QUEENSTOWN LAKES DISTRICT COUNCIL

Cardrona Valley

Assessment of Infrastructure Requirements

April 2007
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QUEENSTOWN LAKES DISTRICT COUNCIL

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TABLE OF CONTENTS

Page

1. INTRODUCTION

1.1 Report Brief

This report has been commissioned by Queenstown Lakes District Council (QLDC) to provide an overview of the infrastructure servicing requirements for the Cardrona Valley, in the immediate vicinity of the historic Cardrona Township.

QLDC has identified the requirement to assess the long term infrastructure servicing for the Mt Cardrona area with some indication that rezoning of land in the area will also take place in the short term.

Several developers are in the process of preparing/submitting applications for subdivision consent within the Cardrona township. In addition to this the Council is currently engaged in considering a Plan Change to relocate an area of Rural Visitor zoned land north of the township in an area known as Mt Cardrona Station. It is estimated that these zones have a combined capacity of approximately 1,500 equivalent domestic units.

There are also currently two QLDC plan change reviews under way, although at the early stages of investigation. Public notification and consultation has yet to be carried out.

The scope and structure of this report is as follows:

Brief

- To assess the existing infrastructure capacities of the township;
- To determine the potential level of development between now and 2020;
- To determine the likely infrastructure requirements to allow development to take place;
- To provide an overview of systems that could be installed to provide the necessary levels of service;
- To outline staging requirements for the construction of upgraded services; and
- To present budget costs for the service upgrades required.

This information is presented as a single strategic planning document for the engineering infrastructure for the area.

The infrastructure services covered by the report are:
- Roading and traffic management;
- Stormwater and snow melt runoff management;
- Water supply, treatment and reticulation;
- Wastewater collection, treatment and disposal; and
- Power / Telecommunication requirements.

2. DESCRIPTION OF THE SITE

The Cardrona Valley extends from The Crown Range to Wanaka, surrounded on eastern and western flanks by steep rugged terrain. The Cardrona River runs through the base of the valley receiving stormwater runoff from the surrounding valley walls.

There are two separate developed/potentially developable areas in the Cardrona Valley, the existing Cardrona township and an area of Rural Visitor zoned land north of the township in an area known as Mt Cardrona Station.

The existing population occupies the generally level historical floodplain of the Cardrona River. There has been a significant population growth in the last 5 years with a number of separate subdivisions being constructed or still in the planning stages.

2.1.1 Historical Land Use

Extensive gold mining took place in Cardrona dating back to the 1800's that saw the formation of the town, through to the late 1980's. Low yields and stricter environmental laws have seen mining activities cease throughout the surrounding areas.

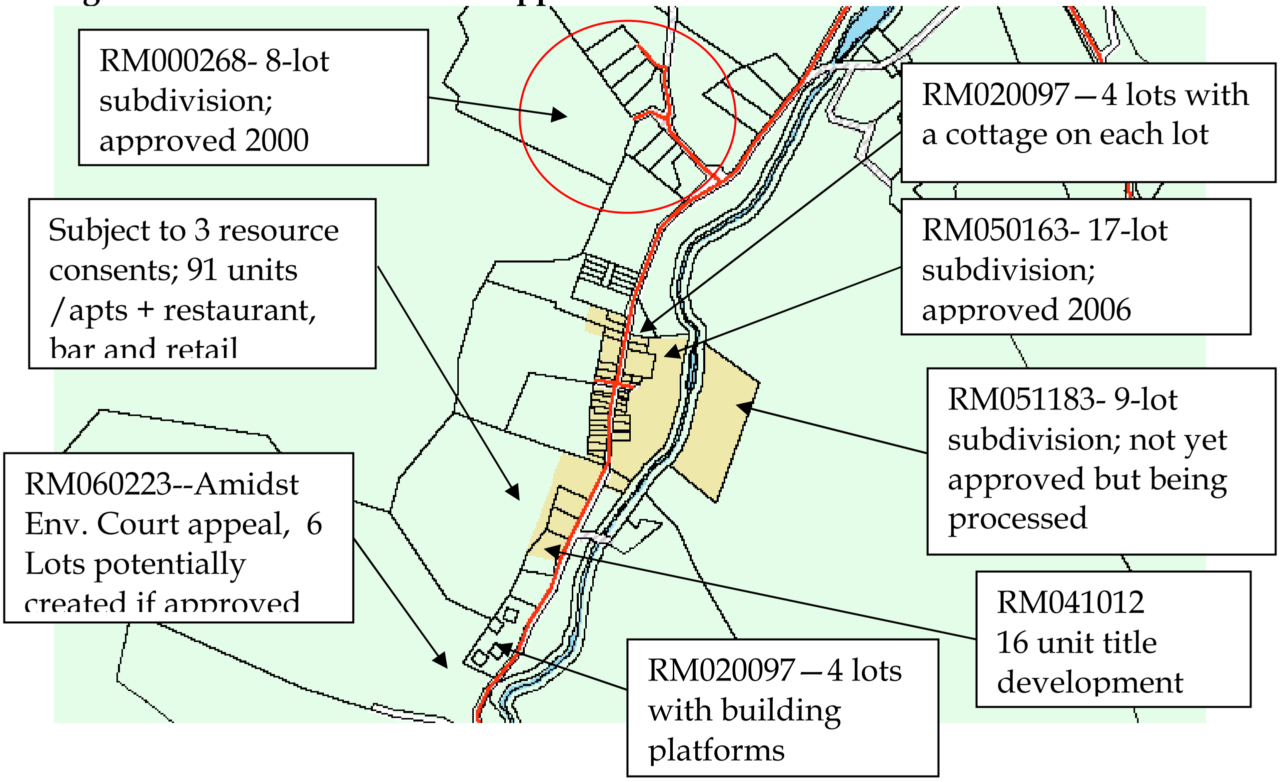
The Cardrona Hotel and general store, established in 1863, still exist and form the focal point of the historic centre.

2.1.2 Current Land Use

The estimated population of Cardrona was put at just 30 residents in 1999. An increase in local residents and a high transient visitor population, drawn to the nearby ski fields have seen a marked increase in the number of developments proposed for the area.

Figure 1 outlines the recent subdivision applications in the area.

Figure 1: Recent Subdivision Applications



3. GEOLOGY

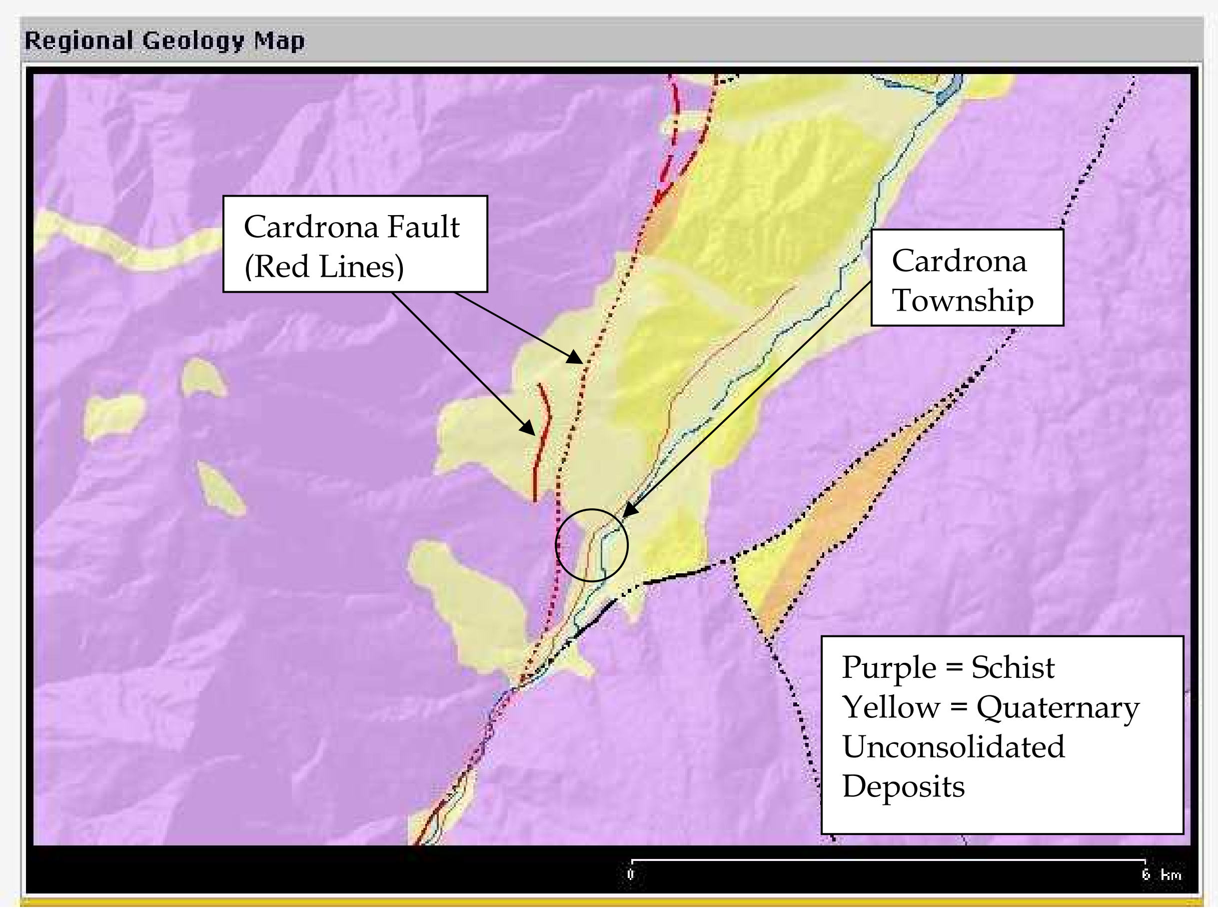
3.1 Geology and Geomorphology

The geology of the Cardrona Valley comprises basement schist and quaternary valley fill deposits (Figure 2). Valley fill deposits may comprise slope talus, large bedrock slip debris and alluvial river deposits. All these rock types are present within the general vicinity of the present day Cardrona Township. Topographic interpretation of the terrain suggests that the gently to moderately sloping development area may be either slope talus deposits or may constitute landslide debris.

Information obtained from the Institute of Geological and Nuclear Sciences website with regard to faulting shows an active fault of moderate recurrence interval (5,000 – 10,000 years) up slope of the Cardrona Township (Figure 2). This fault may well be responsible for the possible landslide debris.

Several geotechnical reports have been produced as part of engineering background data to support individual residential subdivision applications. It is not intended to reproduce any of this technical information in this report.

Figure 2: Regional Geological Map



Bore logs taken during well drillings suggest that the valley floor comprises silts, sandy gravels and clay bound gravels. The effect of this ground type will be further discussed in the Water Supply section of this report.

4. EXISTING SERVICES

4.1 Water Supply

Data received from the Otago Regional Council (ORC) suggest that there are nine groundwater bores in the immediate vicinity of the Cardrona Township, as detailed in Table 1 (see plan in Appendix B).

Table 1 : Groundwater Bores

Well ID #	Owner	Consented to take	Consent Number
F41/0139	J Lee		
F41/0199	TM Scurr		
F41/0279	J Lee		
F41/0228	Gilbert		
F41/0221	TM Scurr	24 m^3 per day	99012
F41/0200	TM Scurr		
F41/0194	R Laidlaw		
F41/0234	C Thompson		
F41/0326	Cardrona Ltd	77 m^3 per day	2006.377
F41/0346	TM Scurr	500 m^3 per day	2003.293

Three of these bores have consented daily water take volumes. Cardrona Ltd has 77 cubic metres per day, Cardrona Water Supply Ltd has two consents, one for 24 cubic metres per day and one for 500 cubic metres per day.

In addition to groundwater bores, there are a number of consented surface water takes (see Appendix C). Records from ORC suggest there are 18 consented surface water takes (see Table 2), principally for irrigation. The majority of these takes are limited to a volume of water per month, with no fixed annual allocation. The ability of each consent holder to take their allocated volume is based on flow rates in the Cardrona River. Accurate positions were only available for 14 takes, as shown on the plan in Appendix C.

Table 2 : Consented Surface Water Takes

Consent #	Owner	Consented Volume	Purpose
97549	Little Bo Peep Sheep Co Ltd	590 m^3/day	Irrigation
99388	Infinity Hillend Developments Ltd	Unknown	Irrigation
98495	JP Robertson & Trust	610 m^3/day	Irrigation
97377	JM Scurr	3285 m^3/day	Irrigation
97378	JM Scurr	1530 m^3/day	Irrigation
99339	Hawthenden Limited	2730 m^3/day	Irrigation
98075B	Anomura Investments Ltd	1585 m^3/day	Irrigation & Stockwater
98494	JP Robertson & Trust	495 m^3/day	Irrigation
97298	PD Gordon & Southern Trustees Ltd	2415 m^3/day	Irrigation
99151B	TM Scurr & CM Scurr	395 m^3/day	Irrigation
97563	TM Scurr	805 m^3/day	Irrigation
97564	TM Scurr	1380 m^3/day	Irrigation
2005.493	Cardrona Ski Resort Ltd	Unknown	Potable
2005.561	Cardrona Ski Resort Ltd	Unknown	Snow Making
2005.604	Cardrona Ski Resort Ltd	Unknown	Potable / Snow
98181	Pure H2O Cardrona Ltd	Unknown	Potable
97216	Mt Cardrona Station Ltd	4735 m^3/day	Irrigation
99151	TM Scurr & CM Scurr	395 m^3/day	Irrigation

Where allocation rates are available, five of the seven consented takes in the immediate vicinity of Cardrona equate to 7,710 m^3 per day (89 Ls^{-1}). Flow data available from all consented takes in the river catchment surrounding Cardrona amounts to 20,950 m^3 per day (242 Ls^{-1}).

