity (as assessed by LandCare Research for Class 1w 1 and 3s 5 land on the Site – see Image 19) is 10.4 stock units per hectare, with top farmers 13.4 su/ha and potential productivity (without scale, technological or economic limitations) at 16.1 su/ha. Note that these definitions of stock units and stocking rates were made in the 1970's and 1980's and are made assuming no climate limitations; they are different to current-era definitions of stock units and stocking rates but are valid for comparative purposes.

		Class 1	Class 3	Site
Effective Hectares		4.2	8.2	12.35
LUC		1w 1	3s 5	1w 1 + 3s 5
Stocking Rate*	Average	13	9	10.4
	Top Farmers	18	11	13.4
	Potential	22	13	16.1

Table Ref: LRIS Portal: NZLRI Land Use Capability 2021

* LRIS definitions of stock units are used for purposes of land polygon comparison

Image 19

Current district farming practise in this location and on similar soil types are benchmarked against Beef & Lamb Farm Class 8 Survey data and adjusted with local knowledge of livestock farming practices. See Image 20.

		Current District Stocking Rates**		Site Average**
Effective Hectares		4.2	8.2	12.35
LUC		1w 1	3s 5	1w 1 + 3s 5
Stocking Rate	Average	13.0	10.5	11.3
	Top Farmers	16.0	13.5	14.3
Total Stock Units	Average	54	86	140
	Top Farmers	67	110	177

** Dryland farming

** Beef & Lamb NZ: Farm Class Survey; local knowledge of farming systems

Image 20

Discussion

Livestock farmers in the district on comparable soils and climate are stocking slightly higher than the Beef & Lamb benchmarks, but for practical purposes it makes little difference to the total livestock able to be run, with 140 su compared to 177 su for average farmers and top farmers respectively.

For the purposes of this report, the stocking rates of top farmers have been used, that is 177 stock units in total.

It is therefore assessed that the potential loss of the Class 1 and Class 3 Highly Productive Land, is 177 stock units (12.35 ha at 14.3 su/ha).

Considerations for Use of HPL land on the site

Site access, neighbours, and infrastructure

General access to Site

Access is from Main North Road which lies along the western boundary of the site.

The majority of contractors or suppliers such as for cultivation & drilling, chemical spraying, harvesting, stock trucks, fertiliser applications, etc. in support of primary production land-use activities are based in the Eyreton, Swannanoa, Cust, Oxford, Rangiora and Amberley hinterland arc and will predominantly need to access the site either by crossing over or driving along SH1 which lies west of Main North Road. See Image 21.

There are only two viable crossing points over SH1 to get to the site.

From the south of the site, access is either from Christchurch across the Waimakariri River (travelling from the south), or from the west along Tram Road. See red line in Image 21. The Tram Road – SH1 crossing is 1.55km from the site along 60 km/hr-controlled roads.

From the north of the site, access is at the Ohoka Road – SH1 crossing allowing access from the near-northern areas such as Rangiora or Woodend and far-north by travelling down SH1 and turning east at Ohoka Road. Access from the west and/or north-west is along Ohoka Road and crossing over SH1 at the over bridge. The overbridge is 2.1km from the site along 50 km/hr urban controlled roads. See blue line in Image 21.

It is possible to access the site by turning off SH1 at the northern end of Kaiapoi (Lee Road), and then travel though urban and CBD Kaiapoi for approximately 5.36 kilometres of 50 km/hr urban controlled roads. It is considered unlikely that this route would be used by choice by contractors.

All contractors will have to manage journeys with consideration of peak road traffic times, particularly commuting hours to and from Christchurch, and school and other educational facilities opening and closing hours and manage mud and dirt transfer from vehicles particularly tractors.

Some site access is required to be time-specific such as chemical spraying which must be done in very low wind conditions, and coordinating traffic flows and local wind conditions can be difficult to manage. Harvesting activities of grains or supplement feeds is also often dictated by requirement for low wind conditions and warm drying weather. Crop-specific conditions can be any time during the day or evening and traffic will need to be taken into consideration.

Overall, it is expected that these high traffic peaks will have a significant impact on farm contractors and suppliers as well as well as on other users.

Truck delivery or removals (e.g., livestock) are less likely to be time bound or difficult to manage on urban roads.

