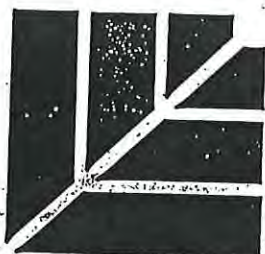

Preliminary Report on the Issues and Options for Land Treatment and Disposal of Sewage from Darfield

SELWYN DISTRICT COUNCIL

Report No 2713/1

June 1996



**LINCOLN
ENVIRONMENTAL**

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1 INTRODUCTION

Lincoln Environmental were commissioned by Selwyn District Council (SDC) to carry out a desk top study to investigate the issues and options for land treatment and disposal of secondary treated sewage from Darfield Township.

2 EXISTING SITUATION

The following information on existing sewage treatment and disposal in Darfield has been obtained from a report on "*Preliminary Assessment of the Effects of Discharges from Unsewered Townships in Canterbury*" prepared for the Canterbury Regional Council (CRC) by Pattle Delamore Partners Ltd. (A copy of the individual report for Darfield is included in Appendix I.)

- The current sewage disposal in Darfield is by way of individual dwelling septic tanks with disposal to boulder holes.
- No failures of these systems have been reported to date.
- Household effluent disposal is not likely to be a limiting factor for future housing development in Darfield.
- Regarding potential environmental concern Darfield is ranked low among the 102 townships considered in the study. Factors considered here were: potential for exposure at the ground surface, distance to surface water, distance to nearest bore, and potential for problems with future development.
- With respect to the less critical categories such as effluent source strength and migration pathways Darfield is ranked above average in terms of the potential for environmental effects.

3 ISSUES TO BE CONSIDERED

There are a number of issues that must be taken into account when looking at land based treatment and disposal options. This section identifies these issues as they relate specifically to Darfield. These would need to be looked at in greater detail once a preferred option is chosen.

3.1 Location

The location of Darfield and the surrounding area is shown on Figure 1. The topography around Darfield is flat land that falls to the southeast as shown by the contours on Figure 1. A site southeast of Darfield would enable gravity to be used to transfer the sewage from the township to the land treatment and disposal site. This would reduce the operating costs. For this reason SDC has asked that this study be confined to the area southeast of Darfield township.

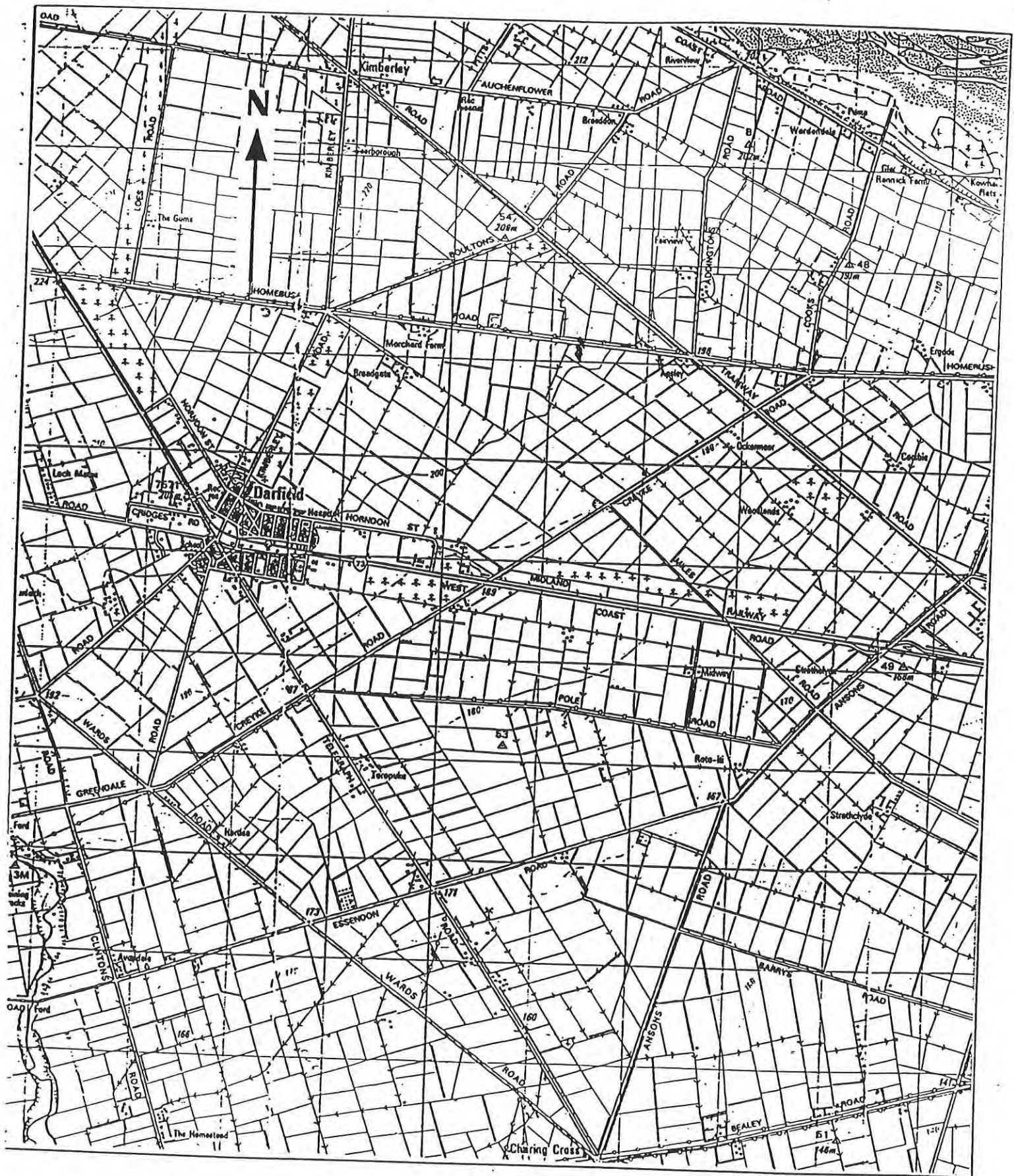


Figure 1: Location Map (Scale 1:50,000)

3.2 Design Population

The current population of Darfield is 1,300 (A Iremonger, SDC, pers comm). For the purposes of this study SDC have requested that a design population of 2,500 be used. It is presumed that this population is considered adequate to meet the future projected growth of Darfield.

3.3 Sewage Loadings

Sewage loadings are used to determine the area of land required to successfully treat and dispose of the wastewater. The average characteristics of untreated domestic sewage are shown in Table 1 together with the total load for a future population of 2,500. These figures have been used in the calculation of hydraulic and nutrient loadings for Darfield. There is no allowance in these figures for any industrial sewage. However provision of capacity for industrial sewage could be made if required.

Table 1: Characteristics of Untreated Domestic Sewage

Parameter	Contribution per Person per Day	Design Load	Design Concentration
Flow	270 l/p/d	675 m ³ /d	
BOD	70 g/p/d	175 kg/d	259 g/m ³
Suspended Solids	80 g/p/d	200 kg/d	296 g/m ³
Nitrogen	10 g/p/d	25 kg/d	37 g/m ³
Phosphorus	3 g/p/d	7.5 kg/d	11 g/m ³
Faecal Coliforms			10 ⁷ -10 ⁸ No/100 ml

It is assumed that the sewage would receive at least secondary treatment by, for example, an oxidation pond or an alternative treatment process, prior to the wastewater being discharged onto the land.