The ORC have indicated that further consents for surface water takes will not be given if demand exceeds half the mean low flow rate in the Cardrona River. ORC flow data available for the Cardrona River indicate that the mean low flow is currently approximately 500 Ls^{-1}.

Uncertainties in the consented volumes and Cardrona River flow rates mean that it is likely to be very difficult to state what the current percentage of flow is allocated. Indications from the data available suggest that the Cardrona River, and therefore its tributaries, are fully allocated.

4.1.1 Hydrogeology

Borehole depths in the area range from 5 m to 32 m below ground level (bgl) with an average depth of 13.5 m bgl. Flow volumes range from 17.3 m^3 to 691 m^3 per day, with a total modelled flow volume of 1,142.2 m^3 per day. This relates to approximately 13 Ls^{-1}.

Bore logs received from McNeill Drilling for four wells (see Appendix E) provide an indication of the likely behaviour of groundwater in the area. A summary of the bore log data is presented in Table 3.

Table 3 : Bore Log Summary Data

Owner	Depth / Dia	Consented Flow Rate*	Flow Test Rate	Drawdown
Cardrona Ltd	14.27 m / 150 mm	2.08 Ls^{-1}	6.00 Ls^{-1}	Nil
B Gilbert	11.60 m / 125 mm	1.5 Ls^{-1}	1.92 Ls^{-1}	1.73 m
R Laidlaw	8.10 m / 100 mm	0.80 Ls^{-1}	0.15 Ls^{-1}	3.10 m
J Lee	6.51 m / 150 mm	Not consented	2.00 Ls^{-1}	0.02 m

* The consented flow rate is based on the daily allocation taken over 24 hours

Bores have been historically located near to the Cardrona River (see Appendix B) or close to other surface water features suggesting a shallow aquifer is recharged by both rainfall and the river itself.

The silts and clays found in some of the bores tend to suggest limited direct hydraulic connectivity with the river. However, these bores are likely to be unreliable and will be low yielding, as can be seen in the Laidlaw bore flow test above. Two of the bore flow tests resulted in minimal drawdown. This suggests a far stronger connection to the river. Bore log data recorded more sandy gravels than silts and clays in these higher yielding wells.

The data available from the surface water takes is indicating that the Cardrona River is fully allocated and that any new bore must demonstrate no hydraulic connection with the river when being pumped. For all practical purposes, there would have to be a confining layer in-between the river and abstraction point.

A recent application by Infinity Hillend Developments Ltd (2004) to take water from shallow bores (8 to 20 metres deep) adjacent to the Cardrona River was declined on the basis that there was a hydraulic connection to the river. The development is being supplied by a 50 metre deep bore with water bearing strata found at over 43 metres deep.

Obtaining conclusive evidence that a bore is not hydraulically linked to the river is likely to be difficult, especially if the bore is shallow.

4.1.2 Water Supply System

The majority of properties within the Cardrona Township obtain a potable water supply from a private water company, Cardrona Water Supply Ltd. This supply is obtained from the company's 300 mm well (ID number F41/0346) described in Table 3. The water is chlorinated at the pump site and piped through a dedicated rising main to a small tank farm on an elevated section above the township.

The tank farm comprises six buried 23 m^3 tanks which provide the fire fighting and emergency storage for the township as well as acting to buffer the daily peak flows through the system. Water is distributed to the township via a dedicated falling main and reticulation network.

Chemical and bacteriological analysis of the water, taken when the bore was drilled, confirms that the water is suitable for human consumption, apart from a low pH (below Drinking Water New Zealand 2000 Guideline Value). This low pH value indicates that the water is "aggressive" and may cause corrosion on metal surfaces. This is most likely to occur where two differing metals come in to contact.

Water samples taken from other wells in the area indicate the quality of the supply is good. One bore, owned by R Laidlaw, exhibited high levels of iron and manganese. Other water samples showed signs of mildly elevated iron levels but did not exceed Drinking Water Standards New Zealand 2005 Guideline Values.

A telephone conversation with Tim Scurr (of Cardrona Water Supply Ltd) confirmed the operation of the water supply system is as described and, in his opinion, that the water take has little effect on the river, mentioning that the river was measured by the ORC.

4.1.3 System Capacity

Queenstown Lakes District Council amendments to NZS4404:2004 require development to consider the average water demand as 700 litres / person / day with an average dwelling occupancy of 3.5 persons / dwelling. Studies in to water demand for Wanaka and Arrowtown have indicated that an average of 800 litres / person / day is required.

Based on the lower value, allocating all of the water from Cardrona Water Supply Ltd's bore, the township's main supply, it is theoretically possible to supply water to 211 properties.

In reality, considering peak day usage, treatment and system losses and the provision of operational, emergency and fire fighting storage, the potential supply base is much smaller. This is discussed in greater detail in subsequent sections of this report.

4.2 Wastewater

Unlike the water supply system, there is no one company or body responsible for the collection, treatment and disposal of wastewater. Individual or small community schemes have been constructed piecemeal as the developments have progressed.

Recent developers have been encouraged to consider isolated community schemes over individual septic tank systems but there are no guidelines or rules in place to require these systems to be installed.

As has been seen with the bore log information, the valley basin consists of silt, sand and clay bound gravels. A slow infiltration rate through the soil provides additional treatment to the discharged effluent water. However, the potential variability of the ground conditions, possibly caused by historical mining activities, could provide a more direct hydraulic link to the river.

4.3 Stormwater

Stormwater runoff generated in the area is directed to the river. Recent developments have been required to demonstrate that the runoff intensity post construction is no greater than pre construction.

Flooding of the low lying arable land adjacent to the river is relatively common. The Otago Regional Council have indicated that more detailed analysis is required to understand the behaviour of stormwater management and flooding.

ORC and QLDC have recently issued a joint document entitled "A Flood Risk Management Strategy for the communities of Lakes Wakatipu and Wanaka". This document is an assessment of the mechanisms that can contribute to flooding adjacent to these two communities. There have been extensive studies into the flow of ground water in the Cardrona Valley, however little data on stormwater flows is currently available.

Isolating stormwater from effluent disposal systems is vital. The ingress of stormwater in to these systems can cause surface ponding or increased leaching rates of the effluent, although the effluent is likely to be diluted.

On a site visit to the Cardrona Township, no formal stormwater detention structures were visible suggesting for the majority of rainfall events, water is simply channelled to the river through the use of swale drains or natural gullies. These drains will provide some level of treatment of the stormwater and reduce the intensity of the water flow.

4.4 Power

A reticulated electricity supply is distributed in the area by Aurora Energy Ltd and maintained by Delta Ltd. Discussions with Aurora engineers suggest that the electricity supply system is robust and can accommodate a moderate increase in demand in the Cardrona area.

The system will require upgrading for larger demands but this can happen incrementally as the developments come on line.

4.5 Telecommunications

Telecom NZ operates the telecommunications infrastructure in the area. Discussions with their engineers suggest that system capacity is available with incremental upgrades to the system being made as demand increased.

A fibre-optic cable extends part of the way from Wanaka towards Cardrona with a section of approximately 9 km operated by a radio link system. The radio link system operates between Hillend and a point approximately 8 km north of the Ski Field Road. Telephone lines in the Cardrona Township are traditional copper twisted pair cables.

The system can operate at broadband speeds and has a reasonable existing capacity. Further discussions on the likely operation of this system are covered in subsequent sections of this report.

4.6 Transportation

The road network between Queenstown and Wanaka, passing through Cardrona is well maintained and recent upgrades to the stream and river crossings have eliminated all of the single lane bridge structures.

The entire length of the road to Wanaka has been sealed. Works were being carried out on the day of a visit to Cardrona to repair the existing surface.

Traffic count records obtained from QLDC indicate that summer daily volumes are a good approximation to average daily volumes. Whilst there is an obvious peaking factor associated with the Cardrona ski field, local accommodation will act to reduce the impact of daily commuters from either Wanaka or Queenstown. Traffic from the ski field is roughly split 80% to 20% between Wanaka and Queenstown respectively.

There are no passing lanes to allow slower moving traffic to be safely overtaken. However, very little open road with clear lines of sight exist in the steeper sections of the route around the Crown Range, making economic construction of passing lanes difficult.

5. FUTURE EXPANSION

5.1 Water

There are several approaches to determine the potential growth capacity of the Cardrona Township. These can be based on the following assumptions:

- Additional well supplies can be secured;
- Other existing well owners are willing to join a community scheme;
- Additional surface water supplies can be secured;
- Other existing surface water take owners are willing to join a community scheme; or
- The existing community supply well is the only available source.

For all new takes, whether they are sourced from wells or from surface takes, applications for resource consent will be required. As discussed in Section 4, any take must prove no detrimental effect to the river level / flow.

For the purpose of analysis this report will consider two options:

- The existing community supply well is the only available source; and
- Additional water can be made available.

5.1.1 Operation of the Existing Water Supply Scheme

The existing community supply well, operated by Cardrona Water Supply Ltd, has a consented daily abstraction volume of 500 m^3, equating to an average flow rate of 6 Ls^{-1}. Storage associated with the scheme amounts to 138 m^3 in six buried tanks.

SNZ PAS 4509:2003 "New Zealand Fire Service Fire Fighting Water Supplies Code of Practice" is used as a guideline document to identify flow and storage requirements to accommodate fire fighting activities.

Differing types of activities are classified by their fire risk and water supply requirements. For example, residential developments consisting of single family dwellings or apartment units (not multi-storey) are classified W3. Fire fighting requirements for the W3 class is 12.5 Ls^{-1} at a hydrant within 135 metres of the dwelling and an additional 12.5 Ls^{-1} within 270 metres of the dwelling. Storage is required for 30 minutes at this flow (representing 45 m^3).

However, properties classed as W4, such as motels, hotels and hostels with a floor area 400 – 599 m^2, require 25 Ls^{-1} at a hydrant within 90 metres of the property and an additional 25 Ls^{-1} within 180 metres of the property from an additional 2 hydrants. Storage is required for 60 minutes at this flow (representing 180 m^3).

Individual properties fitted with approved sprinkler systems can reduce the risk and be classified in a lower class. The current system cannot support properties that would be classed as W4.

Assuming the trend of development continues, it is likely that a small commercial centre will evolve around the existing Cardrona Hotel. The fire fighting requirements for this area may be to the W4 standard, though buildings can be designed to meet the W3 requirements. The existing storage capacity is sufficient for the township as the Cardrona Hotel is classed as W3 due to its floor area coverage.

The operational storage requirement for the tank farm is based on a number of assumptions based upon WSA 03-2002 "Water Supply Code of Australia" and NZS 4404:2004 – QLDC Amendments and Modifications 2004:

- Average Daily (AD) demand is considered to be 700 Litres / person / day;
- Mean Day Max Month (MDMM) demand is 1.5 times AD;
- Peak Day (PD) is 2 times AD; and
- Peak Hour (PH) is 1/12th of PD.

In a Peak Day scenario, the total allocation from the existing bore plus a proportion of the available storage could be required. Available storage can be calculated as the total volume, less fire fighting requirements less an operational volume (nominally 15% of the total volume).

For the Cardrona Ltd system this equates to:

$$138 - 45 - 20.7 = 72.3 \text{ m}^3$$

It is standard design practice to consider the occurrence of three Peak Day events occurring concurrently. Therefore the available storage is:

$$72.3 / 3 = 24.1 \text{ m}^3$$

The Cardrona Hotel receives a water supply by agreement with Cardrona Water Supply Ltd of 10 m^3 per day. Therefore the maximum available water on any Peak Day is:

$$500 + 24.1 - 10 = 514.1 \text{ m}^3$$ (ignoring any potential leakage values at this time)

Using this volume, the maximum number of dwellings or equivalent domestic units (EDU) supported by the system can be deduced:

$$EDU = 514.1 / (3.5 * 2 * 0.7) = 105$$

Therefore under the current arrangements of storage and daily volume, a theoretical limit to development in Cardrona is 108 equivalent domestic units.

Referring to Figure 1 in this report, there are 155 EDUs identified in the Cardrona Township in addition to the existing properties.

Some data, in support of previous applications, has been presented to suggest that smaller apartment type developments would require less water (as low as 200 Litres / person / day). If this lower value is confirmed and accepted, three and a half times as many apartment units could be constructed as equivalent domestic units.

It is clear that the existing Cardrona Water Supply Ltd supply is approaching its limit in terms of a reliable community water system. No metering data was available from the Cardrona Township to modify the generic QLDC demand assumptions.

In addition to the available storage, there are limitations on the instantaneous delivery of water. Pump sizing is normally based on delivering the maximum daily volume over a 20 hour pumped period. Therefore, for 518.4 m^3, the pumps will, in theory, be able to deliver 7.2 Ls^{-1}. Peak Hour is calculated as one twelfth of Peak Day flows. In this case Peak Hour is:

$$PH = 514.1 / 12 = 42.8 \ m^3 / hr \quad = 11.9 \ Ls^{-1}$$

For the Peak Hour period the demand will outstrip the pumping rate by 4.7 Ls^{-1} requiring 18.5 m^3 of storage. This can be accommodated by the operational volume of 20.7 m^3. Higher capacity pumps could be installed but in general, for the majority of the year, these will be more expensive to operate.

For each additional 100 m^3 per day available, assuming the existing storage and fire fighting capacities, an additional 20 EDU can be considered.

Leakage in Council operated reticulated networks throughout New Zealand averages around 10% to 15%. Leakage from this small private scheme, where leaks are likely to be visible and repaired quickly, is likely to be lower. However, no reticulated pipework system is leak free. Water lost through leakage and the treatment system should be considered.

Conservatively assuming 5% loss through leakage and other losses, this reduces the daily volume available by 25.92 m^3.

Re-running the calculations, the supportable client base from the Cardrona Ltd system is 103 EDU.