The paddock effective areas are small (<4.65 ha), and it is most likely that the maximum area of any one activity would be no more than on 4.65 ha, based on likely crop rotations. Experience supervising farming activities adjacent to urban areas would indicate that most contractors would be unwilling to put up with the difficulties of managing traffic and potential mud and noise pollution issues for such a small job. It would be uneconomic for them at normal contract rates and even if they were willing to do the work, they would not prioritise work on the Site over and above closer and larger long-standing clients.

In summary this means that the pool of available contractors is relatively small and less likely to respond when needed for time-sensitive or condition-sensitive activities.

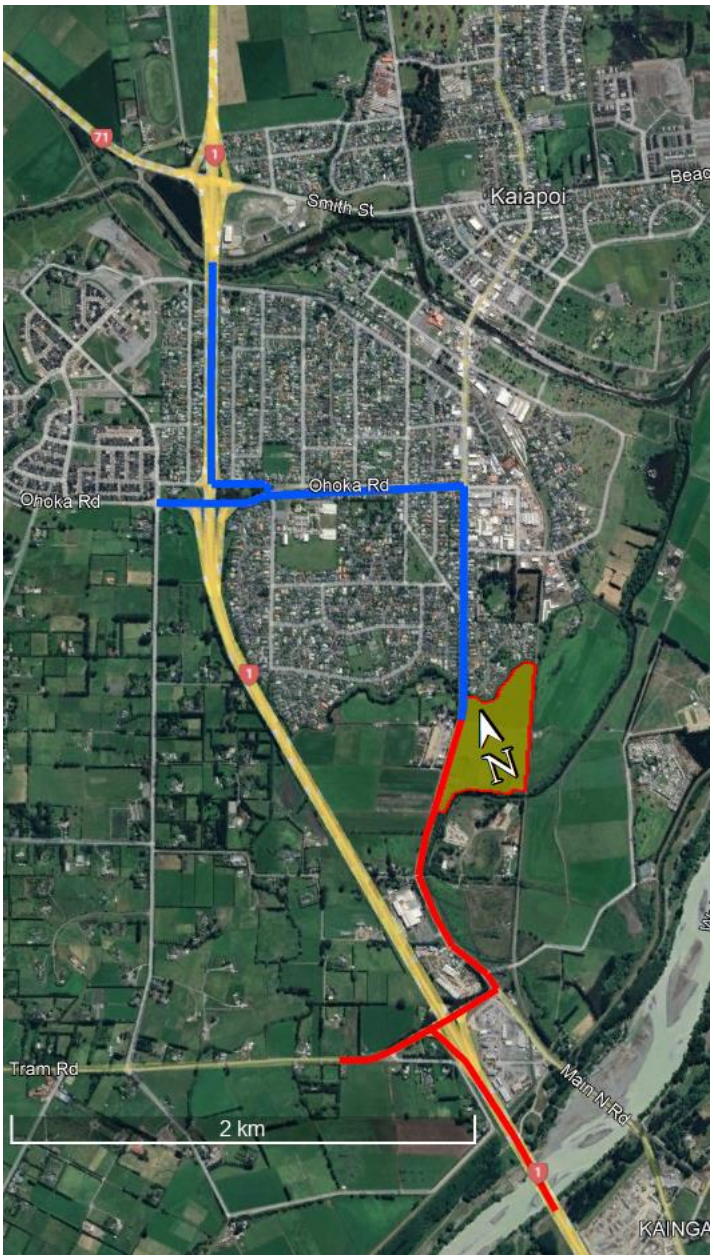

Image 21

Neighbours

Direct neighbours are (see Image 22):

- East – Pastoral farmland (green)
- North – Residential houses, Kaiapoi Township (red)
- West – Light industrial, rural (Waghorn Builders, Easy Lawn, et al - yellow)

- South – Light industrial, rural (Clemence Drilling, et al - blue)

Image 22

Potential impacts from primary production activities that may be carried out on the Site include agricultural chemical spraying, dust from land cultivation and fertiliser spreading, and noise pollution from machinery and vehicle use.

These activities are not expected to have negative impacts on Site neighbours to the west, south or east, because of either similar land use activities within the Rural Zone, or distance.

Existing residential housing (red in Image 22) lies directly north of the site. The closest housing to the closest land use on the site is between 40m to 50m straight-line. It is expected that the residences adjacent to and further back from the Site will be potential impacted by rural activities on the Site.