3.4 Soils

Soils are important when considering land treatment and disposal because they are an integral part of the process to treat the wastewater. A soils map of the area around Darfield taken from Soil Bureau Bulletin 14 "Soils of the Downs and Plains Canterbury and North Otago New Zealand" is shown in Figure 2. The soils surrounding Darfield are Chertsey shallow silt loam soils with Lismore stony silt loam soils southeast of the township. These soils are described as free draining and are subject to seasonal drought.

The Chertsey soils are deeper than the Lismore soils having a greater depth of fines on top of the gravels. The available water holding capacity of both these soils is 70-120 mm. Both the Chertsey shallow silt loam soils and the Lismore stony silt loam soils would be suitable for all year round wastewater disposal by either border dyke or spray irrigation (T Webb, Landcare Research, pers comm).

Therefore any land south east of Darfield that has Chertsey shallow silt loam or Lismore stony silt loam soils would be suitable for all year round application of wastewater providing consideration is given to hydraulic loadings.

3.5 Climatic Factors

Rainfall and Potential Evapotranspiration

Rainfall and potential evapotranspiration (PET) data identify the periods when there is the greatest potential for drainage of water into the groundwater to occur. The nearest rainfall station with long term rainfall records is Darfield (station number H32412). At this site the mean annual rainfall for the 76 year period 1920-1995 is 793 mm. The average monthly rainfall figures at the Darfield site are shown in Table 2. On average, rainfall is reasonably even throughout the year and there is no regular pattern, in the monthly range of rainfall, as to which seasons most rain is likely to occur. The highest rainfall in a year was 1207 mm in 1978 and the lowest was 499 mm in 1969.

The average monthly PET figures for Lincoln (the closest long term records) for the period 1960-1995 are shown in Table 2. Comparing average monthly totals of rainfall and PET, it is only in the months of May to August that rainfall exceeds PET. In fact, during the summer months, there is a substantial soil moisture deficit. Therefore the application of wastewater during this period would reduce this deficit and enhance plant growth. The winter months of May to August, during which mean monthly rainfall exceeds PET, is the period with the highest potential for the applied wastewater to be leached into the groundwater. The application of wastewater will be critical in these months when the soils are wetter and PET rates are low.

Table 2: Average Monthly Rainfall and Potential Evapotranspiration Data

Month	Mean Monthly Rainfall ^(a) mm	Mean Monthly Potential Evapotranspiration ^(b) mm
January	66	151
February	60	120
March	65	100
April	63	69
May	75	49
June	63	37
July	66	41
August	69	56
September	62	74
October	67	110
November	65	127
December	72	144
Totals	793	1076

(a) Darfield rainfall data
(b) Lincoln potential evapotranspiration data based on Penman estimates

Wind

The prevailing winds should be considered when identifying potential land treatment and disposal sites on account of air quality issues discussed in Section 3.7 *Air Quality*. Figure 3 is a wind rose for Darfield which depicts the frequency of wind from the various directions. This figure shows that the dominant wind directions at Darfield are northeasterly (22.7% of the time), northwesterly (22% of the time) and southwesterly (19.5% of the time). On average calm conditions exist for 11% of the time.

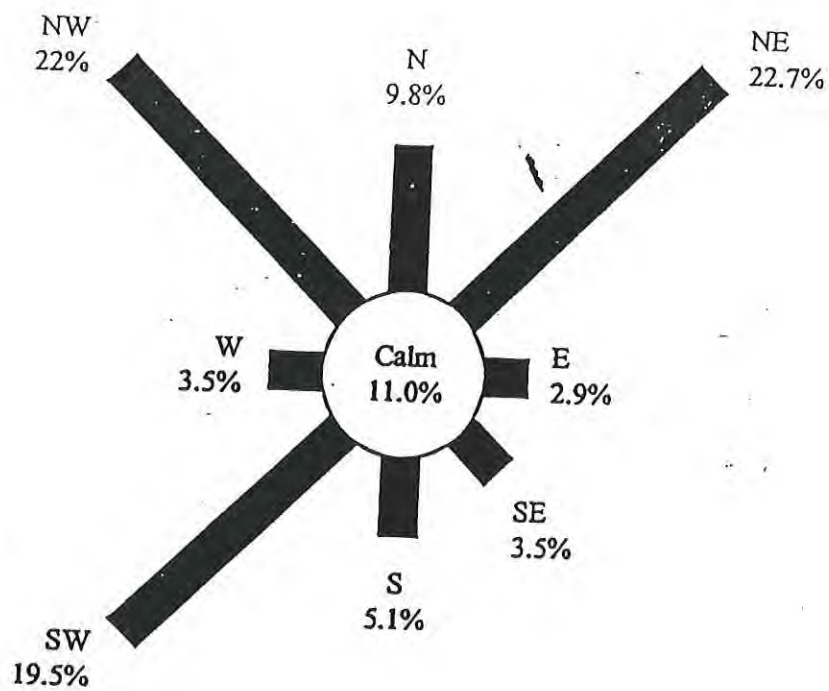


Figure 3: Mean Annual Wind Direction Frequencies for Darfield (% of total time)
(Source: NZ Air Department & NZ Meteorological Services)

Summary climatic information for the Darfield site on rainfall, air and ground temperatures, frosts, relative humidity, vapour pressure, pan evaporation and special phenomena such as snow, hail, thunder, gales and fog is included in Appendix II. There is no wind speed data available for Darfield.

3.6 Groundwater

In land treatment and disposal systems wastewater can be leached onto the groundwater and potentially effect the water quality. Therefore it is important to understand the hydrogeology of the area and the existing water quality.

Hydrogeology

The CRC's report on *"The Natural Resources of Lake Ellesmere and its Catchment"* subdivides the Canterbury Plains part of the Ellesmere Catchment into hydrogeological zones that have similar aquifer structures and characteristics specific to that part of the groundwater system.

The hydrogeological zone which covers the area around Darfield is the central plains zone. This zone has a surface unconfined aquifer underlain by semi-confined aquifers. The predominant inputs into this groundwater zone are rainfall recharge and seepage from the Waimakariri River. In this locality the groundwater surface is generally inclined towards the southeast at a gentle gradient. The land surface also slopes towards the southeast, though at a slightly steeper gradient than the groundwater surface. Therefore, the depth to groundwater will decrease to the southeast of Darfield. The direction of groundwater flow is in a southeasterly direction, following the grade of the groundwater surface.

The location of wells around this area are shown on Figure 4. The owner, grid reference, depth, diameter and the purpose for which the water is used for each of these wells (taken the CRC's wells database) is included in Appendix III.

The depth to groundwater in the area southeast of Darfield is approximately 90-100 m. CRC have limited records of depth to groundwater measurements from wells in this area. These measurements are summarised as follows (refer to Figure 4 for location of wells):

- Well No L35/0190 (RH Williams), average depth to groundwater 91.9 m, range 73.8-99.7 m (187 water level readings between 1979 and 1993).
- Well No L35/0213 (JW Anderson), average depth to groundwater 97.1 m, range 91.6-98.7 m (29 water level readings between 1983 and 1984).
- Well No L35/0248 (MR & PR Cattell), average depth to groundwater 95.8 m, range 77.9-97.5 m (38 water level readings between 1984 and 1987).