5.1.2 Modifications to the Existing Water Supply Scheme

Increasing the volume of water available or the storage capacity at the tank farm will have the effect of increasing the potential population served by the system. The cheapest and easiest option is to increase water storage. However, there is a limit to the volume that can be stored due to water quality issues.

General practice is for any storage system to turn over roughly one third to one half of its capacity on a daily basis. This ensures the age of water held in storage is kept to a minimum and thus water quality is maintained.

Average Day demand for the Cardrona Water Supply Ltd system is potentially:

$$AD = 103 * 3.5 * 0.7 = 252\ m^3$$

Therefore, in its current configuration of 138 m^3 storage capacity, if the township was developed to its maximum capacity for the bore, water would be turned over 1.8 times per day.

Storage could be increased, certainly to 500 m^3. This would provide a far more secure supply in terms of Peak Day flows and operational, emergency and fire fighting volumes. The limitation will be how to construct a storage system to provide this capacity.

Tank farms are popular due to their low construction costs and modular nature allowing progressive expansion as demand increases. A storage capacity of 500 m^3 would require over 20 tanks equivalent to those already in use. This is clearly unfeasible. Pre-cast concrete tanks are available, off the shelf, with capacities ranging from small 20 m^3 tank farm units to over 100 m^3. Larger tanks are available but would be built to special order.

The location of a storage reservoir will also require detailed investigation. Issues such as geotechnical investigations, overflow paths and the elevation of the reservoir will need to be resolved.

Increasing the storage capacity to 500 m^3 has the following effect on the potential supply base:

$$518.4 – 25.92 + (500 – 45 - 75) / 3 – 10 = 609.18\ m^3 \text{ available per day.}$$

$$EDU = 609.18 / (3.5 * 2 * 0.7) = 124$$

Therefore an additional 21 properties can be accommodated by the system if the storage is increased to 500 m^3. If W4 fire fighting flows are required, the supportable population drops to 115 EDU, even with the additional storage. The cost of increasing storage is of the order of $100 to $200 per m^3 on even level terrain. The cost is likely to be higher in this area due to the topography and relatively remote location.

Development of an additional source is the other alternative to increase the population supplied with water in Cardrona. Two existing wells are in close proximity to the Cardrona Water Supply Ltd bore (see Appendix B). Both have potential yields of 126.9 m^3 / day. These wells are owned by B Gilbert (ID # F41/0228) and C Thompson (ID # F41/0234). As discussed in Section 5.1.1 an additional 20 EDU can be supplied for every 100 m^3 per day supply made available. The addition of one of these wells will allow 25 EDU to be connected.

5.1.3 Cardrona Township Growth

The Cardrona Community Plan, issued in 2003, discusses the preference for development of the existing township to be controlled and scaled to match the historical and rural environment. The perception in that document was that the growth of the existing township would increase by 100 EDU from the 2003 levels by the year 2020.

They also considered the Northern Rural Visitor Zone could be developed to accommodate 220 EDU. A recent application by Mount Cardrona Station Ltd is for the subdivision of the Northern Rural Visitor Zone into 575 EDU.

The Cardrona Water Supply Ltd supply appears to be approaching its supply limit, assuming all of the developments identified in Figure 1 are connected to the system. Further growth will require an additional water source and greater storage capacity will need to be constructed.

The development identified in the Northern Rural Visitor Zone is beyond the scope of the Cardrona Water Supply Ltd reticulated network and supply capacity. An existing surface water irrigation take has been identified as a potential source for a community supply. Mount Cardrona Station Ltd holds a consent for 4,735 m^3/ day from Pringle Creek for irrigation. This take will be conditional on certain flow conditions in the Cardrona River.

Mount Cardrona Station Ltd proposes to construct a Tarn to store water during low flow periods. No information was available regarding the location or elevation of this tarn at the time of writing this report. However, the potential to provide a security supply may be possible if a suitable pipeline route, to act in both directions, can be identified. This should be considered at the detailed design stage of the Mount Cardrona Station Ltd development.

5.1.4 Water Treatment

The identified water quality for bore water in the Cardrona valley is generally high. Elevated levels of iron have been found in one bore above the Drinking Water

Standards NZ 2005 guideline value (repeated in a subsequent sample from the same bore). Cardrona Ltd operate a simple chlorination dosing plant on their community supply to ensure the water meets the current DWSNZ:2005 standards.

Water derived from surface sources will require a higher level of treatment before it can be considered suitable for human consumption. Bacteriological content, nutrient levels, colour, pH and mineral content must be determined before treatment options can be determined.

5.2 Wastewater

5.2.1 Background

This assessment outlines some options regarding developing a community sewerage scheme (centralised or de-centralised) for Cardrona and will discuss sewage reticulation, treatment and land application or disposal systems that could be developed to meet the future long-term requirements of the settlement.

In regard to future population growth and wastewater flows generated in Cardrona, at the current time it is difficult to predict given that growth of the settlement is likely to be limited by a combination of factors, such as the availability of land for development and water supply. Therefore, for the purposes of this assessment, we have only made a broad appraisal of the likely wastewater treatment and application systems that could be suitable for the settlement. We have stopped short of recommending any one system for the settlement as this cannot be made before likely growth forecasts are known.

5.2.2 Reticulation Options

5.2.2.1 Gravity Flow to Pump Stations or Gravity Direct to Sewage Treatment Plant

This is a conventional sewerage system. Laterals are required to connect individual residential dwellings to the main sewer lines leading to the treatment unit or pump station. Standard laterals are 100 mm diameter PVC pipeline. Manholes are required in the sewer lines to allow access to sewers for maintenance and also to allow for changes in direction and grade.

Sewage flows from the residential dwellings through the 100 mm lateral to 100 – 150 mm pipes to a pump station located at the low point of each grouping of residential zones. From there, raw sewage would be pumped to the treatment plant for primary settling and further treatment.

An advantage of this system is that all the sewage would be primary treated at one site. However, pipe sizes would be larger than for a STEP/STEG system (see below) and the raw sewage pump at the pump station would need higher specifications and more maintenance than a standard effluent pump. In addition, pipelines need to follow a set gradient and a number of manholes are required. Wet weather flows are generally needed to be catered for in design due to the ability to accidentally connect stormwater into the system, infiltration of high groundwater into the system, and inflows during periods of temporary inundation into manholes.

Pump stations are expensive and reticulation would need to be carefully designed, particularly over undulating ground. There is a general fall of approximately 80 metres between the historic township and the area identified as the Northern Rural Visitor Zone, a distance of approximately 2.7 km. The installation of a gravity main between the two discrete areas is, in theory, possible.

Installation costs for a gravity sewer main will be dependant on the ground conditions and excavations / reinstatement requirements en route. A brief visual survey of the route indicated that there is limited space in the roadside berm and there may be significant lengths of pipe that would need to be installed in the sealed road surface. Pipe installation costs could vary from $150 to $300 per metre. Assuming an average of $200 per metre a budget figure of $540,000 should be considered appropriate.

The location of a suitable treatment and disposal site to allow the connection of both development areas should be considered.

5.2.2.2 STEP/STEG System

This system would also require main sewer lines into which dwelling laterals would be connected. No manholes would be required to allow access to sewers as the sewage would be primary treated and conveyed through small diameter medium density polyethylene pipe or PVC pipe. Laterals are required to connect individual dwellings to the settlement tank on the property before connecting to the main sewer lines leading to the treatment unit.

Sewage passes into a sedimentation tank near the source(s) and is primary treated before being coarse screened (through a filtered pump vault or filter prior to gravity flow) and pumped with a standard effluent pump (STEP system) or gravity flow (STEG system) via 50 - 100 mm plastic pipes to the treatment plant.

This system has the advantages of: transporting primary treated effluent through small diameter pipes to the treatment plant, and pipes can follow the contour rather than a set grade – this is important where ground is undulating or rocky or there is a high water table. Manholes are not required and thus risk of infiltration into the conveyance system and treatment plant is minimised. It also removes the need for large capacity primary sedimentation tanks at the treatment plant (reducing the area needed) and the pumps would require less maintenance.

The flexibility, durability and small diameter of the effluent pipe allow the pipe to be installed in the standard service trench prepared for phone lines and power cables. In addition, there is also more buffering capacity (24 hours emergency storage) using a STEP/STEG reticulation system if there is a breakdown in the system than with a traditional gravity flow and pump station option.

The sedimentation tanks require cleaning out approximately every 8 – 15 years.

5.2.2.3 Grinder Pump System

This system would entail installing grinder pumps for each individual dwelling to macerate all wastes and convey the material under pressure through small diameter pipes to a treatment plant. Grinder pump systems exhibit many of the advantages of the STEP/STEG system, i.e. only small diameter pressure pipes, ideal for undulating topography, reduced inflow and infiltration, and is suited to areas with high rock or high groundwater levels. Additional advantages of grinder pumps are that sedimentation tanks are not required, all sewage is removed off site, and the effluent is aerobic when it reaches the treatment plant. However, grinder pumps do have higher maintenance requirements compared to STEP/STEG systems.

5.2.3 Wastewater Treatment Options

The following options were identified from experience Glasson Potts Fowler Ltd has gained from previous small community treatment system designs and upgrade options assessment:

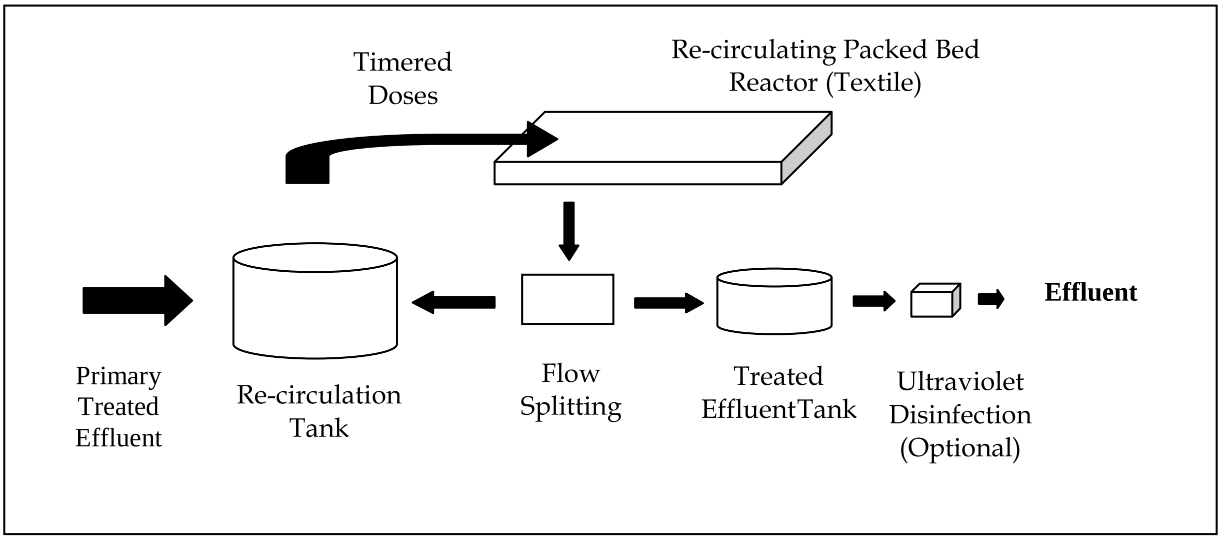
- Intermittent Sand Filters
- Peat-Soil-Sand Filters
- Re-circulating Sand Contactors (rSC) or Packed Bed Reactors (rPBR)
- Re-circulating Textile Packed Bed Reactors (rtPBR)
- Membrane Bioreactors (MBR)
- Submerged Aerated Systems (SAF)
- Fixed Activated Sludge Treatment (FAST)
- Trickling Filters (TF)
- Rotating Biological Contactors (RBC)
- Activated Sludge Systems (ASS) or Extended Aeration Systems (EAS)
- Pond Systems
- Secondary Treatment Wetlands
- Tertiary Treatment Wetlands

The options that were considered further are given below, with flow diagrams of the options on the following pages:

- Re-circulating Textile Packed Bed Reactor (rtPBR)
- Membrane Bioreactor (MBR)

- Fixed Activated Sludge Treatment (FAST)
- Activated Sludge System (ASS)

5.2.3.1 Option 1: Re-circulating Textile Packed Bed Reactor (rtPBR)

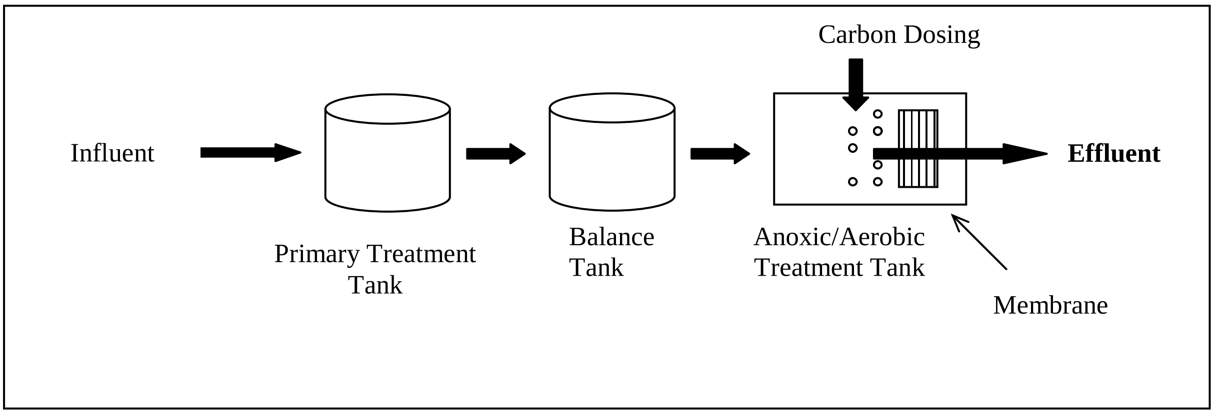


Re-circulating Textile Packed Bed Reactor Plants consist of two main components - a recirculation tank and a packed textile bed. Effluent, having been treated in a primary settling tank (or on-site interceptor tanks) enters the re-circulation tank and mixes with already treated and oxygenated wastewater. Discharge from the re-circulation tank enters the packed bed reactor. Effluent is sequentially applied to the top of the reactor. Percolate is collected in an under-drain system. Suspended solids (SS) are removed by mechanical straining and biological films, which form upon the textile. Intermittent application of wastewater and venting of under drains helps maintain anaerobic conditions followed by aerobic conditions throughout the system. This encourages 5-day biological oxygen demand (BOD_5) reduction and nitrification/denitrification of nitrogen (N). The effluent from the under-drain is collected and part is re-circulated back to the textile packed bed reactor. The recycle ratio is usually 3 – 4 recycled back to 1 treated wastewater to irrigation.