Reverse sensitivities also apply. Any prudent land user of the Site considering grazing livestock particularly sheep, but also young cattle, will also take into account the high probability of neighbourhood dog harassment of livestock and impact from injury and deaths through to reduced productivity. Further, cats are vectors for spreading sheep disease (e.g., toxoplasmosis), affecting lambing percentages.

Vandalism and theft are also more frequent in locations close to residential areas. Livestock and machinery security will need to be at higher levels than more rural located farms with similar farm policies.

Current Consents

Apart from the irrigation application consent (CRC992605) and the two shallow bores (one for the residence and one for stock water) there are no other consents on the site.

Class 1 and 3 Primary Production Land Use Options

In order to analyse possible primary production land uses on the Class 1 & 3 land, the following assumptions have been made.

1 Stock water

The existing stock water supply from the shallow bore next to the access lane and supplemented from house supply water is expected to continue and meet sheep and cattle requirements for production and for animal welfare purposes.

Annual running costs of approximately $600/year for electricity.

2 Irrigation water

When the site is separated from the larger land title (i.e. land east of the railway line), it will remove the irrigation water supply, and become dryland.

The significant soil moisture deficit of 294mm is approximately 50% of annual rainfall and when combined with high evapotranspiration rates, pastures or crops are in moisture deficit conditions typically requiring irrigation between late December and late March in most years. A pasture-based stock system can be designed around this limitation with its implicit lower summer animal productivity performance, and conventional arable crops (cereals, small seeds, and peas) can be grown but at lower average yields with wider yield variance range than under irrigation. Any more-intensive cropping or higher productivity or product requirements (seed or grain quality), or soil based horticultural activity will require irrigation water. Some of the latter crops such as market garden vegetables can be grown dryland but require irrigation to produce consistent yields of the very high quality required to be meet contract buyer specification and at economically profitable prices.

To install irrigation the cost of a bore, screen, pumps & electrics, power supply (it is assumed that the power supply currently over the land is sufficient but will require either an upgrade or new transformer), and a water application system tailored to the land use activity (but assumed to be sprinkler based) would cost approximately $180,000 - $200,000 including consenting fees.

Annual running costs are seasonally dependent estimated at $5,000 - $7,000/year depending on electricity line fees, with annualized consent renewal fees, consent audit fees, Farm Environment Plan costs, water use monitoring charges estimated at an additional $2,000-$2,500/year.

Irrigation consents would be required to take water and to use water. Gaining appropriate consents with satisfactory water use conditions that don’t restrict crop irrigation timing or annual volumes (the water must be reliable in daily flow during the crop growing to harvest period, and with sufficient total annual volume) is not guaranteed. Successful consent application would require that the applicant’s well would not impact on existing wells and bores within 1.5km of the planned well

site, but particularly on the Kaikainui and Courtenay stream flows and existing irrigation users.

It is considered that the likelihood of obtaining irrigation consents is low to very low given the location and the general over-allocation of groundwater resources in the Waimakariri Irrigation Zones and the very close proximity to existing streams and existing irrigation users.

The applicant will also need to be prepared to take a total loss of approximately $60,000 - $70,000 if the consent is not granted (drilling a test well, flow rate testing, preparation of application, ECAN application fees, etc).

In summary, as the likelihood of being granted an irrigation consent is highly unlikely, primary production land use activities that require irrigation have been ruled out. This excludes viticulture and horticulture and market gardening activities; while these could be pursued as dryland ventures, in my opinion no prudent land user would undertake investment with the levels of summer and autumn drought risk involved.

3 Physical Access
Access is from Main North Road

4 Electricity Supply
Electricity is from the existing metered supply at the stock water bore.

5 Stock yards and load-out ramp
There are existing cattle and sheep yards on the site. Assumes that $2,000 is required to complete maintenance.

6 Sheep Shearing
Normally a shearing shed is needed, but given the small number of sheep, it is assumed that shearing outdoors or under cover of the existing shed with electric battery shears is sufficient to harvest wool and meet sheep welfare requirements (flystrike, etc).

7 Fencing
It is assumed that the Site has permanent livestock fencing around it. Any further fencing beyond the existing seven paddocks is assumed to be provided by temporary electric fencing, using mains energizer. Cost $1500

8 Contractors
It is assumed that all the contractors required, depending on the type of land use activity, are available in the district, and are not limiting in terms of potential land use choices available.

9 Other costs
The land and house will have rates costs from the Waimakariri District Council and Environment Canterbury (GST exclusive, calculated pro rata on land area) of approximately $4,253 per year.