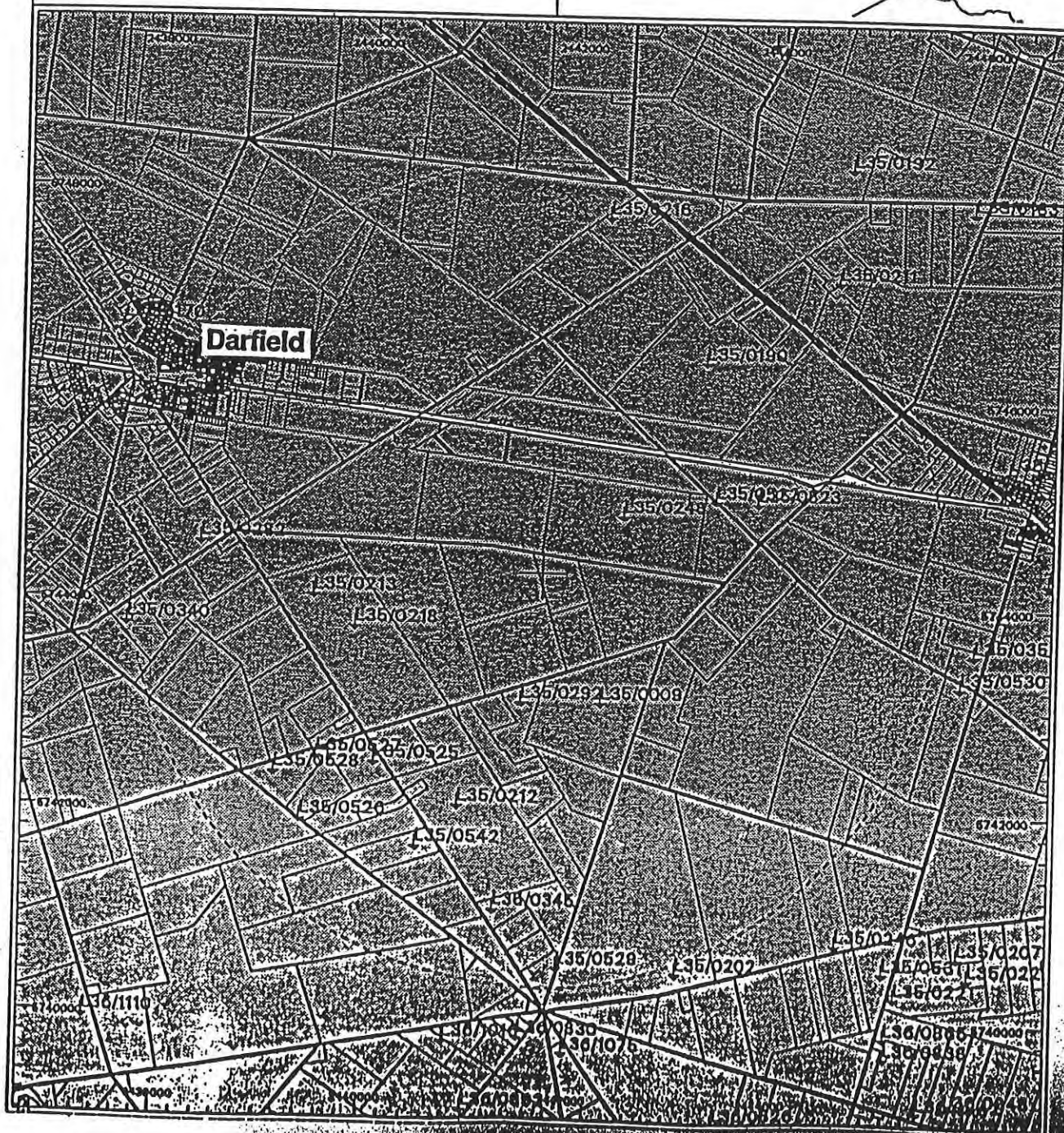
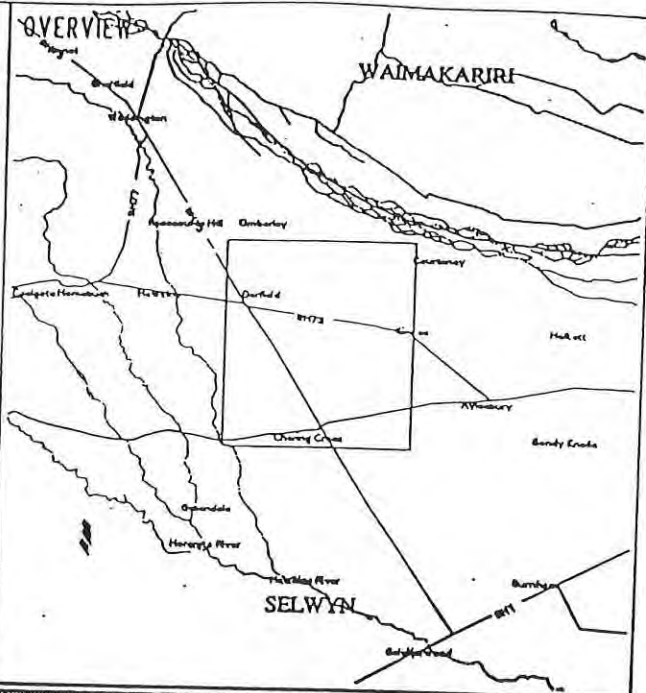
Prepared by the
CANTERBURY REGIONAL COUNCIL
June 1996

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Most well locations accurate up to +/- 100m. The Canterbury Regional Council does not hold out that the information contained in this document to be a comprehensive and accurate record of all wells.



Flourens: Wells, 1911

Groundwater Quality

The following information on groundwater quality has been obtained from a report on "Preliminary Groundwater Study" for Darfield Water Supply prepared for SDC by Royds Consulting. This report said that there is little information on groundwater quality in the immediate area of Darfield. The following description was therefore derived largely from trends prevalent in the wider area.

In the Canterbury Plains as a whole, the quality of unconfined groundwater in 'recharge zones' generally becomes better with depth. This is predominantly due to the susceptibility of shallow groundwater to be affected by surface water contamination. Groundwater quality monitoring carried out by the CRC within a 10-25 km radius of Darfield broadly confirms this trend.

In the case of Darfield, the presence of a considerable thickness of unsaturated deposits above the water table will act to filter any contaminants derived from surface water infiltration. Although CRC monitoring suggests that even deep groundwater shows a slight effect from surface contamination, the effects on deep groundwater are not on the whole significant.

Therefore, although the aquifer beneath Darfield is not 'protected' by confining aquicludes (extensive low permeability layers), the water quality is likely to be relatively good. While protection of the groundwater quality is an issue that must be considered, the depth to groundwater in this area is an advantage.

3.7 Air Quality

There are two aspects of air quality that need to be considered. These are odours and aerosols. Odours are compounds which are detected by the human sense of smell and if sufficiently concentrated will result in annoyance to those exposed to them. Odours can be emitted as the wastewater comes into contact with the air.