This system generates very little sludge as such, however minimal accumulation of bioslimes and some residual biomass will require removal on an approximate 5 - 8 year cycle. This system has recently been consented by Otago Regional Council (ORC) for the 900 lot, via several clusters, for the Jacks Point development which will be generating up to 850 m^3 of wastewater per day.

Predicted effluent quality produced and the major advantages/disadvantages of a rtPBR system are presented in Table 4.

5.2.3.2 Option 2: Membrane Bioreactor (MBR)

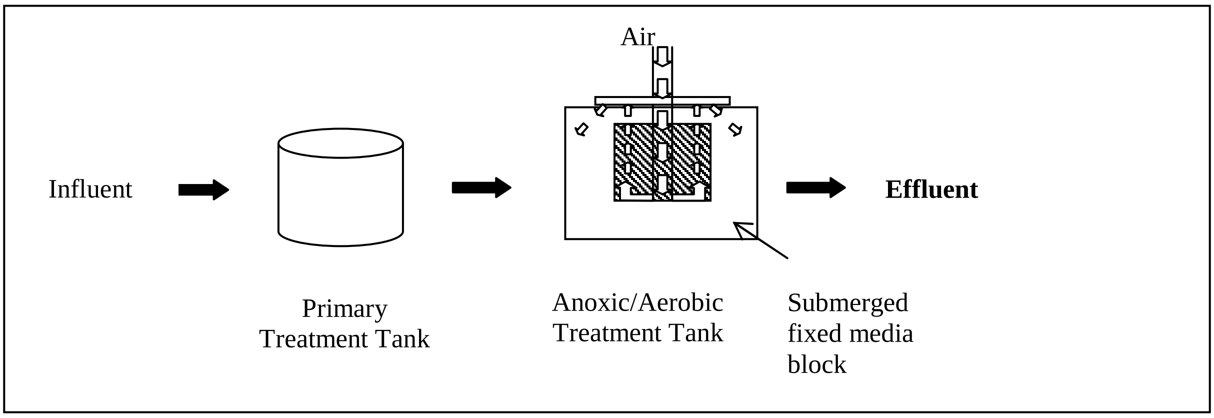


A MBR system is a combination of the activated sludge process (a wastewater treatment process characterised by a suspended growth of biomass) with a micro- or ultra-filtration system that rejects particles. MBRs have two basic configurations: (1) an integrated configuration that uses membranes immersed in the bioreactor (as above) and (2) a re-circulating configuration where the mixed liquor circulates through a membrane module situated outside the bioreactor.

The membrane filtration system replaces the traditional final gravity sedimentation unit (clarifier) in the activated sludge process. In addition to removing biodegradable organics, suspended solids, and inorganic nutrients (such as nitrogen and phosphorus), MBR's retain particulate and slow growing organisms, thereby allowing treatment of more slowly biodegradable organics. They also remove a very high percentage of pathogens (protozoa, bacteria, and viruses), which alleviates the need for additional disinfection processes.

Predicted effluent quality produced and the major advantages/disadvantages of a MBR system are presented in Table 4.

5.2.3.3 Option 3: Fixed Activated Sludge Treatment (FAST)



The FAST system uses a fixed activated sludge treatment process to treat wastewater. Wastewater from dwellings is collected in a primary settling zone of a centralised anoxic/aerobic treatment tank where initial settling out of heavy solids from the wastewater occurs. Submerged inside the treatment tank is a fixed media block that has a very high surface area to volume ratio and which serves as a site for the growth of nitrifying bacteria. Air is forced down a draft tube through the centre of the fixed media block to the bottom. As air is expelled from the draft tube and rises up through the media, it acts as an airlift and circulates the wastewater up through the media block, where it breaks down the BOD_5 and undergoes nitrification. The high rate of air exchange maintains the media in an aerobic state, allowing for efficient nitrification to occur. When the wastewater reaches the top of media, a portion is re-circulated to the anoxic zone of the treatment tank for denitrification to occur before it is discharged.

The two zone (aerobic and anoxic) design of the FAST system provides for a stable treatment process. In addition, because the fixed growth media bed is submerged and remains wet, it is capable of maintaining bacterial growth during periods of low wastewater flows.

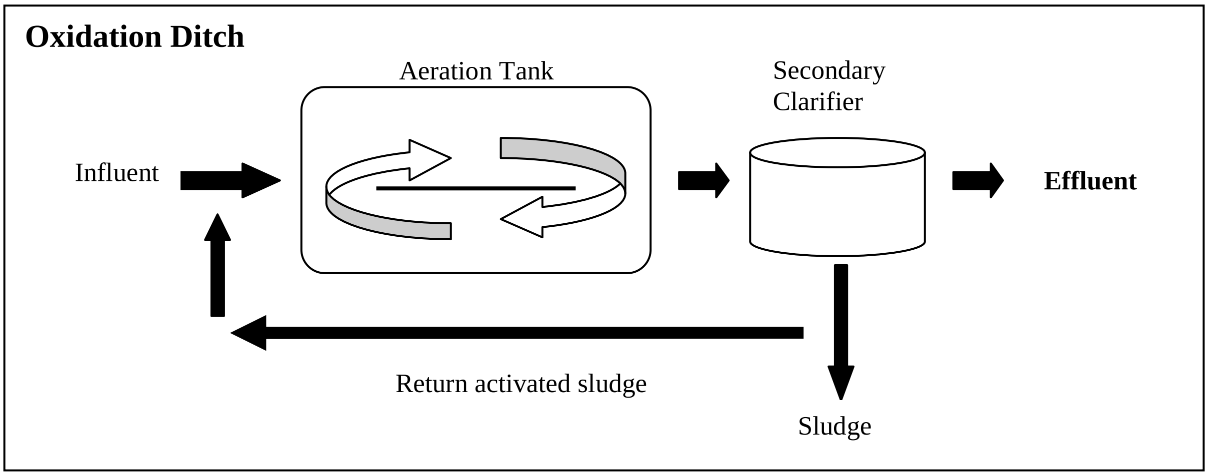
Predicted effluent quality produced and the major advantages/disadvantages of a FAST system are presented in Table 4.

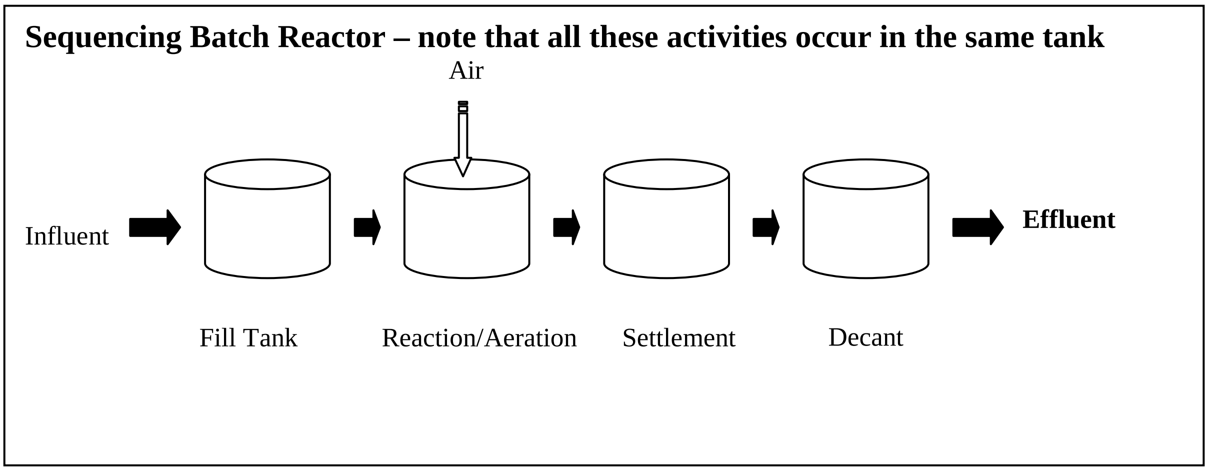
5.2.3.4 Option 4: Activated Sludge Systems (ASS)

Activated-sludge systems (also known as suspended growth systems) use a biological treatment process where the microbiological community responsible for treatment are suspended in solution. The basic process of ASS consists of the following three basic steps:

- ► Aeration – where the microbial biomass responsible for treatment of the effluent is maintained in suspension and aerated;
- ► Clarification or sedimentation – where treated effluent is separated from the microbial biomass and other solids; and
- ► Activated sludge re-circulation – where the settled microbial biomass is returned to the aeration tank for further treat effluent.

There are various design configurations for ASS, however two common designs that are widely used to treat municipal and industrial wastewaters throughout the world are oxidation ditches (OD) and sequencing batch reactors (SBRs). The basic process steps of these two configurations are presented below.





Predicted effluent quality produced and the major advantages/disadvantages of ASS systems are presented in Table 4.

Table 4: Summary of Expected Effluent Quality, Advantages and Disadvantages of Treatment System Options

Option	System	Effluent Quality				Advantages	Disadvantages
		BOD_5 (g m^{-3})	TSS (g m^{-3})	Total N (g m^{-3})	FC (cfu 100 mL^{-1})		
1	Recirculating Textile Packed Bed Reactor (rtPBR) + UV disinfection	< 5 - 15	< 5 - 15	10 - 25	< 10^4 < 200	■ High effluent quality ■ Can buffer peak loads ■ Low maintenance requirements ■ Treatment process is not too sensitive to temperature ■ Very low sludge production (7 – 8 year pump out) ■ Remote system servicing and troubleshooting available ■ Low odour production ■ Good for anoxic pre-settled wastewater ■ Water suitable for re-use after disinfection ■ Modular design – can increase capacity and install incrementally ■ Simple to operate with minimal operator knowledge required ■ Small footprint ■ Effective and reliable system operation in New Zealand ■ Low power requirements	■ Limited control of biological process if nutrient removal is required. However, additional tanks can be added to boost carbon ■ Problems treating aerobically pre-treated effluent containing flocculating agents ■ The treatment media relies on an area/flow unit, so economies of scale are small
2	Membrane Bioreactor (MBR)	< 5	< 5	10 - 25	0	■ Very high quality effluent ■ Water suitable for re-use without any additional disinfection (eg. Via UV, chlorination, ozonation) ■ Modular design – can increase capacity and install incrementally ■ Small footprint ■ Tried and tested internationally	■ Moderate operator input and maintenance requirements ■ High operating costs due to the need to replace membranes ■ Moderate energy costs ■ Treatment efficiency reduced under fluctuating loads ■ Carbon dosing often required to reduce effluent nitrogen levels to low levels ■ Only a few systems recently installed in New Zealand ■ Some sludge removal required
3	Fixed Activated Sludge Treatment System (FAST) + UV disinfection	< 15	< 25	15 - 30	< 10^5 < 200	■ High effluent quality ■ Low maintenance requirements ■ Treatment process is not too sensitive to temperature ■ Remote system alarm monitoring and servicing ■ Very low odour production ■ Modular design – can increase capacity and install incrementally ■ Small footprint	■ Only a few systems currently installed in New Zealand ■ Moderate to high sludge production that requires disposal ■ Reasonable operator knowledge and input required
4	Activated Sludge Systems (AS)	< 30	< 30	25 - 40	< 10^5	■ High quality effluent ■ Robust well proven technology ■ Small footprint ■ Good economies in scaling up	■ Complex system to manage – skilled operator input required ■ Moderate operating costs ■ High sludge production that requires disposal

5.2.4 Wastewater Disposal - Discharge Options

There are a number of methods available that could be used for wastewater application/disposal ranging from land irrigation, or subsurface disposal trench methods, or constructed wetlands and discharge into nearby waterways, such as the Cardrona River.

A preliminary coarse screening of potential land in the locality of Cardrona that could be utilised for wastewater application from any community sewage system has been undertaken. This survey identified potential land areas based on topography, with flat to moderate sloping areas being considered suitable. At the current time, no soil investigations have been conducted in any of these areas to determine their suitability for land application methods, however for the purposes for this exercise we have assumed that most of the areas indicated have soils hydraulically favourable to land treatment, as soil mapping data on the GROWOTAGO® website[1] indicates that the soils in the area are predominantly sandy to silt loam in texture.

Based on our preliminary survey, we have identified approximately 370 ha of land that could be suitable for land application. Potential areas are marked out on the plan attached in Appendix D. Photos of some of the respective areas are also included.

The discharge options considered for the discharge of treated wastewater from any community treatment plant constructed at Cardrona are presented below:

- Land treatment of wastewater via drip or spray irrigation;
- Land disposal via subsurface infiltration trenches;
- Land dispsosal via rapid infiltration basins; and
- Discharge to water via constructed wetlands.

It should be noted that although the methods listed above are potential options which merit consideration, and although the systems will provide additional wastewater treatment to varying degrees, it is likely that not all of the methods will be viable if tight nutrient loading thresholds are imposed by ORC at the consenting stage. The ORC prefer a maximum wastewater N loading limit to land of 200 to 550 kg ha^{-1} y^{-1}, depending upon the land management system employed. Phosphorus (P) loadings to land and water from wastewater discharges are also becoming an increasing concern that may have to be accounted for but at the above nitrogen loading limits is unlikely to be an issue. We have included the discharge to wetlands and waterways as an option, however whether in reality it is a viable option remains to be seen, given that the Otago Regional Council (ORC) may not be in favour of such a discharge method given that other more preferable land application options appear to be available.