Farming Land Use Options

Technically feasible options for this site are:

- Dry-stock sheep
- Dry-stock cattle
- Mixed cropping (arable and dry-stock sheep)
- Sale of hay and baleage
- Dairy heifer contract grazing

Discussion of Options

Dairy heifers

Dairy heifer contract grazing options are restricted by heavy winter wet soils being easily pugged, and best practise would be to remove heifers over winter. Grazing contracts are typically:

- A - 21 weeks (as calves - December to April)
- B - 52 weeks (yearlings - May to April)
- C - 73 weeks (calf to R2 - December to April)

The vast majority of contracts are type-C with only a few of type A or B which are only occasionally and inconsistently available.

Generally dairy farmers do not place small number of calves out grazing as it splits mobs up and requires additional supervision time and additional freight cost for calves. 60 dairy calves are calculated as potentially summer-autumn grazed on site, when grazing contracts typically are for herd sizes of 125 - 150 calves, or more.

Only type A contracts would suit the soils on this site (lightest weight calves and no winter pugging damage).

For comparative purposes in this report, it is assumed that a Type-A contract calves can be found, and in small enough lines, and spring grass is made into baleage for sale.

Dry stock Sheep

There are a number of permutations, but district practise sheep policy would be breeding ewes, selling the progeny finished to a processor or store to other farmers to finish. Usually with small flocks, replacement ewes are purchased, rather than bred and grown out.

Using the *Beef & Lamb NZ Economic Service; Class 8 SI Finishing* as a benchmark, the site would carry 154 breeding ewes (177 stock units). However typically, small blocks carry slightly higher stocking rates, at +10% would therefore carry 169 breeding ewes (195 stock units).

Dry stock cattle

The usual small block cattle policy is to purchase yearling cattle and graze for approximately 12-14 months before sale to meat processors, however given the very wet winter soils, the policy is more likely to be purchase of calves at weaning (March/April) and sell forward-store prior to the second winter as 21-month-olds. Using the Beef & Lamb Economic Service data, and at +10% higher small block stocking rate, this site would be expected to carry 48 head.

Mixed cropping
Dryland arable cropping is carried out in Canterbury on a small scale and as part of an integrated crop and stock policy. The most common crops grown are barley, and sometimes low-specification old varieties of perennial grass seed. Given the winter wetness limitations from high water tables, it is typically not until late spring (mid-October) before soils are dry enough to prepare a viable seed bed; despite this, yields are expected to be higher than average because of the high fertility of the soils.

Rotations typically would be spring sown barley, to permanent pasture for 4-5 years, then repeat; with sheep or light-cattle grazing the pasture.

Dryland barley yields 7.0 t/ha, and barley straw at 6 medium round bales per hectare; and during pasture years 169 breeding ewes.

Supplementary feed hay or baleage
Permanent perennial pasture with commonly two spring and early summer cuts, and two mid-late autumn cuts assuming there has been sufficient autumn rainfall. Harvest 496 bales hay or baleage (144+144+104+104).

Note: in all scenarios, perennial pastures require replacement after 6-8 years to maintain quality & vigour.

Economic Viability

The five technically feasible options with markets to support them, and able to be undertaken as part of normal farming practise year-in-year-out are:

- Dry-stock sheep
- Dry-stock cattle
- Mixed cropping
- Sale of hay and baleage
- Dairy calves and sale of baleage (included for comparative purposes only)

Assumptions
There is no payment included for wages or owners time in undertaking the land use activity, such as shifting stock, undertaking animal health activities, buying and selling of livestock and produce, shifting hay or baleage, and administrative & regulatory requirements related to the farming activity.

It is assumed that the land is debt free and there are no interest and or principle payments attached to the land purchase, and the owner does not require a return on investment.

Infrastructure costs only include permanent improvements specific and essential to the proposed land use activity, such as stock yards, irrigation, access, etc.

The general machinery required such motorbikes or 4WD utility vehicles or tractors are all assumed to be on hand and suitable for the activities required, excluding cropping or pasture renewal which are all undertaken by contractors. A nominal contribution is allowed for fuel and vehicle servicing operating expenses, and no allowance is made for depreciation or vehicle replacement costs.

The economic viability of each option is detailed in Images 23, 24 & 25.

Summary

All land use options are able to generate sufficient income to cover direct operating expenses.