Frequency and duration of odours are normally determined by climatic conditions. Therefore from a study of the prevailing climatic conditions, the relative frequency with which surrounding neighbours might be exposed to odours can be assessed. The intensity of an odour can be controlled by minimising the rate at which the odours are produced or released, by reducing the concentration of the odorous air at source, or by maintaining adequate clearance from surrounding neighbours. The offensiveness of odours can be attributed to the processes by which they are created. Odours as a result of anaerobic activity are often the source of odour nuisance complaints. For this reason it is essential to maintain the wastewater in an aerobic state in order to minimise the potential for creating odour problems. The treatment of the wastewater to a high degree to reduce the organic content prior to disposal will also reduce the potential for odour problems.

When wastewater is applied to land there will be odours released. The factors which are important in this matter are the frequency with which the wastewater is applied to any block of land, prevailing winds, the distance to neighbours, the condition of the wastewater and the method of application. It is essential to avoid surface ponding of the wastewater on the land.

Aerosols are very small particles of water and solid material. The potential risk from aerosols comes from the ingestion of the aerosols which may contain organisms which are harmful to health. Aerosols are carried in a similar manner to odours and will disperse as they move away from the site. The potential for migration of such particles can be assessed by considering wind speed and direction, the frequency with which the wastewater is applied to any block of land, the distance to neighbours, and the method of application.

Ideally a site should be chosen that is relatively distant from the neighbouring residences. The planting of shelter belts around the boundaries would aid in the filtering and dispersion of the odours and aerosols before they leave the site. If a site is to be chosen close to neighbouring residences then there is a case to be made for a higher level of treatment of the wastewater to reduce organisms.

3.8 Site Considerations

It is preferable to site the land treatment and disposal area in a location of low settlement density. The area that potentially could be used for land treatment and disposal of wastewater is the area southeast of Darfield Township that is zoned as rural B as shown on Figure 5. Figure 5 also shows the title boundaries and areas of the land southeast of Darfield. A table detailing the owners/occupiers of each of these parcels of land is included in Appendix IV.

The adjoining land uses and the proximity to existing dwellings need to be considered when selecting a site.

The land treatment and disposal site will require a buffer zone of 20 m around all boundaries. It is desirable that this buffer zone be planted with at least three rows of evergreen trees to screen the area and to also reduce the potential for odour and aerosol problems. If a site has an existing water race running through it then a buffer zone of 20 m would be required between the water race and areas of land receiving wastewater. Alternatively a water race could be realigned around the property boundary.

In addition the sewage treatment facility would most likely be located on the land treatment and disposal site.

3.9 Land Management of the Land Treatment and Disposal Area

The use of land for wastewater treatment and disposal must incorporate the concept of sustainability as encompassed by the Resource Management Act.

In land treatment and disposal systems the land management practices employed need to ensure an environmentally sustainable system. For the system to be acceptable it needs to ensure that the environmental impact is minimised and the system is simple and robust. Maximising returns from the land should not compromise the above criteria.

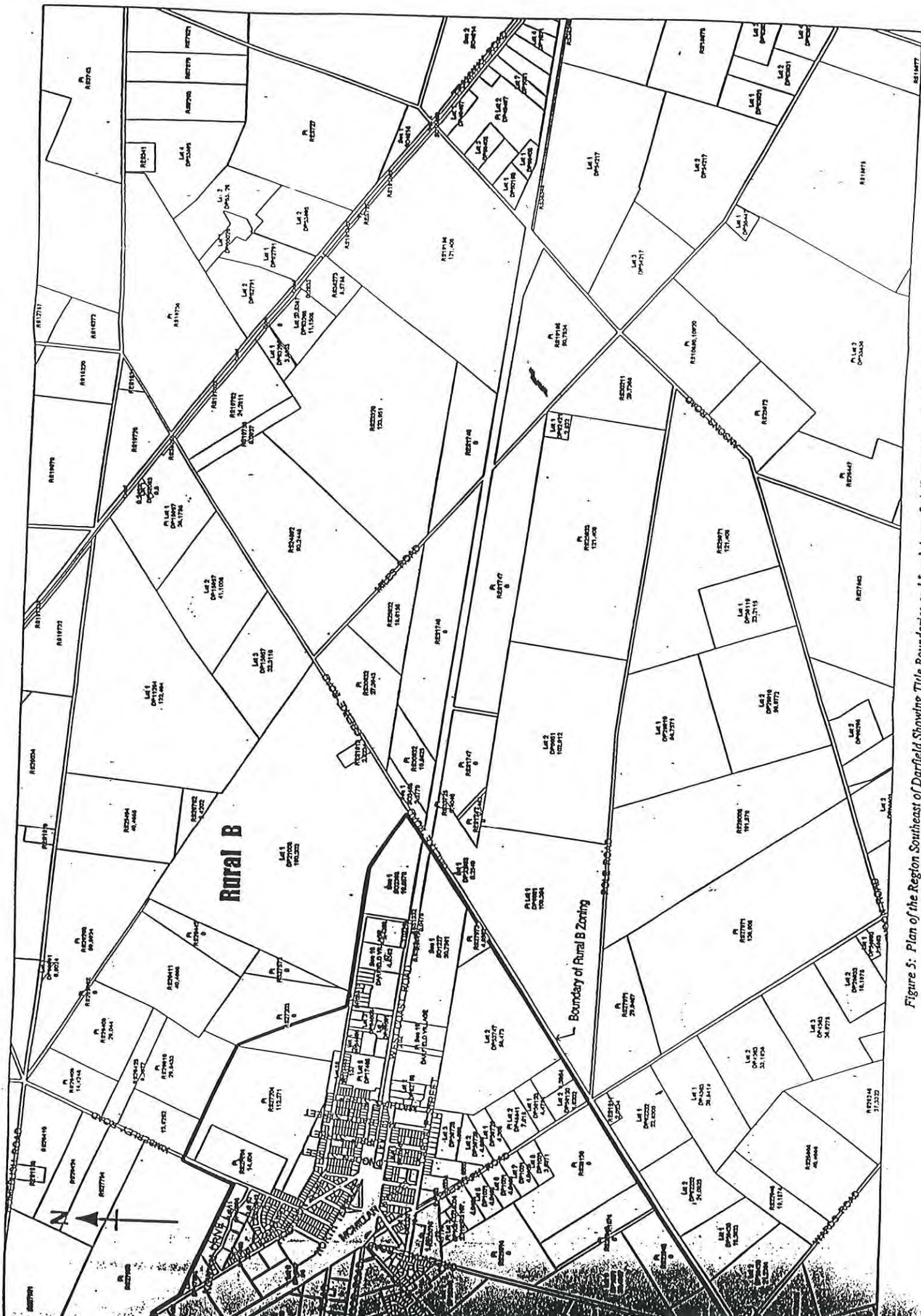


Figure 5: Plan of the Region Southeast of Darfield Showing Title Boundaries and Land Areas (ha) (Source: Selwyn District Council)

The inputs of nitrogen, phosphorus and other nutrients contained in the wastewater will improve the fertility of the soil. The added moisture and nutrients will enhance plant growth which will aid in keeping the soil friable and free draining. The organic matter in the wastewater will also benefit the soil. The objective of the system is to minimise the amount of wastewater that leaches through the soil profile and also to ensure that any leachate water contains minimal amounts of nutrients.

It would be preferable for the land treatment and disposal area to be owned by SDC and possibly leased to neighbouring land owners for farming. By owning the land SDC maintain control over how the site is managed. However leasing land could be considered.