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[1] www.growotago.orc.govt.nz

5.2.4.1 Land Application via Drip or Spray Irrigation

Land application for this option involves the discharge of high quality secondary treated wastewater into or onto land over an appropriately sized area using either surface applied spray irrigation systems (i.e. travelling boom or gun irrigators, centre-pivots, solid-set or moveable systems) or surface or sub-surface drip line irrigation.

The type of irrigation equipment selected is dependent on the topography and land use of the area receiving the wastewater. It is likely that any land utilised for land treatment of wastewater would still be able to be used for grazed pastoral farming activities, which appears to be the current land use of all the potential land treatment areas currently identified (see map in Appendix D).

Installation of a drip line irrigation system would use solid set UniRaam drip line which is a pressure compensating emitter system that does not have to follow the contour. The drip irrigation lines would ideally be installed at 150 mm depth below the soil surface. This depth will reduce land use constraints over the disposal field, protect public health, and also minimise risk of frost and mechanical damage to the irrigation system. However, if burying the irrigation lines is impractical, they can be installed on the soil surface, although this would also require preventing public and stock access. Irrigation lines placed on the surface are at risk from frost damage; however this can be mitigated by appropriate design that will ensure that the irrigation system will drain itself free of effluent between application doses. Dripper irrigation is relatively easy to install and irrigation lines can be easily configured to the land contours, making use of unusual shaped land areas and sloping sites.

One main land use constraint when using drip irrigation systems in a grazed pastoral situation is that the land can probably only be grazed with sheep and not cattle which can cause mechanical damage to the drip lines. Further assessment of this is occurring. This is not the case for spray irrigation systems, however any surface applied wastewater spray irrigation will place other constraints on the system with respect to requiring non-irrigated buffer areas around land treatment areas and the implementation of grazing with-holding periods to mitigate possible stock health and pasture palatability issues.

Based on the ORC recommended maximum wastewater N loading rates for cut and leave (200 kg N ha^{-1} y^{-1}), grazed (300 kg N ha^{-1} y^{-1}) and cut and carry (550 kg N ha^{-1} y^{-1}) systems, the daily hydraulic loading and the land area required per unit volume of wastewater applied for a given effluent quality are presented in Table 5 and Table 6 below. For example, effluent with an average quality of 20 g N m^{-3} applied at a maximum N loading of 300 kg ha^{-1} y^{-1}, the hydraulic loading will be approximately 4 mm d^{-1} with approximately 243 m^2 required for each cubic metre of wastewater applied.

Table 5: Daily Hydraulic Loadings for a given Effluent Quality Applied at an Annual Maximum Permitable Wastewater N Loading to Land (mm/day)

Wastewater Quality (g N m^{-3})	Maximum Permitable N Loading (kg N ha^{-1} y^{-1})		
	200	**300**	**550**
5	11	16	30
10	6	8	15
15	4	6	10
20	3	4	8
25	2	3	6

Table 6: Required Area per Unit Volume (m^2 m^{-3}) of Applied Wastewater for a given Effluent Quality Applied at an Annual Maximum Permitable Wastewater N Loading to Land

Wastewater Quality (g N m^{-3})	Maximum Permitable N Loading (kg N ha^{-1} y^{-1})		
	200	**300**	**550**
5	91	61	33
10	183	122	66
15	274	183	100
20	365	243	133
25	455	305	165

The advantages of land treatment are:

- Natural treatment system and discharge method;
- Beneficial reuse of water for irrigation;
- The soil has a high ability to retain nutrients, thus further polishing the wastewater;
- The soil has a high ability to reduce pathogens through filtration and wetting and drying cycles; and
- Is generally culturally acceptable.

The main disadvantage of land treatment is that a large area of land is often required as wastewater is applied at low rates to ensure land treatment is effective.

5.2.4.2 Infiltration Trenches

This is a traditional means of on-site wastewater disposal, where treated effluent is discharged to land via soakage trenches (0.6 m width) with perforated distribution pipes at 1 m spacings.

Typical recommended application rates of secondary treated effluent to discharge trenches over loamy soils (Category 3 soils) is 30 to 50 mm d^{-1} [2]. These recommended rates are generally designed for individual on-site treatment and disposal systems and are inherently conservative. Nevertheless, assuming that wastewater is applied at rates of 30 and 50 mm d^{-1}, then approximately 55 and 33 m of trenching (assuming that trenches are 0.6 m in width) will be required for disposal of each cubic metre of applied wastewater respectively. Taking into account the 1 m spacings between trenches, the total land area required for each cubic metre of applied wastewater for hydraulic loadings of 30 and 50 mm d^{-1} would be approximately 110 and 66 m^2 respectively.

The advantages of this disposal method are:

- Natural treatment system and discharge method (although nutrient removal is severely limited);
- Reduced amenity impact; and
- Is generally culturally acceptable.

The main disadvantages of this disposal method are:

- Suitable only for relatively flat ground;
- May not be acceptable to Regional Council as not considered land treatment;
- Substantial on-site works are required; and
- Further nitrogen and phosphorus removal may be required prior to discharge.

5.2.4.3 Rapid Infiltration Basins

Rapid infiltration systems are a cost effective means to dispose of treated wastewater. They are suited to sites where the soil permeability is at least 25 mm h^{-1} and where the topography is level[3]. Design hydraulic loadings for rapid infiltration systems are usually based on a percentage of the measured soil infiltration rate on a site. However, hydraulic loading can also be based on the BOD_5 loading of the wastewater. Other constituents such as N and P can also be taken into account, but not for hydraulic reasons.

Recent percolation testing (via a basin infiltration test) undertaken on flat land located near the Cardrona airstrip reported a measured infiltration rate of approximately 900 mm d^{-1}. Designing the hydraulic loading as 10 - 15% of this measured infiltration rate, the design hydraulic loading rate for a rapid infiltration system constructed at the site would be in the vicinity if 90 – 135 mm d^{-1}.

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[2] AS./NZS 1547:2000: On-site Domestic-Wastewater Management. Standards New Zealand and Standards Australia.

[3] Wastewater Engineering, Third Edition (1991). Metcalf & Eddy. McGraw-Hill, Inc.

Rapid infiltration basins are managed under wet-dry operating cycles to ensure adequate soil drying periods are maintained to allow for soil aeration and enable the breakdown of organic matter residues between applications. For example, a system with an operating cycle of 1-day application and 7-days drying, would typically require 8 basins of equal proportion.

In terms of required area per volume of wastewater disposed, and assuming that the hydraulic loading (100 mm d^{-1}) will be based on the measured soil permeability only (not taking into account BOD_5, N or P loading), then approximately 80 m^2 of infiltration area (based on a 1-day wet and 7-day drying cycle) would be required per cubic metre of wastewater discharged.

The main advantages of rapid infiltration systems are:

- Natural discharge and treatment method;
- Relatively cost effective;
- Easy to maintain; and
- Adaptable to cold climates.

The major disadvantages of rapid infiltration systems are:

- They are open above ground systems that have a visual impact on local amenity values;
- May not be acceptable to Regional Council as not considered land treatment;
- Further nutrient removal is likely to be required at the treatment plant; and
- They require regular maintenance to break up the organic mat that will form at the base of the basins to maintain its infiltration capacity.

5.2.4.4 Discharge to Constructed Wetland Areas

This option would involve discharging treated wastewater into constructed wetland areas before eventual discharge into a nearby water body (Cardrona River). In constructed wetlands, wastewater is slowly conveyed through water tolerant plants, or media containing plant roots, which filter out contaminants and assist in the uptake of nutrients. Contaminants are also removed from wastewater via a combination of settling, microbial decomposition and assimilation and absorption processes.

The primary design parameters used in constructed wetland systems are hydraulic detention time, basin depth, basin geometry, BOD_5 loading rate and hydraulic loading rate. However as a rule of thumb, approximately 10 to 20 m^2 of wetland is required per cubic metre of wastewater[4].

The main advantages of wetland systems are:

[4] Waterways, Wetlands and Drainage Guide, Part B: Design. Christchurch City Council. Pg. 6-33.

- Natural treatment system and discharge method;
- Decreased capital cost for disposal compared to land disposal methods;
- Less land area required;
- Generally considered to be culturally acceptable; and
- Can be made to be aesthetically pleasing.

The main disadvantages of wetland systems are:

- Wastewater will likely have to undergo tertiary treatment (i.e. ultra-filtration or UV disinfection) to remove pathogenic bacteria and viruses before discharge into the wetland;
- Enhanced nutrient (i.e. for N and P) removal in the secondary treatment system may be required;
- Does not beneficially reuse the effluent;
- Surface water discharges are not always desirable to downstream users; and
- Capital cost could be increased depending on contours over the wetland area.

5.2.4.5 Costs and Land Area Requirements

The following table summarises the land area requirements for the likely population growth in the Cardrona Township:

Table 7: Effluent Discharge Land Area Requirement

Land Discharge Method	**Historic Township (assumes 103 EDU = 108 $m^3\ d^{-1}$)**	**Northern Rural Visitor Zone (assumes 575 EDU = 603 $m^3\ d^{-1}$)**	**Total Area Required**
Drip / Spray Irrigation			
5 g N m^{-3} / 200 kg N $ha^{-1}\ y^{-1}$	0.98 ha	5.49 ha	6.47 ha
10 g N m^{-3} / 200 kg N $ha^{-1}\ y^{-1}$	1.98 ha	11.03 ha	13.01 ha
15 g N m^{-3} / 200 kg N $ha^{-1}\ y^{-1}$	2.96 ha	16.52 ha	19.48 ha
20 g N m^{-3} / 200 kg N $ha^{-1}\ y^{-1}$	3.94 ha	22.01 ha	25.95 ha
5 g N m^{-3} / 300 kg N $ha^{-1}\ y^{-1}$	0.66 ha	3.68 ha	4.34 ha
10 g N m^{-3} / 300 kg N $ha^{-1}\ y^{-1}$	1.32 ha	7.36 ha	8.68 ha
15 g N m^{-3} / 300 kg N $ha^{-1}\ y^{-1}$	1.98 ha	11.03 ha	13.01 ha
20 g N m^{-3} / 300 kg N $ha^{-1}\ y^{-1}$	2.62 ha	14.65 ha	17.27 ha
5 g N m^{-3} / 550 kg N $ha^{-1}\ y^{-1}$	0.36 ha	1.99 ha	2.35 ha
10 g N m^{-3} / 550 kg N $ha^{-1}\ y^{-1}$	0.71 ha	3.98 ha	4.69 ha
15 g N m^{-3} / 550 kg N $ha^{-1}\ y^{-1}$	1.08 ha	6.03 ha	7.11 ha
20 g N m^{-3} / 550 kg N $ha^{-1}\ y^{-1}$	1.44 ha	8.02 ha	9.46 ha
Infiltration Trenches			
30 mm d^{-1}	1.19 ha	6.63 ha	7.82 ha
50 mm d^{-1}	0.71 ha	3.98 ha	4.69 ha
Rapid Infiltration Basins			

8 day system	0.86 ha	4.82 ha	5.68 ha
Constructed Wetland			
Estimated requirement	0.22 ha	1.21 ha	1.43 ha

As can be seen in Table 7: Effluent Discharge Land Area Requirement the land area requirement of each system varies considerably with effluent quality and Nitrogen loading restrictions. For example Drip / Spray irrigation will require from 2.35 ha to 25.95 ha taking best case and worst case requirements.

A total of 370 ha of land has been identified as being suitable for land discharge of treated effluent. Further work into the possibility of securing long term leases on any portion of this land together with detailed soil / infiltration investigations will be required.

Overall costs for wastewater treatment systems vary considerably with each treatment and disposal method. The following tables give an indication of the level of investment required to construct each system. Prices have been sourced from recent tendered rates associated with the Jacks Point development south of Queenstown and other recent contractor's rates.

Table 8

Treatment System	Capital Cost ($ /m^3)
Packed Bed Reactor	7,000
Membrane Reactor	6,500 – 9,500
Fixed Activated Sludge	4,000
Activated Sludge	1,800 – 2,000

Table 9

Disposal System	Capital Cost ($ /ha)
Drip Irrigation (@ $5 /m)	50,000
Spray Irrigation	20 – 30,000
Infiltration Trenches (@ $85 /m)	850,000
Rapid Infiltration Trenches	As Above
Constructed Wetlands	300,000

5.3 Stormwater

There is no integrated stormwater management plan for the Cardrona area. Individual stormwater flow paths are managed directing water to the Cardrona River.

Up to this point, the impact of small scale developments on stormwater flows has been negligible when compared to the overall catchment from the valley. However, the cumulative effect of a number of small developments will have an effect on the long term management of stormwater especially at the confluence of local creeks with the Cardrona River.

Future expansion of the area should take in to account the retention and disposal of stormwater to mitigate the increased impervious surfaces created and to provide a level of treatment to the stormwater before discharge. Retention systems can then be designed and located to provide the best coverage to the existing township properties.

Reserve land vested as part of the development or land purchases will be required to site the retention systems. These systems will also have to be isolated from any existing effluent disposal systems to minimise the risk of leeching effluent contaminants.

5.4 Power

The information provided by Aurora Energy Ltd suggests that there is scope for the continued growth of the Cardrona Valley in their distribution network.

Transpower have identified future main transmission / substation upgrades at Cromwell and Frankton to cope with the increasing demand.

5.5 Telecommunications

Telecom have indicated that they will incrementally upgrade their system in response to developer demand. Contributions from developers will fund these upgrades and will often be eligible for rebates or fixed price fees.