	Net annual trading result (rounded)
• Dry-stock sheep	+$7,100
• Dry-stock cattle	+$4,800
• Mixed cropping	+$4,600
• Sale of hay/baleage	+$3,300
• Dairy calves and sale of baleage	+$4,200

Capital investment is required to purchase livestock and to provide the infrastructure to efficiently carry out most land use options. Using an interest cost of capital at 5.0% and principle payments are made over 5-years for livestock and 10-years for infrastructure, then annual Net Cash Results are:

	Capital Improvements	Capital Livestock	Net Annual Cash Result*
Dry-stock Sheep	$3,500	$21,960	$1,000
Dry-stock Cattle	$3,500	$36,425	-$4,800
Mixed Cropping	$3,500	$13,781	$600
Sale hay/baleage	$0	$0	$2,000
Dairy calves/baleage	$3,500	$0	$2,800
Average	$2,800	$14,433	$320

* rounded

Only the dry-stock cattle policy is unable to generate sufficient income to cover direct expenses, cost of livestock and cost of infrastructure improvements (interest & principle).

The average Net Cash Result of the other four options is +$1,600 which is considered to be very small with low profit resilience; future combinations of input cost increases and normal seasonal variations in yield or animal growth rates or reproductive rates resulting from poor climatic conditions (primarily late spring and longer summer-autumn dry periods) would easily result in a breakeven or below breakeven position.

In summary, even using higher stocking rates (+10% above 'top farmers') and given that there is no provision for owner's labour, no return on the assumed debt-free Site land purchase, no replacement provision on the assumed in-place vehicles & machinery suite, the Net Cash Result is very low, and no prudent farmer would view any of these options as economically viable on this site.

Sheep

Policy: 168 ewes, 140% lambing, all lambs to kill, 4.2 kg wool/ssu, 5.1% deaths

Effective Hectares	12.35				
SU/ha (+10% higher)	15.73				
Total SU	194				
Gross Income - incl sire costs		**$22,718**			
Direct Farming Expenses					
Rates (pro rata)	$4,253				
Insurance	$1,050				
Animal health	$1,088				
Electricity	$600				
Shearing	$1,351				
Annual fertiliser	$1,834				
Pasture renewal - annualised	$1,906				
Hay/Baleage made	$890				
R&M	$760				
Freight IN	$207				
ACC	$34				
Administration contribution	$1,088				
Vehicle Opex Contribution	$600	**$15,662**		**$7,057**	A
Livestock Loan Interest	$1,098	5.0%	$21,960		
Livestock Loan Principle	$4,392	5-years			
		$5,490		**$1,567**	B
Improvements Loan Interest	$175	5.0%	$3,500		
Improvements Loan Principle	$350	10-years			
		$525		**$1,042**	C

Beef

Policy: 48 yearling purchased, 47 sold at 21mths, 2.0% deaths

Effective Hectares	12.35				
SU/ha	15.73				
Total SU	194				
Gross Income - net of purchase costs		**$20,655**			
Direct Farming Expenses					
Rates (pro rata)	$4,253				
Insurance	$1,050				
Animal health	$762				
Electricity	$600				
Shearing	$0				
Annual fertiliser	$1,834				
Annual Pasture renewal	$1,906				
Hay/Baleage made	$2,003				
R&M	$760				
Freight IN	$971				
ACC	$34				
Administration contribution	$1,088				
Vehicle Opex Contribution	$600	**$15,861**		**$4,794**	A
Livestock Loan Interest	$1,821	5.0%	$36,425		
Livestock Loan Principle	$7,285	5-years			
		$9,106		**-$4,312**	B
Improvements Loan Interest	$175	5.0%	$3,500		
Improvements Loan Principle	$350	10-years			
		$525		**-$4,837**	C

Image 23

Mixed Farming (Barley + drystock sheep)

Policy: Barley at 7.0 t/ha, 6 b/ha straw & 4yrs sheep

Effective Hectares	12.35				
SU/ha	15.73				
Total SU	194				
Gross Income - annualised		**$29,758**			
Barley price average last 5yrs less 10% for sale off header					
Direct Farming Expenses					
Rates (pro rata)	$4,253				
Insurance	$1,050				
Animal health	$683				
Electricity	$600				
Shearing	$848				
Annual fertiliser	$1,151				
Pasture renewal - annualised	$1,065				
Hay/Baleage made	$559				
R&M	$760				
Freight IN	$130				
Barley Crop Direct Exp	$12,351				
ACC	$34				
Administration contribution	$1,088				
Vehicle Opex Contribution	$600	**$25,171**		**$4,587**	A
Livestock Loan Interest	$689	5.0%	$13,781		
Livestock Loan Principle	$2,756	5-years			
		$3,445		**$1,142**	B
Improvements Loan Interest	$175	5.0%	$3,500		
Improvements Loan Principle	$350	10-years			
		$525		**$617**	C