The preferred land management practice for nutrient uptake is pasture for grazing by sheep and cutting for hay or silage with cropping only occurring when there is a need for pasture renewal. Alternatively it would be possible to irrigate the wastewater onto the nearby Selwyn Plantation Board pinus radiata plantations. However trees are not as efficient in absorbing nutrients as pasture.

Since the soils will be moist for most of the year, particular care will need to be taken to avoid soil compaction by vehicles and stock. This could reduce the infiltration rate of the soil leading to undesirable ponding on the soil surface which could create a potential odour source and also restrict the development of plant roots.

As with all land treatment and disposal systems a monitoring programme will be required to regularly monitor the effects of this activity on the environment.

3.10 Cultural Values of the Tangata Whenua

The preferred method of the Tangata Whenua for wastewater treatment and disposal is by application to the land. In this way waste products are returned to the land. The Taumutu Runanga should be consulted at the time when specific sites are being considered to ensure that cultural concerns are addressed.

4 OPTIONS

4.1 Methods of Wastewater Treatment and Disposal

Options considered for the land treatment and disposal of the wastewater are:

- Spray irrigation.
- Border dyke irrigation.
- Overland flow into rapid infiltration basins.

These options are discussed briefly below together with their advantages and disadvantages.

Spray Irrigation

This option would involve pumping the wastewater from storage, for example an oxidation pond, to a travelling irrigator via an underground pipeline system and hydrants. Low pressure self propelled irrigators with a low trajectory discharge, designed to minimise potential adverse effects of aerosols and odours, could be used. Alternatively the wastewater could be applied to the land using a solid set irrigation system which consists of a pipe network connected to fixed sprinklers installed in a grid pattern over the area to be irrigated. Irrigation with a solid set irrigation system can be easily automated.

Advantages:

- It is possible to control the depth of application. This is particularly important in the winter so that the potential for leaching to groundwater can be minimised.
- Utilises the nutrient value in the wastewater to improve the soil and to enhance plant growth.
- Lower potential for leaching of wastewater to groundwater because the depth of application can be controlled.
- No land forming is required and hence topsoil is not disturbed during construction.

Disadvantages:

- Power extension is required and there are ongoing pumping costs.
- Higher running costs than border dyke irrigation.
- Potential for creation of spray drift and aerosols.

Border Dyke Irrigation

In this option the wastewater would be discharged by gravity from a storage, for example an oxidation pond, into a constructed headrace system for distribution down formed border strips. The watering of the borders could be automated.

Advantages:

- A gravity system with no pumping required.
- Utilises the nutrient value in the wastewater to improve the soil and to enhance plant growth.
- Negligible potential for the creation aerosols.
- Lower running costs than spray irrigation.

Disadvantages:

- Can not control the depth of application so that it is not possible to apply smaller application depths as may be required during the winter to minimise the potential for leaching to the groundwater.
- Greater potential for leaching of wastewater to the groundwater than with spray irrigation.
- Ponding of wastewater in headraces after use has the potential to generate odour.

Overland Flow into Rapid Infiltration Basins

In overland flow systems the wastewater is distributed across the upper portions of carefully graded slopes planted in pasture species and allowed to flow over the slope surfaces to runoff collection drains at the bottom of the slopes. The collected wastewater would then discharge into large open infiltration basins where it can infiltrate the porous ground and enter the groundwater system.

Advantages:

- Requires less land area than for irrigation options.
- Negligible potential for the creation aerosols.
- Lower running costs than spray irrigation

Disadvantages:

- Requires a higher level of treatment of the wastewater to protect the groundwater quality, eg ultra-violet light disinfection.
- The potential impacts on the groundwater are greater than for irrigation options because the soil profile is not used as a treatment medium.
- The nutrient value in the wastewater is not utilised.

This method of wastewater treatment and disposal is not favoured due to its potential to effect groundwater quality.

4.2 Land Area Requirements

The area required for irrigation of the wastewater is dependant upon the hydraulic and nitrogen loadings, the soil type and to a lesser extent on the shape and location of the site.

Based on a design population of 2,500 the daily volume of wastewater would be $675 \text{ m}^3/\text{d}$ and the estimated nitrogen load would be 25 kg/day (refer to Table 1) or $9,125 \text{ kg N/year}$. Not all of this nitrogen will be applied to the land treatment site; some of the nitrogen will be removed in the treatment process. For preliminary purposes, assume that 30% of the nitrogen will be removed through the secondary treatment system that is installed. Therefore, $6,388 \text{ kg N/year}$ will need to be discharged onto the land.

There is no simple criteria that can be used to determine what nitrogen loading rate is acceptable. The CRC, in their Regional Rule for the application of animal effluent onto land, use an areal loading rate for nitrogen of 200 kg/ha/year . It must be remembered that this applies to animal wastes which are very different to treated sewage. However on this basis an area of approximately 32 ha would be required. Allowing for reducing the above nitrogen loading by 10% would give a net required area of 36 ha . If the pasture was cut for hay or silage for removal off site, in addition to being grazed, then the areal loading rate for nitrogen could be increased, reducing the required net area.

Based on an estimated phosphorus load of 7.5 kg/day (refer to Table 1) the annual amount of phosphorus produced is 2728 kg/year. For preliminary purposes, assume that no phosphorus will be removed through the secondary treatment system that is installed. Therefore the phosphorus loading on a net area of 36 ha is 76 kg/ha/year. The assimilative capacity for phosphorus is based on crop uptake and the soil capacity to retain or fix phosphates. The phosphorus removal rate for grazed grass pasture is 30 kg/ha/year and 40 kg/ha/year for grass pasture for hay (*"Agriculture! Waste Manual"*, NZAEI, Project Report No 32). The balance of phosphorus not removed by crop uptake could readily be absorbed by the soil without causing any detrimental environmental effects. Phosphorus is an immobile element. The transport mechanisms associated with losses from agricultural systems are largely through soil erosion.

The depth of application of wastewater will be critical during the winter months when the wastewater will be applied during periods of rainfall. At this time the soils are wetter and evapotranspiration rates are low. The ability of the soils on the site to cope with additional water through the wet winters will need to be assessed.

If there was a net area of 36 ha available, this would require an average depth of application of 1.9 mm/day or 25 mm with a return period of 13 days. These application rates would be acceptable on the Chertsey and Lismore soils identified in Section 3.4.

In addition to this minimum net area of 36 ha, are the areas required as buffers zones around the property boundaries, separation distances to any water races on the property, an area for the sewage treatment facility, an allowance for any buildings etc. on the site, and an allowance for the shape of the site which may prevent the total area from being economically available for irrigation. The additional area required would be approximately 9 ha. Therefore the required area of land will be in the order of 45 ha.

The area required for the option of overland flow into rapid infiltration basins would be approximately 12 ha.

5 CONCLUSIONS

- When selecting a site for land treatment and disposal of sewage from Darfield consideration should be given to the environmental effects, in particular the effects on groundwater and air quality. The preferred site should also be economically, socially and culturally acceptable to the community.
- The land southeast of Darfield that is in the rural B zone and has Chertsey shallow silt loam or Lismore stony silt loam soils would be suitable for all year round application of wastewater.
- Application of wastewater by either spray or border dyke irrigation would be preferable due to lower potential impacts on groundwater quality.
- The gross area of land required for land treatment and disposal by either spray or border dyke irrigation of the wastewater onto grazed pasture would be about 45 ha. If the pasture was cut for hay or silage for removal off site, this area could be reduced.
- In depth consideration of the aforementioned issues would be required before deciding on a preferred land treatment and disposal site for Darfield.