Cost contributions range in price from approximately $100 per connection in high density urban areas to $1,000 per connection in Medium density urban areas and $2,000 per connection in rural areas.

Where considerable investment is required by Telecom, such as the laying of a main cable or construction of a new exchange, costs are apportioned on a project by project basis. The installation of a fibre-optic cable between Hillend and Cardrona may fall in to this category.

5.6 Transportation

Data provided from QLDC records and estimates produced by Traffic Design Group Ltd indicate that there has been an increase in local traffic in the last year. Orchard Road is north of Cardrona (on the outskirts of Wanaka) and the Branchburn Bridge is south of Cardrona.

The survey data shown in Table 10 shows how over the last 12 months traffic flows have increased by over 1,800 vehicle movements per day (vpd). The lack of accommodation within the Cardrona area means that visitors will travel to either Wanaka or Queenstown each day.

The development of the area will provide local accommodation and although it will not reduce the traffic volumes it will reduce the daily peak hour traffic loading.

Table 10: Traffic Survey Data

CARDRONA VALLEY ROAD COUNT LOCATION	DAILY TRAFFIC (vpd)	DATE OF COUNT SOURCE OF DATA
North of Cardrona Ski field Road	3,000	Aug 2006 TDG estimate, based on ski field activity
South of Cardrona Ski field Road	2,300	Aug 2006 TDG estimate, based on ski field activity
Between Branchburn Bridge and Riverbank Road	1,536	Feb 2005 QLDC RAMM database
Between Riverbank Road and Orchard Road	1,881	Nov 2005 QLDC RAMM database

6. CONCLUSIONS / RECOMMENDATIONS

The sustainable growth of the Cardrona Township is dependant on securing a reliable water supply source and managing that source in an effective manner. Provision of the water supply will, in an engineering sense rather than a town planning sense, dictate the number of dwellings that can be accommodated and sizing of wastewater, stormwater, power and telecommunication services will follow.

Following the QLDC water supply guidelines, the theoretical limit to the number of equivalent domestic units connected to the Cardrona Limited water supply is 103 without modification to the existing supply system.

Figure 1 highlights the potential development requirements in the existing township with 155 dwellings identified. It is noted that the greatest proportion of these properties are identified as residential units. It is worth noting Twort, Ratnayaka & Brandt, Water Supply 5th edition, provide a summary of demand characteristics for domestic water supplies throughout the developed and undeveloped world. They suggest the domestic component to be between 150 and 300 litres per person per day with an irrigation component of 400 litres per person per day in arid areas.

It appears that the irrigation component is a factor built in to the QLDC figure of 700 litres per person per day. Developers wishing to connect more properties to the existing system need to identify methods of monitoring and controlling water use and limiting the volumes of potable water used for irrigation. Methods such as metered billing, irrigation bans or schedules, rainwater collection and storage are all potential methods that should form part of an integrated demand management plan.

Securing an additional source, such as the Mount Cardrona Station surface water supply, can provide the necessary resource to allow further growth. Best management practices should be encouraged to ensure the sustainable use of this limited resource.

Wastewater disposal, on a community basis, should be investigated further. The likely requirement for the proposed Mount Cardrona Station development in the Northern Rural Visitor Zone to construct a wastewater treatment facility should be used as a catalyst to provide reticulated wastewater services to the surrounding area.

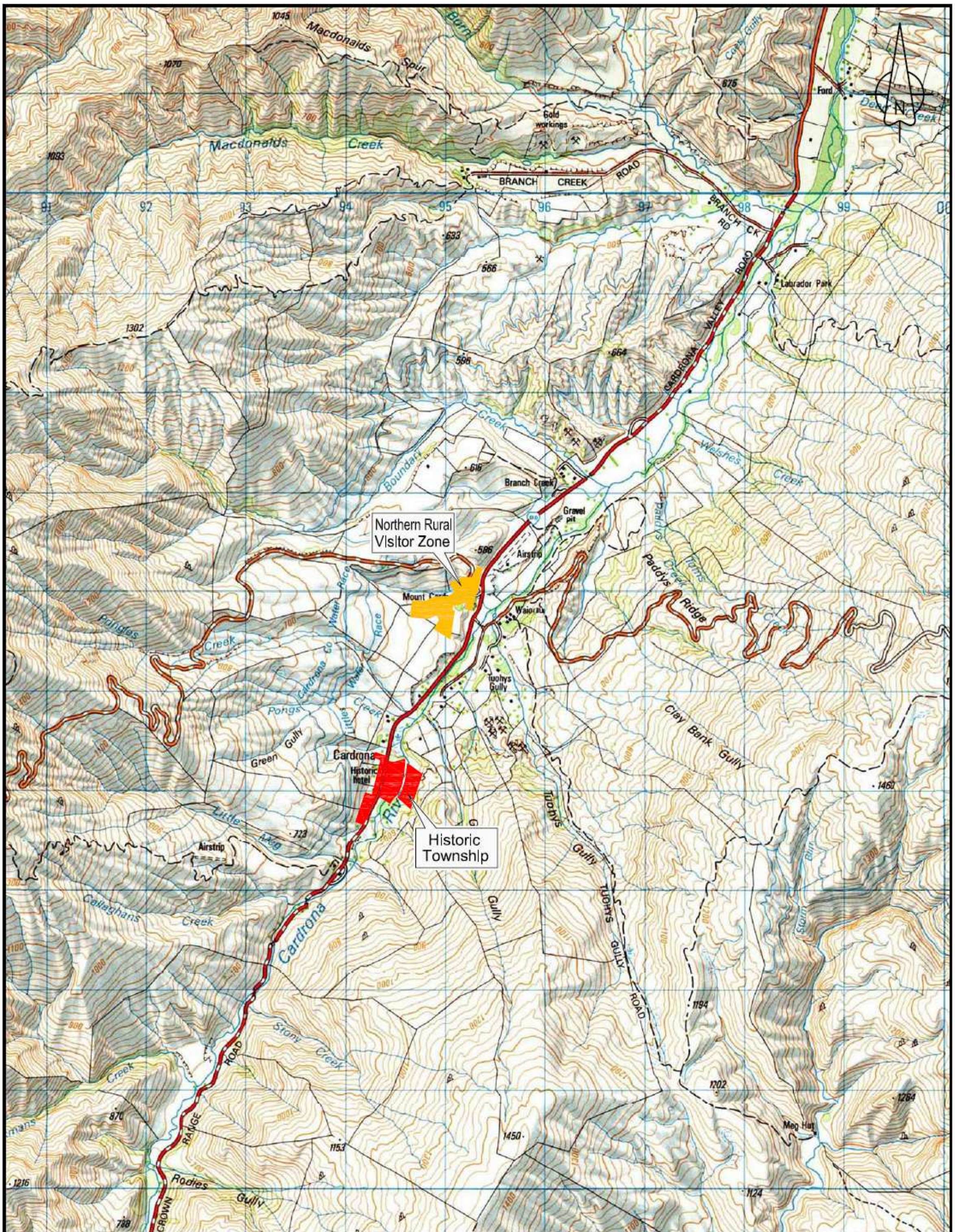
There is the potential to link the historic township with the new development with a gravity pipeline. Combinations of treatment techniques and disposal methods based on environmental requirements will dictate the land area required for the system. The historic township wastewater component is relatively minor when compared to the proposed northern development. The principal cost will be in providing reticulation to the township and laying a trunk sewer main to the treatment facility.

By providing a reticulated system, effluent discharges in the vicinity of the township community supply bore will be removed thus further protecting the potable water supply.

The development timescale suggests that the majority of the growth identified in the Cardrona Community Plan, between now and 2020, will occur in the next few years. Continued growth beyond the current levels, including the ongoing subdivision applications, is possible providing natural resources are available within the environmental limits. Innovative approaches to provide sustainable developments should be encouraged in an area where the natural resources are limited.

APPENDIX A

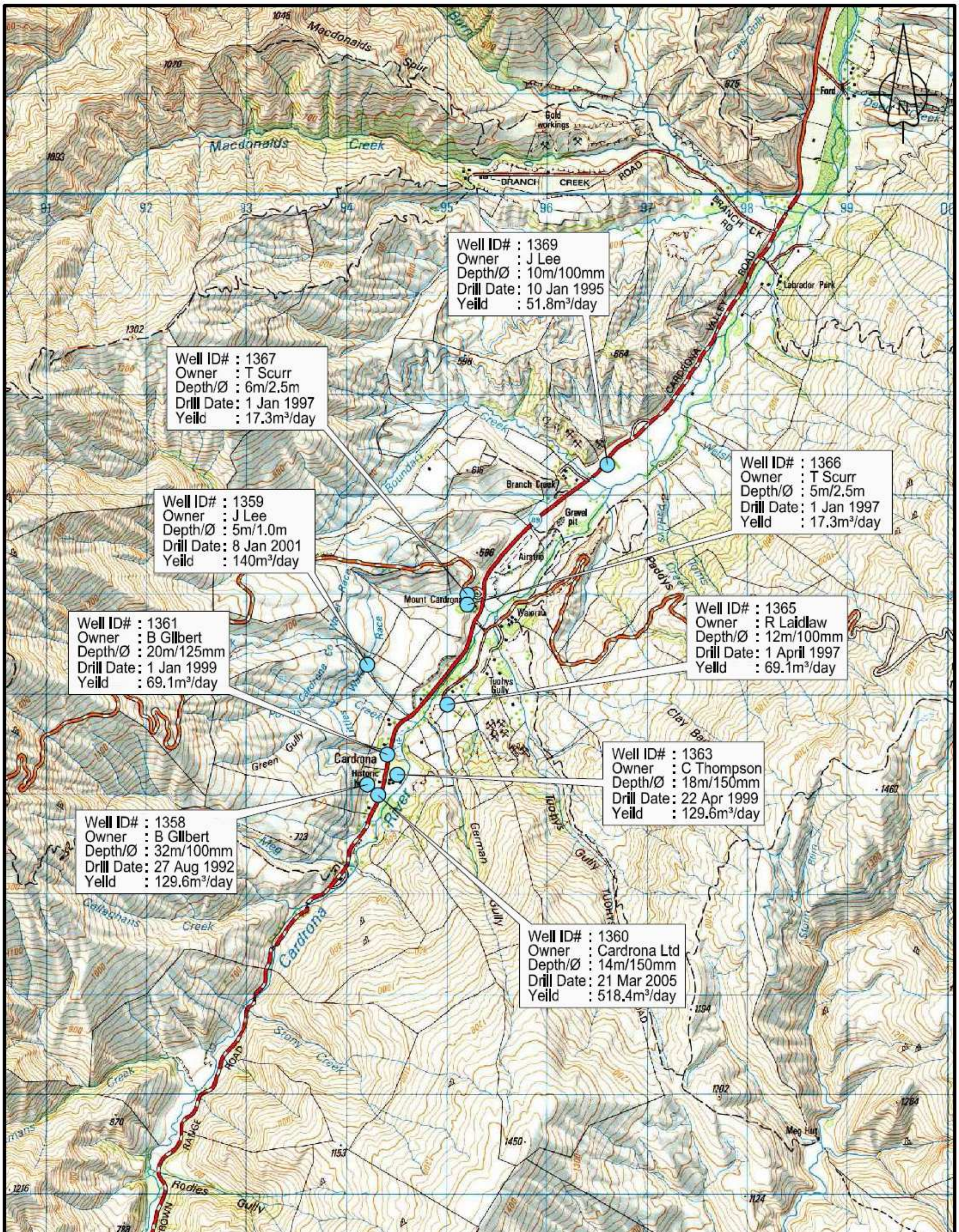
Site Location Plan



GLASSON POTTS FOWLER BNZ Armagh, 137 Armagh Street, Christchurch 8031, New Zealand Ph (03)374-6515 Fax (03)374-6516 P.O.Box 13875 Email: chch@gpf.co.nz	Site Location Plan	Scale: 1:50,000@A4 Date: November 2006 Drawing No:9205-05A Sheet 1 of 1 Sheets