Hay/Baleage Supplement

Annual Policy: 497 bales (4x cuts) grass, stored & sold during winter

Effective Hectares	12.35				
SU/ha	15.73				
Total SU	194				
Gross Income		**$46,577**			
Direct Farming Expenses					
Rates (pro rata)	$4,253				
Insurance	$1,050				
Animal health	$0				
Electricity	$600				
Shearing	$0				
Annual fertiliser	$6,221				
Pasture renewal - annualised	$1,906				
Hay/Baleage made	$27,333				
R&M	$152				
Freight IN	$0				
ACC	$34				
Administration contribution	$1,088				
Vehicle Opex Contribution	$600	**$43,237**		**$3,340**	A
Delayed sale Interest	$33,554	5.0%	$1,258		
		$1,258		**$2,082**	B
Improvements Loan Interest	$0	5.0%	$0		
Improvements Loan Principle	$0	10-years			
		$0		**$2,082**	C

Image 24

Dairy Heifer Grazing + Baleage					
Annual Policy: 60 Calves Jan-Apr + 2x spring cuts baleage					
Effective Hectares	12.35				
SU/ha	15.73				
Total SU	194				
Gross Income		**$33,957**			
Direct Farming Expenses					
Rates (pro rata)	$4,253				
Insurance	$1,050				
Animal health	$0				
Electricity	$600				
Shearing	$0				
Annual fertiliser	$3,543				
Pasture renewal - annualised	$1,906				
Hay/Baleage made	$15,894				
R&M	$760				
Freight IN	$0				
ACC	$34				
Administration contribution	$1,088				
Vehicle Opex Contribution	$600	**$29,729**		**$4,229**	A
Delayed sale Interest	$24,700	5.0%	$926		
		$926		**$3,302**	B
Improvements Loan Interest	$175	5.0%	$3,500		
Improvements Loan Principle	$350	10-years			
		$525		**$2,777**	C

Image 25

Summary and Conclusions

- The site is classified as Land Use Classes *1w 1* and *3s 5* which brings it under the NES Highly Productive Land regulations.
- The Kaiapoi and Matapihi soils are imperfectly or poorly drained and are winter wet from high water tables and have slowly permeable lower soil horizons which limits the range and types of primary production that can be undertaken.
- The winter wet soils are also structurally vulnerable soils that are easily damaged by livestock pugging or by machinery and vehicle activity such as winter feeding out of supplements (best practise is to not grow winter green feed crops), which limits the range and type of livestock policies especially those including heavier cattle, as well as arable crops and horticulture crops.
- There is a marked summer soil moisture deficit (294mm) which limits pasture production from mid-January to late March and requires more conservative stocking rates, animal growth rates, and arable and supplement yields expectations.
- Spring establishment of arable crops are late (mid-October) by the time soils are sufficiently

dry, which reduces potential crop yields.