APPENDIX I

Unsewered Township Report for Darfield

(Source: "Preliminary Assessment of the Effects of Discharges from Unsewered Townships in Canterbury",

Canterbury Unsewered Township Report

DARFIELD

1. General Description:

- (a) Location: State Highway 73. A location map of the township is attached.
- (b) Grid Reference: L35:382-461.
- (c) Territorial Authority: Selwyn District Council.
- (d) Population (estimated): 1,149 (1991 NZ Statistics).
- (e) Number of Dwellings (estimated): 300.
- (f) Geology: Glacial outwash gravels.

2. Source of Contamination from Household Sewage:

- (a) Number of dwellings with individual effluent disposal systems = 300.
- (b) Treatment systems - septic tanks - all (assumed).
- (c) Disposal systems - boulder holes - all (assumed).
- (d) Anticipated contaminant loading per disposal system
 - Volume = $1 \text{ m}^3/\text{d}$.
 - Average faecal coliform concentration = $5 \times 10^9/\text{m}^3$.
- (e) Area over which discharge occurs = approximately 125 hectares.
- (f) Effluent loading for entire township = $2.4 \text{ m}^3/\text{ha}/\text{day}$.

3. Effluent Migration:

- (a) Soakage characteristics: Good.
- (b) Depth to water: 70 m (estimated).
- (c) Direction of groundwater flow: South-east.
- (d) Potential groundwater velocity: 5-300 m/d.

4. Effluent Destination and Potential Problems:

- (a) Emergence above ground surface: Unlikely.
- (b) Surface water bodies: The topographic map for this area shows stockwater race on southern boundary of township. It is unlikely that household effluent would contribute to this.
- (c) Groundwater: Household effluent enters groundwater. A search of CRC well records is attached to this report. It shows the nearest downgradient well is located 1,300 m from the township (use and depth unknown). There is one well within the township, 104 m deep labelled as exploratory.

(d) **Township drinking water:** Supply is from an infiltration gallery in the Waimakariri River, 6 km to the north-east. Consequently, this supply is not at risk from household effluent disposal at Darfield.

(e) **Failure of treatment or disposal systems:** No failures reported.

(f) **Township development:** Household effluent disposal is not likely to be a limiting factor for future housing development.

5. **Other Potential Sources of Contamination:**

- **Rural setting:** Darfield is sited in a rural area surrounded by farmland, which could contribute bacterial and nitrate contamination to the unconfined aquifer beneath the township.
- **Flooding:** The risk of flooding is unlikely to affect household effluent discharge.
- **Discharge Permits:** A search of the CRC's consents database is attached to this report. It shows a number of non-agricultural discharges - probably for a subdivision.

6. **Conclusions:**

Household effluent disposal at Darfield has been causing no known problems to date.

7. **Suggested Further Investigations:**

No potential environmental problems have been identified.

8. **Sources of Information:**

This report has been prepared from an interpretation of data gathered from the following sources:

Department of Survey and Land Information Map 260-L35.
NZ Geological Survey Map.
Information from the Selwyn District Council.
Information from the Canterbury Regional Council.

This report is the result of a preliminary desk top assessment. More detailed, site specific assessment should be undertaken to confirm or modify the findings of this report. Within the limitations of a desk top assessment, the reliability of this information is considered to be speculative.

APPENDIX II

Summary of Darfield Climatic Data

(Source: "Summaries of Climatological Observations to 1980",
NZ Meteorological Service Miscellaneous Publication 117)

H32412 DARFIELD

GRID REFS. NZMS 1, 1:63360 S076604816
NZMS 260, 1:60000 L36402468

LAT. 43 28S LONG. 172 08E HT. 186 M.

PERIOD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL, MILLIMETRES													
HIGHEST MONTHLY/ANNUAL TOTAL													
90 PERCENTILE VALUE	1919-1980	187	242	196	256	336	203	246	243	178	178	188	1207
MEAN	1919-1980	127	109	138	137	150	115	106	137	130	121	117	1009
10 PERCENTILE VALUE	1919-1980	71	61	62	67	78	62	65	68	62	69	64	72
LOWEST MONTHLY/ANNUAL TOTAL	1919-1980	25	16	19	20	26	18	19	17	23	19	24	801
	1919-1980	17	1	6	6	18	11	12	8	10	5	4	596
AVERAGE RAIN DAYS, 1.0MM OR MORE	1939-1980	8	7	7	7	9	8	9	8	8	8	8	96
MAXIMUM 1-DAY RAINFALL	1939-1980	91	84	117	83	88	62	51	114	76	57	46	77
MAXIMUM 2-DAY RAINFALL	1939-1980	106	169	125	131	111	107	91	176	101	70	65	117
TEMPERATURE OF THE AIR, DEGREES CELSIUS													
HIGHEST RECORDED	1939-1980	36.3	39.4	33.6	28.6	23.9	21.7	19.9	22.4	26.4	30.0	31.9	34.3
AVERAGE MONTHLY/ANNUAL MAXIMUM	1939-1980	31.8	32.3	29.1	26.2	20.3	16.6	16.4	18.4	21.8	25.3	27.6	30.2
AVERAGE DAILY MAXIMUM	1939-1980	23.0	23.0	20.6	17.3	13.3	10.3	9.8	11.8	14.9	17.4	19.7	21.6
MEAN	1939-1980	16.5	16.5	14.7	11.7	8.2	5.6	5.1	6.6	9.1	11.3	13.3	15.2
AVERAGE DAILY RANGE	1939-1980	13.0	13.0	11.9	11.3	10.2	9.5	8.5	10.5	11.6	12.2	12.8	11.5
AVERAGE DAILY MINIMUM	1939-1980	10.0	10.0	8.7	6.0	3.1	0.8	0.3	1.3	3.3	5.2	6.9	8.9
AVERAGE MONTHLY/ANNUAL MINIMUM	1939-1980	4.1	3.7	2.1	-0.1	-2.3	-3.6	-4.1	-3.4	-1.9	-0.7	0.6	2.9
LOWEST RECORDED	1939-1980	0.6	-0.4	-0.4	-2.6	-6.3	-7.4	-8.0	-6.1	-4.8	-3.5	-2.6	0.1
TEMPERATURE OF THE GROUND, DEGREES CELSIUS													
LOWEST GRASS MINIMUM RECORDED	1944-1980	-0.9	-1.6	-3.7	-5.8	-8.2	-9.7	-14.1	-10.7	-8.6	-8.0	-6.7	-2.6
AVERAGE GRASS MINIMUM	1944-1980	8.1	8.2	6.5	3.3	0.3	-2.3	-2.7	-1.9	0.2	2.5	4.4	6.7
FROST													
AVERAGE DAYS OF GROUND FROST	1944-1980		0.1	0.8	5.0	13.6	20.8	22.3	18.8	13.2	6.7	2.9	0.3
AVERAGE DAYS OF AIR FROST	1939-1980				1.0	5.3	12.7	14.9	11.4	4.5	1.5	0.4	104.5
RELATIVE HUMIDITY, (%)													
AVERAGE AT 9 A.M.	1939-1980	68	72	78	82	84	84	82	77	70	67	68	76
VAPOUR PRESSURE, MILLIBARS													
AVERAGE AT 9 A.M.	1971-1980	12.8	13.0	12.3	10.8	8.5	7.1	7.0	7.2	8.4	9.5	10.7	11.9
EVAPORATION, MILLIMETRES													
RAISED PAN AVERAGE	1951-1980	135	107	73	44	23	16	18	30	51	84	108	814
SPECIAL PHENOMENA, AVERAGE DAYS OF													
SNOW	1939-1980												
HAUL	1939-1980	0.2	0.1	0.1	0.1	0.4	0.8	1.3	0.8	0.5	0.4	0.1	4.3
THUNDER	1955-1980	0.5	0.2	0.2	0.1	0.1	0.2	0.1	0.2	0.3	0.2	0.1	1.7
GALE	1939-1980	0.3	0.3	0.4	0.5	0.4	0.3	0.2	0.4	0.5	0.6	0.4	2.2
FOG	1939-1980	0.5	1.2	1.7	2.3	1.2	1.4	1.0	1.6	1.6	1.1	0.5	14.6