APPENDIX B

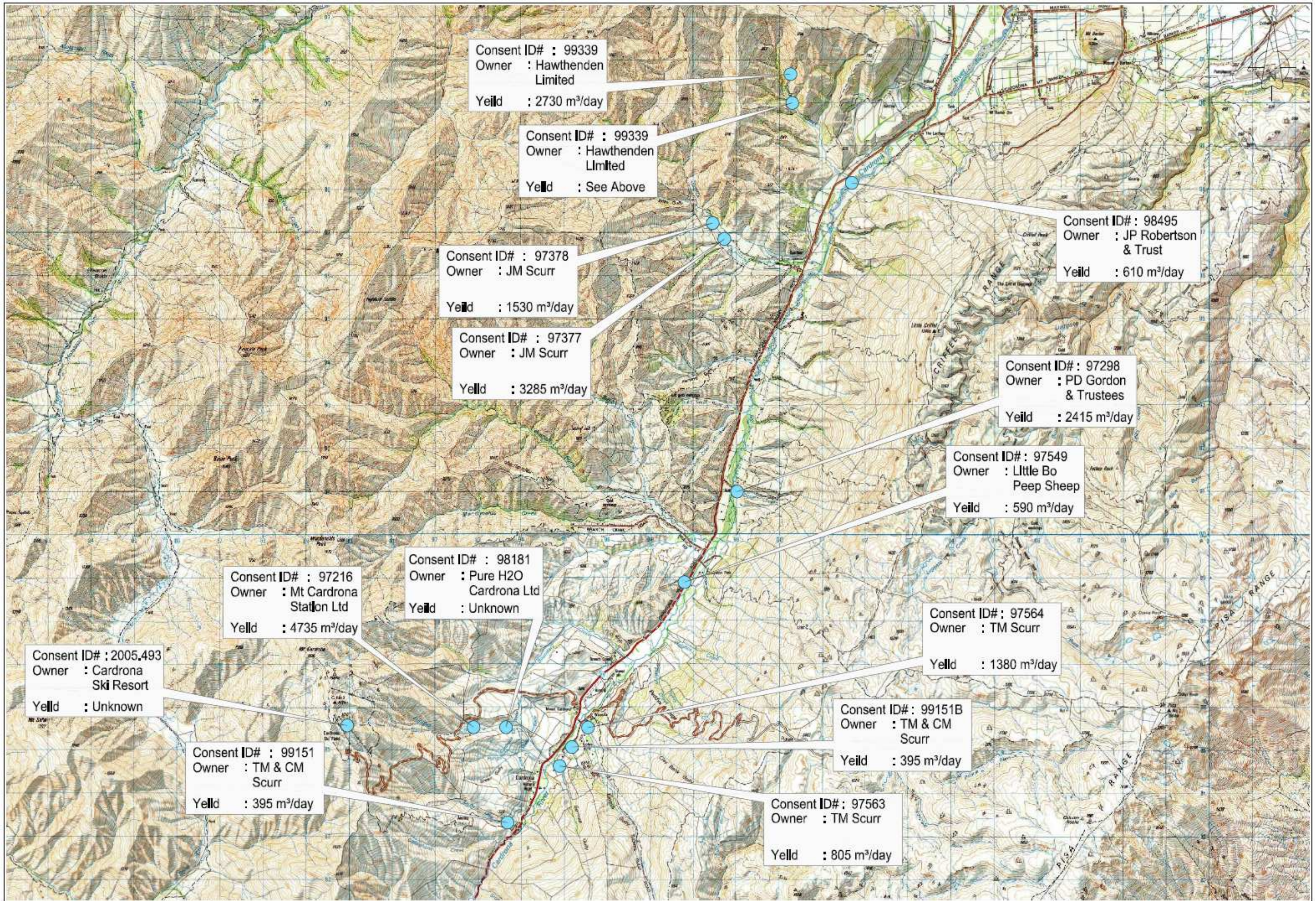
Groundwater Takes



GLASSON POTTS FOWLER BNZ Armagh, 137 Armagh Street, Christchurch 8031, New Zealand Ph (03)374-6515 Fax (03)374-6516 P.O.Box 13875 Email: chch@gpf.co.nz	Cardrona Valley Existing Bore Locations	Scale: 1:50,000@A4 Date: August 2006 Drawing No:9205-01A Sheet 1 of 1 Sheets

APPENDIX C

Surface Water Takes



GLASSON POTTS FOWLER

Designed | Origin of Levels:
Drawn AEG
Checked

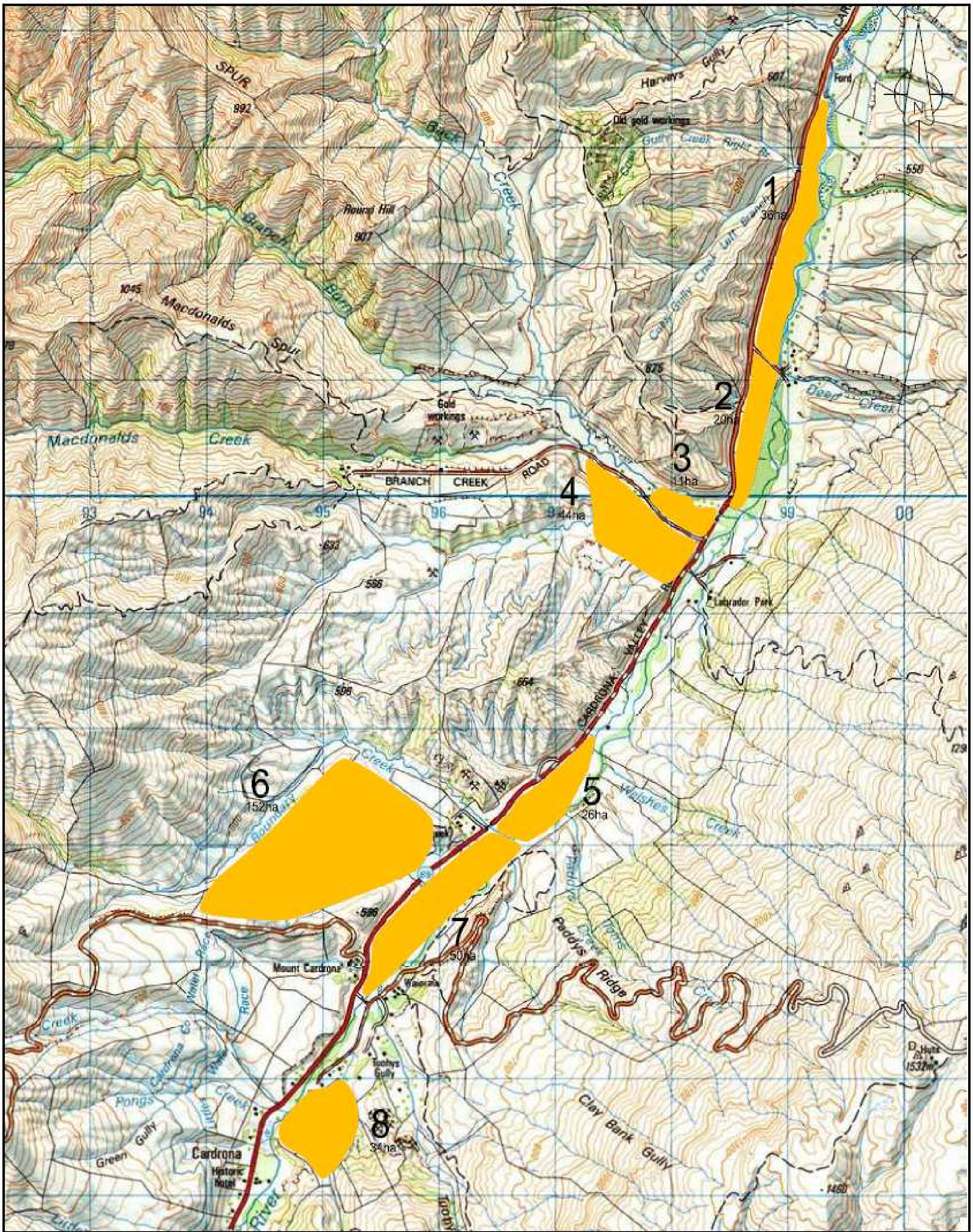
CONSENTED SURFACE WATER TAKES, CARDRONA

No.	Date	By	Amendment
A			

Scale: 1:80,000@A3
Date: September 2006
Drawing No:9205-02A
Sheet 1 of 1 Sheets

APPENDIX D

Land Treatment Areas



GLASSON POTTS FOWLER

LAND TREATMENT AREAS – CARDRONA

Scale: 1:30,000@A3
Date: October 2006
Drawing No:9205–03A
Sheet 1 of 1 Sheets

APPENDIX E

Well Drilling Bore Logs

McNEILL DRILLING CO LTD

Since 1918

Specialist in Drilling, Piling, Water Pumping and Irrigation

Fax Cover Sheet

Date: 22.08.06 **Time:**

To: TERRY HUGHES **Phone:**
Fax: 03 3746516

From: Graeme Stewart **Phone:** 03 4487 049
Fax: 03 4489 420

Re: BORE LOGS - CARDRONA. **Page 1 of**

TERRY

AVAILABLE BORE LOGS ATTACHED.

(1) CARDRONA LTD LOCATED SOUTH OF HOTEL SITE

(2) GILBERT B SITE SOUTH OF HOTEL (CARDRONA HOTEL BORE) BUT RETAINED BY GILBERT

(3) B GILBERT NORTH OF HOTEL WAS UNSUCCESSFUL.

? (4) THOMPSON? COULD BE TIM SCURRS EXCAVATED WELL SITE FOR CARDRONA TOWNSHIP SUPPLY

(5) ROSS LAIDLAW SHALLOW BORE HIGH IN IRON/MANGANESE.

(6) JOHN LEE WEST OF CARDRONA - DON'T KNOW ABOUT THIS BUT IT COULD BE A CREEK INTAKE.

(7) MOUNT CARDRONA — NO DATA

(8) THERE IS A SHALLOW EAST OF THE AIR STRIP

(9) JOHN LEE BORE TO NORTH EAST OF ROAD IS IDENTIFIED ON BORE LOG - I DOUBT IF IT HAS CONSENT

GOOD LUCK

REGARDS GRAEME STEWART

Head Office:
• Alexandra
Boundary Road
PO Box 95
Phone 03 448 7049
Fax 03 448 9420

• Christchurch
151 Waterloo Road
PO Box 16019
Phone 03 349 4443
Fax 03 349 4449

• Dunedin
Donald Street
PO Box 7021
Phone 03 488 4227
Fax 03 488 3042

• Invercargill
Otepuni Ave
PO Box 1041
Phone 03 216 6035
Fax 03 216 6010

NZDF

REG No. 1279

MCNEILL DRILLING

MCNEILL DRILLING CO. LTD

WATER BORE/WELL SUMMARY FORM

CLIENTS NAME: Cardrona Ltd c/- Dean Franklin	RESOURCE CONSENT NO:
FULL ADDRESS: Cardrona	BORE SIZE: 150mm
RAPID NO:	START DATE: 18.03.05
GRID REFERENCE: E2194308 N5583995	FINISH DATE: 21.03.05
DRILLER: Mike Simmons	
MEASURED FROM: Ground Level	MACHINE: TH60
TOTAL DEPTH BORE: 14.27	DRILL METHOD: Tubex
TOP LEADER: 13.69	
STATIC WATER LEVEL: 7.85	
SCREEN: SLOT: 2.5mm	LENGTH: 1.50
TYPE: Stainless Steel	SIZE: 140mm
PVC SLOTTED: TOP:	BASE:
SCREEN/LEADER/SUMP: 1.58	SUMP SIZE:
TOTAL CASING USED: 13.14	
AIRLIFTED/PUMPED AT: 6 litres per second	
TEST PUMP PERIOD: 5 hours	
DRAWDOWN FROM SWL: Nil	
AIR/PUMP INTAKE: 9.80	
BACTERIAL WATER TEST: Citilab	
CHEMICAL WATER TEST: Citilab	
EXTRA NOTES:	

BORE LOG:	
0.00 – 1.80	Silts
1.80 – 6.80	Silty sandy gravels boulders
6.80 – 9.00	Sandy gravels
9.00 – 14.30	Very silty sandy angular gravels and boulders
14.30 – 14.50	Clay bound gravels

Citilab Analysis Consultants

McNeill Drilling
(Boundary Rd)
P.O. Box 95
ALEXANDRA
ATTENTION: Graeme Stewart

LABORATORY ANALYSIS REPORT

#21940

Thursday, 14 April 2005

Your Order #:- D61458 Job Start:23/03/05 16:21:15

	Test start:	Test complete:	ANALYSIS	RESULT	Analytical Method	Detection Limits
	23/03/05 16:56:09	29/03/05 15:47:20	Acidity Requires CO2	38 g/m³ as CaCO3	APHA 2310, B	1 g/m³ as CaCO3
	23/03/05 16:56:10	29/03/05 10:14:26	Alkalinity to pH 4.5	48 g/m³ as CaCO3	APHA 2320, B	1 g/m³ as CaCO3
	24/03/05 09:21:10	29/03/05 10:14:53	Alkalinity to pH 8.3	<1 g/m³ as CaCO3	APHA 2320, B	1 g/m³ as CaCO3
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:56:15	14/04/05 10:54:31	Bromide (IC) Referral	<0.05 g/m³	Ion Chromatography	0.05 g/m³
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:56:19	14/04/05 10:54:38	Chloride (IC) Referral	1.0 g/m³	Ion Chromatography	0.5 g/m³
	23/03/05 16:56:37	31/03/05 17:11:20	Colour *	<0.5 C.P.U	Spectrophotometer	0.5 C.P.U.
	23/03/05 16:56:38	24/03/05 12:53:30	Conductivity	11 mS/m	APHA 2510, B	0.01 mS/m
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:56:39	14/04/05 10:54:42	Fluoride (IC) Referral	0.13 g/m³	Ion Chromatography	0.05 g/m³
	13/04/05 16:33:51	14/04/05 10:54:58	Total Hardness By Calculation	46.2 g/m³ as CaCO3	APHA 2340, C	2 g/m³ as CaCO3
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:56:59	24/03/05 16:47:57	pH	6.32 @ 20°C	APHA 4500 - H+, B	0.02 pH unit
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:57:00	14/04/05 10:55:00	Phosphate (IC) Referral	<0.4 g/m³	Ion Chromatography	0.4 g/m³
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:57:03	14/04/05 10:55:08	Sulphate (IC) Referral	4.0 g/m³	Ion Chromatography	0.5 g/m³
	23/03/05 16:57:16	24/03/05 14:06:55	Turbidity - class 1	0.65 NTU	APHA 2130, B	0.05 NTU
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:56:12	14/04/05 10:55:13	Arsenic-Total Referral	<0.001 g/m³	ICP-MS	0.001 g/m³
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:56:16	14/04/05 10:55:18	Calcium-Total (ICP) ICP-MS (Referral)	15.2 g/m³	ICP-MS	0.05 g/m³
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:56:40	14/04/05 10:55:23	Iron-Total (ICP) ICP-MS (Referral)	0.08 g/m³	ICP-MS	0.02 g/m³
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:56:42	14/04/05 10:55:24	Magnesium-Total (ICP) ICP-MS (Referral)	2.00 g/m³	ICP-MS	0.02 g/m³
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:56:55	14/04/05 10:55:27	Manganese-Total (ICP) ICP-MS (Referral)	0.0030 g/m³	ICP-MS	0.0005 g/m³
	23/03/05 16:35:51	29/03/05 16:11:00	E. coli (Quanti-Tray)	<1.0 MPN/100 mL	Inhouse	1.0 MPN/100 mL
>> Referral: Hill Laboratories, Hamilton.	23/03/05 16:56:58	14/04/05 10:55:31	Nitrate (IC) Referral	1.5 g/m³	Ion Chromatography	0.02 g/m³

Analyst's Comments: Units: In accordance with modern practice the previous 'mg/L' is now expressed as the equivalent 'g/m³'.
These samples were collected by yourselves and analysed as received at the laboratory.
The detection limits given are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
This report must not be reproduced except in full without the written consent of the signatory.