- A very limited range of arable crops can be grown dryland (typically barley) but can be grown repeatedly and rotated with perennial pasture every approximately four years for soil restoration.
- Light weight livestock (sheep and calves) minimise winter pugging risk as long as baleage or hay is used for supplement. Heavier cattle can be grazed late spring to end autumn but need to be destocked over winter.
- Site is currently irrigated but will revert to dryland as its water source is located off-site. Current stock water, mains electricity, cattle and sheep stock yards, and shed are all suitable for light livestock and pasture-based systems.
- Irrigation consents are highly unlikely to be granted on this site, so only dryland land use options are available. This excludes horticulture and viticulture options.
- Even in the unlikely event of irrigation consent being granted, the high capital cost of up to approximately $200,000 would add approximately $10,000 per year in interest costs (5%) and $10,000 per year in principle repayments (20-year term)
- While the full range of contractors and suppliers are expected to be available from the North Canterbury hinterland, the site's urban fringe location significantly limits the ability of contractors to reliably deliver time-critical work for some weather condition-specific activities such as spraying & harvesting, and consequently when combined with the small size of the Site, contractor costs are expected to be higher per-hectare than normal.
- There is expected to be high potential impact on site neighbours to the north from dust, spray-drift, and noise as well as mud & debris on the access roads.
- There are five technically feasible land use options, including one (dairy calf summer & autumn grazing) that has a low likelihood due to low availability of contracts which are not commonly available or at the low heifer numbers that can be carried on this site.
- Potential land use options include dryland sheep, dryland beef cattle, mixed cropping arable & sheep, selling supplementary feed (hay or baleage), and dairy heifer calf grazing & spring supplementary feed harvesting.
- All options are able to produce a trading profit and cover direct expenses (range +$3,300 to +$7,100).
- Total infrastructure development is minimal (stock yard maintenance, electric fence energizer) at $3,500 for four options, and $0 for one option.
- Livestock purchase costs average $14,400 ($0 to $36,400) and interest and principle costs ranges between $3,500 and $9,100.
- When the cost of capital (5.0% interest) and principle payments are included, then total Net Cash results are breakeven for mixed farming (+$600), a loss for dry-stock beef (-$4,800), and small profits for the remaining options of between +$1,000 to +$2,800/yr.
- The average Net Cash Result of all options is +$320, which is considered to be very small with low profit resilience, and easily result in a breakeven or below breakeven position as a result of climate or market variability.
- Livestock economic viability has been calculated using stocking rates higher than the

district benchmark averages by using stocking rates of top-farmers plus 10%, which indicates that higher stocking rates are not able to overcome lack of economic viability while at the same time significantly increasing productivity risk with more stock being grazed during summer drought months.

- Even using higher stocking rates (+10% above 'top farmers') and given that there is no provision for owner's labour, no return on the assumed debt-free Site land purchase, no replacement provision on an assumed in-place vehicle & machinery suite, the Net Cash Result is very low.

- No prudent farmer would view any of these options as economically viable on this site.

- It is difficult to see any prudent land user placing themselves under these kinds of risks to farm the land on this site and with little likelihood of recouping any capital invested into land purchase; full recovery of cost of improvements is at risk given the essentially breakeven status of the land use options.

- The small scale of the site, high vulnerability of the soils to structural damage from high water tables, summer drought periods, late spring crop establishment timing, restrictive site access for contractors, very low chance of obtaining irrigation water consents, as well as very expensive irrigation infrastructure means that there is no reliable long term economically viable primary production land use for this site.

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Appendix A

Land Use Capability Definitions

Land Classes 1 to 4 are suitable for arable cropping (including vegetable cropping), horticultural (including vineyards and berry fields), pastoral grazing, tree crop or production forestry use.

Land Classes 5 to 7 are not suitable for arable cropping but are suitable for pastoral grazing, tree crop or production forestry use, and, in some cases, vineyards and berry fields. The limitations to use reach a maximum with LUC class 8.

Land Class 8 land is unsuitable for grazing or production forestry and is best managed for catchment protection and/or conservation or biodiversity.

LUC 1	Land with virtually no limitations for arable use and suitable for cultivated crops, pasture, or forestry.
LUC 2	Land with slight limitations for arable use and suitable for cultivated crops, pasture, or forestry.
LUC 3	Land with moderate limitations for arable use and suitable for cultivated crops, pasture, or forestry.
LUC 4	Land with moderate limitations for arable use and suitable for occasional cultivated crops, pasture, or forestry.
LUC 5	High producing land unsuitable for arable use, but only slight limitations for pastoral or forestry use
LUC 6	Non-arable land with moderate limitations for use under perennial vegetation such as pasture or forestry
LUC 7	Non-arable land with severe limitations for use under perennial vegetation such as pasture or forestry
LUC 8	Land with very severe to extreme limitations or hazards that make it unsuitable. for cropping pasture or forestry.

Land use capability subcategory

Each LUC unit has a subcategory of the LUC class through which the main kind of physical limitation or hazard to use is identified. Four limitations are recognised:

- 'e' erodibility – where erosion susceptibility, deposition, or the effects of past erosion damage *first* limits production
- 'w' wetness – where soil wetness resulting from poor drainage or a high-water table, or from frequent overflow from streams or coastal waters *first* limits production
- 's' soil – where soil physical or chemical properties in the rooting zone such as shallowness, stoniness, low moisture holding capacity, low fertility (which is difficult to correct), salinity, or toxicity *first* limits production.
- 'c' climate – where climatic limitations such as coldness, frost frequency, and salt-laden onshore winds first limits production