APPENDIX III:

Well Information

(Source: CRC)

PAGE 1

Top	Bottom
Screen	Screen
2	2

Well	Read	Bacto Chem
Log	ings	
Data		

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Y
Y

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Y

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2

IN

0444 L35:453-403

IR

0243 L35:439-495

IR DO

0246 L35:447-408

IR

0248 L35:425-449

IR DO

0282 L35:384-446

0292 L35:415-431

0310 L35:3768-4380

IR

0345 L35:4126-4110

IR DO

0355 L35:460-436

IR

110.400 230

PARKER, J.R.S.

123.500 300

NZ AGRISEEDS LTD

108.000 300

STOTT D.W. & I.M.

120.000 300

CATTELL MR & PR

22.7

4.100

5.54

00679

108.000 110.400

32.6

13.700

2.38

00836

115.700 124.200

34.1

8.500

4.01

00700

105.000 108.000

37.1

6.100

6.08

00000

117.000 120.000

00000

YOUNGMAN J.A.

74.000 150

ADAMS AL & JA

100.000 250

ARNOLD DA & JM

120.000 250

PAGE H.D

108.000 110.400

115.700 124.200

105.000 108.000

117.000 120.000

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1001

Requested by user JOHNTW on 27-JUN-1996 at 14:25:59

2

Depth	Diameter	Yield	Drawdown	Specific Capacity	Bore Consent	Top		Bottom	
						Screen	1	Screen	2
					No	1	2	Screen	2

Well Read Bacto Chem
Log ings
Data

[illegible]

2 136:4099-3910	80.000	200							
DO IR	AUSTIN, S.L. & H.H.								
6 136:408-398	100.000	200							
DO FU IR	TRICAT COMMERCIAL LTD								
5 136:4197-3970	70.000	150							
FU DO	TURNER, B.H. & M.L.								
0 136:373-400	88.200	300	55.8	7.500	7.44				
DO IR	MARSHALL G.J. FAMILY TRUST					82.200	88.200		
						Y		N	N

CRC941166

CRC950635

///

APPENDIX IV

Land Ownership Information

(Source: SDC)

[illegible]

APPENDIX II

Summary of Darfield Climatic Data

*(Source: "Summaries of Climatological Observations to 1980",
NZ Meteorological Service Miscellaneous Publication 117)*

H32412 DARFIELD

GRID REFS. NZMS 1, 1:83360 S076504616
NZMS 260, 1:50000 L36402469

LAT. 43 29S LONG. 172 08E HT. 196 M.

PERIOD	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL, MILLIMETRES													
HIGHEST MONTHLY/ANNUAL TOTAL	1919-1980	187	242	196	256	336	203	246	243	178	178	178	1207
90 PERCENTILE VALUE	1919-1980	127	109	138	137	160	116	106	137	130	121	117	1009
MEAN	1919-1980	71	61	62	67	78	62	66	68	62	69	64	72
10 PERCENTILE VALUE	1919-1980	25	16	19	20	26	18	19	17	23	19	24	801
LOWEST MONTHLY/ANNUAL TOTAL	1919-1980	17	1	5	6	18	11	12	8	10	5	5	499
AVERAGE RAIN DAYS, 1.0MM OR MORE	1939-1980	8	7	7	9	8	9	8	8	8	8	8	96
MAXIMUM 1-DAY RAINFALL	1939-1980	91	84	117	83	88	62	51	114	76	57	46	77
MAXIMUM 2-DAY RAINFALL	1939-1980	106	159	125	131	111	107	91	176	101	70	65	126
TEMPERATURE OF THE AIR, DEGREES CELSIUS													
HIGHEST RECORDED	1939-1980	36.3	39.4	33.6	28.6	23.9	21.7	19.9	22.4	26.4	30.0	31.9	34.3
AVERAGE MONTHLY/ANNUAL MAXIMUM	1939-1980	31.8	32.3	29.1	26.2	20.3	16.6	16.4	18.4	21.8	25.3	27.6	30.2
AVERAGE DAILY MAXIMUM	1939-1980	23.0	23.0	20.6	17.3	13.3	10.3	9.8	11.8	14.9	17.4	19.7	21.6
MEAN	1939-1980	16.5	16.5	14.7	11.7	8.2	5.6	5.1	6.6	9.1	11.3	13.3	15.2
AVERAGE DAILY RANGE	1939-1980	13.0	13.0	11.9	11.3	10.2	9.5	9.5	10.5	11.8	12.2	12.8	12.7
AVERAGE DAILY MINIMUM	1939-1980	10.0	10.0	8.7	6.0	3.1	0.8	0.3	1.3	3.3	5.2	6.9	8.9
AVERAGE MONTHLY/ANNUAL MINIMUM	1939-1980	4.1	3.7	2.1	-0.1	-2.3	-3.6	-4.1	-3.4	-1.9	-0.7	0.6	2.9
LOWEST RECORDED	1939-1980	0.6	-0.4	-0.4	-2.6	-6.3	-7.4	-9.0	-6.1	-4.8	-3.5	-2.6	-9.0
TEMPERATURE OF THE GROUND, DEGREES CELSIUS													
LOWEST GRASS MINIMUM RECORDED	1944-1980	-0.9	-1.6	-3.7	-6.8	-8.2	-9.7	-14.1	-10.7	-8.6	-8.0	-6.7	-2.6
AVERAGE GRASS MINIMUM	1944-1980	8.1	8.2	6.5	3.3	0.3	-2.3	-2.7	-1.9	0.2	2.5	4.4	6.7
FROST													
AVERAGE DAYS OF GROUND FROST	1944-1980	.	0.1	0.8	5.0	13.6	20.8	22.3	18.8	13.2	6.7	2.9	0.3
AVERAGE DAYS OF AIR FROST	1939-1980	.	.	.	1.0	5.3	12.7	14.9	11.4	4.5	1.5	0.4	0.3
RELATIVE HUMIDITY, (%)													
AVERAGE AT 9 A.M.	1939-1980	68	72	78	82	84	84	82	77	70	67	68	76
VAPOUR PRESSURE, MILLIBARS													
AVERAGE AT 9 A.M.	1971-1980	12.8	13.0	12.3	10.8	8.5	7.1	7.0	7.2	8.4	9.5	10.7	11.9
EVAPORATION, MILLIMETRES													
RAISED PAN AVERAGE	1951-1980	135	107	73	44	23	16	18	30	51	84	108	814
SPECIAL PHENOMENA, AVERAGE DAYS OF													
SNOW	1939-1980	.	.	.	.	0.4	0.8	1.3	0.8	0.5	0.4	0.1	.
HAIL	1939-1980	0.2	0.1	0.1	0.1	0.1	.	0.2	0.1	0.2	0.3	0.2	4.3
THUNDER	1955-1980	0.5	0.2	0.2	.	0.1	.	.	.	0.2	0.4	0.3	1.7
GALE	1939-1980	0.3	0.3	0.4	0.5	0.4	0.3	0.2	0.4	0.5	0.6	0.4	2.2
FOG	1939-1980	0.5	1.2	1.7	2.3	1.2	1.4	1.0	1.6	1.6	1.1	0.5	4.6

APPENDIX III

Well Information

(Source: CRC)

WELLS REPORT
Requested by user JOHNW on 27-JUN-1996 at 14:25:59

PAGE 1

Well No	Grid Reference	Depth	Diameter	Yield	Drawdown	Specific Capacity	Bore Consent	No	Top Screen	Bottom Screen	Top Screen	Bottom Screen
L35/0009	L35:423-431 NO	125.000 CATHERWOOD	300					00000				
L35/0162	L35:465-448	79.200						00000				
L35/0163	L35:459-479 OB	83.800	30					00000				
L35/0170	L35:376-467 EX	103.600	150					00000				
L35/0190	L35:433-464 IR	120.100	305	60.6	10.000	6.06	00020					
L35/0191	L35:463-454 PU	115.200	300	34.1	6.000	5.68	00021					
L35/0192	L35:447-483 IR	121.000	305	27.3	6.000	4.55	00023					
L35/0202	L35:431-405 DO	78.600	102	0.8			00000					
L35/0207	L35:459-407 NO	CATHERWOOD, L.A. 131.400	300	15.2	61.000	.25	00385					
L35/0210	L35:467-443 IR	PASCOE, J.G.E. 120.100	300	26.5	3.700	7.16	00277					
L35/0211	L35:446-472 IR	REDMOND, D.K.& L.A. 142.300	300	22.7	3.300	6.88	00211					
L35/0212	L35:409-421 IR	GALLAGHER, T.D. 117.400	300	21.0	6.000	3.50	92120					
L35/0213	L35:395-441 IR	KIPSTRA 122.800	300	15.2	0.900	16.89	00297					
L35/0216	L35:423-478	ANDERSON, J.W. 129.500	300	11.4	5.800	1.97	00375					
L35/0218	L35:399-438	SAMPSON, S.H.& K.A. 22.900	200				00000					
L35/0220	L35:460-405 EX	ANDERSON, J.W. 95.000	230	3.8	20.000	.19	00505					

5/0221 L35:453-403	110.400	230	22.7	4.100	5.54	00679	108.000	110.400	N	Y	N	N
IR	PARKER, J.R.S.											
5/0243 L35:439-495	123.500	300	32.6	13.700	2.38	00836	115.700	124.200	N	S	N	N
IR DO	NZ AGRISEEDS LTD											
5/0246 L35:447-408	108.000	300	34.1	8.500	4.01	00700	105.000	108.000	Y	N	N	N
IR	STOTT D.W. & I.M.											
5/0248 L35:425-449	120.000	300	37.1	6.100	6.08	00000	117.000	120.000	Y	Y	N	N
IR DO	CATELL MR & PR											
5/0282 L35:384-446						00000			N			
5/0292 L35:415-431						00568			N			
5/0340 L35:3768-4380	74.000	150				1891			N			
IR	ADAMS AL & JA								Y	S	N	N
5/0345 L35:4126-4110	100.000	250				1999			N	N	N	N
IR DO	ARNOLD DA & JM								N			
5/0355 L35:460-436	120.000	250				92067			N			
IR	PAGE H.D								N		N	N

PAGE 2

Requested by user JOHNW on 27-JUN-1996 at 14:25:59

Well No	Grid Reference	Depth	Diameter	Yield	Drawdown	Specific Capacity	Bore Consent No	Top Screen	Bottom Screen	Top Screen	Bottom Screen	Well Read Log Data
								1	1	2	2	
35/0522	L35:4342-4506 IR DO PU MAYBERRY, A.J.	118.000	150	11.4	10.500	1.09	CRC951145	111.000	118.000			Y
35/0523	L35:4384-4504 IR DO PU MAYBERRY, A.J.	118.200	150	11.4	9.500	1.20	CRC951148	115.200	118.200			Y
35/0525	L35:4010-4250 DO IR PU DAWSON, G.R. & N.P.	100.000	150	10.0	12.000	.83		96.000	100.000			Y
35/0526	L35:3940-4195 DO IR PU ANDERSON, C.J.	94.000	150	10.8	12.000	.90		87.500	94.000			N
35/0527	L35:3955-4255 DO IR PU GLIDDEN, J.M.	120.000	300									Y
35/0528	L35:3915-4240 DO IR PU FEAST, D.G. & BELL, G.P.	109.000	150	10.4	10.400	1.00		106.000	109.000			N
35/0529	L35:4190-4055 DO PU IR HEALEY, J.F. & S.L.	120.000	300									Y
35/0530	L35:4588-4329 IR TRUSCOTT, K.J.	120.000	300									N
35/0531	L35:4518-4054 DO ADAMS, R.D.	100.000	150									N
35/0542	L35:4050-4170 DO SEATON, A. & MAY, C.W.	100.000	150	2.3	12.000	.19		98.000	100.000			N
36/0526	L36:435-390 EX PASCOE P	123.200	300	1.5	24.400	.06	00525	106.700	115.900			Y
36/0830	L36:4152-3985 PU REDFERN B.R. & C.E.	82.000	200	3.8	1.000	3.80	21435	79.000	82.000			Y
36/0838	L36:4521-3970 IR DO CAMPBELL DR & AK	105.000	150	9.2	10.500	.87	CRC921912	99.000	105.000			Y
36/0842	L36:4554-3915 IR DO SEATON J.H.	107.700	150	10.6	6.500	1.63	22110	100.700	102.700	106.700	107.700	Y N
36/0848	L36:4580-3920 IR GRIMWOOD, K.B.	74.000	150				CRC930363					Y S
36/0865	L36:4521-3990 CORRAN, P.A.	87.000	150	1.9	1.200	1.58		75.000	77.000	85.000	87.000	Y N

0892	L36:4099-3910		80.000	200	CRC941166		N	N
	DO IR	AUSTIN, S.L.& H.H.						
1016	L36:408-398		100.000	200	CRC950635		N	N
	DO PU IR	TRICAT COMMERCIAL LTD						
1075	L36:4197-3970		70.000	150			N	N
	PU DO	TURNER, B.H.& M.L.						
1110	L36:373-400		88.200	300		82.200	N	N
	DO IR	MARSHALL G.J. FAMILY TRUST					Y	N

APPENDIX IV

Land Ownership Information

(Source: SDC)

[illegible]