Dr. Frank Ho
Laboratory Services Manager

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The tests reported here have been performed in accordance with its terms of accreditation - with exception of any marked *, which are not accredited.

Richard Allan
Microbiology Technician

10 Tahuna Rd, P.O. Box 781, Dunedin
Telephone (03) 455 7938, Fax (03) 455 7940
Email: mail@citilab.co.nz
Website: www.citilab.co.nz

Citilab
Analysts
Consultants

Sample 85902 Cardrona Ltd Batch 21940

Determinants	Results (mg/L or specified)	MAV[1] or GV[2]	Target range	Comments
Acidity	38	-	Low	Ok
Alkalinity	48	-	Low	Ok
Bromide	<0.05	-	Low	Ok
Chloride	1.0	250	<250	Ok
Colour	<0.5	10 (CPU)	<5 (CPU)	Ok
Conductivity	11	-	<40, low	Ok
Fluoride	0.13	1.5	<0.75	Ok
Total hardness	46.2	200	<200	Soft
pH	6.32	7.0 to 8.0	7.0 to 8.5	Low*
Phosphate	<0.4	-	low	Ok
Sulphate	4.0	250	<125	Ok
Turbidity (1)	0.65	<2.5 NTU	<2.5 NTU	Ok
Total arsenic	<0.001	0.01	<0.005	Ok
Total calcium	15.2	-	low	Ok
Total iron	0.08	0.2	<0.2	Ok
Total magnesium	2.00	-	low	Ok
Total manganese	0.003	0.5	<0.5	Ok
E.coli	<1.0	<1	<1	Ok
Nitrate	1.5	50	<25	Ok

[1]MAV means Maximum Acceptable Values quoted from Drinking Water Standards for New Zealand 2000. [2]GV means Guideline Values from the same source above. mg/L equals to g/L and is often quoted as ppm (parts per million).

Overall comment:

The water is deemed to be **SUITABLE** for drinking purpose with respect to the tested parameters according to the New Zealand Drinking Water Standards. The low pH indicated that the water was "aggressive" and as such may cause corrosion on metal surfaces under certain circumstances.

Frank Ho

Dr. Frank Ho
Manager
Laboratory Services

10 Tahuna Rd, P.O. Box 781, Dunedin
Telephone (03) 455 7938, Fax (03) 455 7940
Email: mail@citilab.co.nz

MCNEILL DRILLING

MCNEILL DRILLING CO. LTD

WATER BORE/WELL SUMMARY FORM

CLIENTS NAME: CARDRONA HOTEL	BORE SIZE: 125
FULL ADDRESS: CARDRONA VALLEY	START DATE: 17-9-98
RAPID NO:	FINISH DATE: 17·9·98
GRID REFERENCE:	
DRILLER: M SIMMONS	MACHINE: TH 60
~~MEASURED FROM~~: G/L	~~DRILL METHOD~~: TOBEX
TOTAL DEPTH BORE: 11·600	
TOP LEADER: 10·430	
SWL: 5·540	
SCREEN: SLOT: 100	LENGTH: 1-000
TYPE: STAINLESS STEEL	SIZE: 100 mm
PVC SLOTTED: TOP:	BASE:
SCREEN/LEADER/~~SUMP~~: 1·120	SUMP SIZE:
TOTAL CASING USED: 11-000	
~~AIRLIFTED~~/PUMPED AT: 115 LPM	
TEST PUMP PERIOD: 1 HOURS 15 MIN	
DRAWDOWN FROM SWL: 7-730	
~~AIR~~/PUMP INTAKE: 9-600	
BACTERIAL WATER TEST: OTAGO HEALTH	
CHEMICAL WATER TEST: INVERCARGILL CITY	

EXTRA NOTES:

BORE LOG:

00.000 – 2·200 bouldery
2·200 – 3·400 very silty gravels
3·400 – 11·700 VERY SANDY SILTY GRAVELS

INVERCARGILL CITY COUNCIL

WATER TESTING LABORATORY

Lake Street Invercargill
ph(03) 216 2189 fax (03) 216 2789

WORKS AND SERVICES DIRECTORATE

When calling please ask for: Your reference: Our reference:

21-Sep-98

Lab Reference Number B 2004

McNeill Drilling Water Test Report: Alexandra

Name:	Cardrona Hotel	
Address:	Cardrona	
Order No:	13740	
Date Received:	17/09/98	11:30 AM
Date Sampled:	16/09/98	04:20 PM
Sample Description:	Water	

PHYSICAL

pH:		6.80
pH after Aeration:		7.92
Turbidity:	NTU	2.44
Total Hardness:	mg per litre as $CaCO_3$	42
Calcium Hardness:	mg per litre as $CaCO_3$	30
Magnesium Hardness:	mg per litre as $CaCO_3$	12

CHEMICAL

Iron:	mg per litre	0.16
Nitrate:	mg per litre as N	0.53
Ammonia:	mg per litre as N	0.01
Chloride:	mg per litre	2
Manganese:	mg per litre	0.01

A soft water sample that was slightly corrosive.

P. A. Rodmell
City Chemist

22.Aug. 2006 16:12 MCNEILL DRILLING ALEXANDRA No.7403 P. 7

MCD
McNEILL DRILLING

MCNEILL DRILLING CO. LTD

WATER BORE/WELL SUMMARY FORM

CLIENTS NAME: ROSS LAIDLAW	BORE SIZE: 100mm
FULL ADDRESS: CARDRONA VALLEY	START DATE: 21. 4. 97
RAPID NO:	FINISH DATE:
GRID REFERENCE:	21. 4. 97
DRILLER: JOHN STEVENSON	MACHINE: GEMCO
MEASURED FROM: GROUND LEVEL.	DRILL METHOD:
TOTAL DEPTH BORE: 8·10 METRES	TUBEX 115.
TOP LEADER: 6.95 METRES.	
SWL: 2·40m.	
SCREEN: SLOT: 100/1000	LENGTH: 0·75m
TYPE: STAINLESS STEEL	SIZE: 4" T.S.
PVC SLOTTED: TOP: -	BASE: -
SCREEN/LEADER/SUMP: 1.15 METRES	SUMP SIZE: -
TOTAL CASING USED:	
AIRLIFTED/PUMPED AT: 540 LITRES/HOUR	
TEST PUMP PERIOD: 5 HOURS - MIN	
DRAWDOWN FROM SWL: 3·10 METRES	
AIR/PUMP INTAKE:	
BACTERIAL WATER TEST:	
CHEMICAL WATER TEST: YES	

EXTRA NOTES: DRILLED TO 15.10m WITH T115 STAINLESS STEEL SCREEN PLACED TO 8.10 METRES AND 100mm CASING TO 0.40 METRES ABOVE GROUND

BORE LOG:

00.000

MCD31.5/97

Invercargill city council
"CITY OF WATER AND LIGHT"

WATER TESTING LABORATORY

Lake Street Invercargill
ph(03) 216 2189 fax (03) 216 2789

19-Apr-00 **Lab Reference Number B 1364**

McNeill Drilling Water Test Report: Alexandra

Name:	Laidlaw	R.
Address:	Cardrona	
Order No:	11964	
Date Received:	23/04/97	12:35
Date Sampled:	22/04/97	12:00
Sample Description:	Water	

BACTERIOLOGICAL

Total Coliform:	Colony Forming Units per 100ml	
Faecal Coliform:	Colony Forming Units per 100ml	
Enterococci:	Colony Forming Units per 100ml	

PHYSICAL

pH:		7.03
pH after Aeration:		8.33
Turbidity:	NTU	98
Total Hardness:	mg per litre as CaCO3	70
Calcium Hardness:	mg per litre as CaCO3	55
Magnesium Hardness:	mg per litre as CaCO3	15

CHEMICAL

Iron:	mg per litre	9.78
Nitrate:	mg per litre as N	0.01
Ammonia:	mg per litre as N	0.02
Chloride:	mg per litre	6

A moderately soft water sample. The iron was high and would lead to taste and staining problems. The high turbidity was probably due to the sand in the sample.

pp **P. A. Rodmell**
City Chemist

PKRene

Invercargill
city council
"CITY OF WATER AND LIGHT"

WATER TESTING LABORATORY

Lake Street Invercargill
ph(03) 216 2189 fax (03) 216 2789

15-May-00

Lab Reference Number B 3119

McNeill Drilling Water Test Report: Alexandra

Name:	Laidlaw	Ross
Address:		
Order No:	17002	
Date Received:	12/05/00	11:30
Date Sampled:	11/05/00	
Sample Description:	Water	

PHYSICAL

pH:		7.80
pH after Aeration:		7.23
Turbidity:	NTU	99.6
Total Hardness:	mg per litre as CaCO3	70
Calcium Hardness:	mg per litre as CaCO3	46
Magnesium Hardness:	mg per litre as CaCO3	24

CHEMICAL

Iron:	mg per litre	1.39
Nitrate:	mg per litre as N	0.19
Ammonia:	mg per litre as N	0.01
Chloride:	mg per litre	4
Manganese:	mg per litre	0.04

A moderately soft water. The iron and magannese levels may cause taste and staining problems.

pp **P. A. Rodmell**
City Chemist
RCBurns.

SOUTHLAND

MCNEILL DRILLING

MCNEILL DRILLING CO. LTD

WATER BORE/WELL SUMMARY FORM

CLIENTS NAME: John Lee	RESOURCE CONSENT NO:
FULL ADDRESS: Cardrona Road, Cardrona	BORE SIZE: 150mm PVC
RAPID NO: 1655	START DATE: 24.02.2006
GRID REFERENCE: E2198370 N5589175	FINISH DATE: 24.02.2006
DRILLER:	
MEASURED FROM: Top of PVC (150mm below ground level)	MACHINE:
TOTAL DEPTH BORE: 6.51 metres	DRILL METHOD:
TOP LEADER:	
STATIC WATER LEVEL: 4.29 metres	
SCREEN :SLOT: Slots unknown	LENGTH:
TYPE:	SIZE:
PVC SLOTTED: TOP:	BASE:
SCREEN/LEADER/SUMP:	SUMP SIZE:
TOTAL CASING USED:	
AIRLIFTED/PUMPED AT: 120 Litres Per Minute	
TEST PUMP PERIOD: 1 Hour	
DRAWDOWN FROM SWL: 20mm	
AIR/PUMP INTAKE: 6.000 metres	
BACTERIAL WATER TEST: Citilab	
CHEMICAL WATER TEST: Citilab	
EXTRA NOTES:	
BORE LOG:	
00.00-	

22 Aug. 2006 16:12 MCNEILL DRILLING ALEXANDRA No.7403 P. 11

Citilab
Analysts
Consultants

McNeill Drilling
(Boundary Rd)
P.O. Box 95
ALEXANDRA
ATTENTION: Graeme Stewart

LABORATORY ANALYSIS REPORT

#25587

Wednesday, 15 March 2006

Your Order #:- 62870 Job Start: 28/02/06 08:09:09

	Test start:	Test complete:	ANALYSIS	RESULT	Analytical Method	Detection Limits
	5/03/06 13:57:41	6/03/06 09:10:01	Acidity Requires CO2	23 g/m³ as CaCO3	APHA 2310, B	1 g/m³ as CaCO3
	28/02/06 14:58:32	28/02/06 15:38:05	Alkalinity to pH 4.5	55 g/m³ as CaCO3	APHA 2320, B	1 g/m³ as CaCO3
	28/02/06 14:58:32	28/02/06 15:38:07	Alkalinity to pH 8.3	<1 g/m³ as CaCO3	APHA 2320, B	1 g/m³ as CaCO3
	3/03/06 18:28:37	5/03/06 14:11:08	Bromide (IC) Referral	0.08 g/m³	Ion Chromatography	0.05 g/m³
	3/03/06 18:29:53	5/03/06 14:11:12	Chloride (IC) Referral	0.93 g/m³	Ion Chromatography	0.5 g/m³
	28/02/06 14:58:34	28/02/06 15:09:55	Colour *	<0.5 C.P.U	Spectrophotometer	0.5 C.P.U.
	28/02/06 17:29:39	1/03/06 13:22:12	Conductivity	12 mS/m	APHA 2510, B	0.01 mS/m
	3/03/06 18:28:22	5/03/06 14:11:06	Fluoride (IC) Referral	0.10 g/m³	Ion Chromatography	0.05 g/m³
	15/03/06 13:33:02	15/03/06 14:45:25	Total Hardness By Calculation	55.4 g/m³ as CaCO3	APHA 2340, C	2 g/m³ as CaCO3
	28/02/06 14:54:51	28/02/06 16:31:03	pH	6.81 @ 20°C	APHA 4500 - H+, B	0.02 pH unit
	3/03/06 18:28:08	5/03/06 14:11:04	Phosphate (IC) Referral	<0.4 g/m³	Ion Chromatography	0.4 g/m³
	3/03/06 18:30:02	5/03/06 14:11:14	Sulphate (IC) Referral	4.2 g/m³	Ion Chromatography	0.5 g/m³
	28/02/06 15:35:01	28/02/06 16:34:22	Turbidity - class 1	0.65 NTU	APHA 2130, B	0.05 NTU
>> Referral: Hill Laboratories, Hamilton.	5/03/06 13:57:34	15/03/06 14:45:16	Arsenic-Total Referral	<0.001 g/m³	ICP-MS	0.001 g/m³
>> Referral: Hill Laboratories, Hamilton.	5/03/06 13:57:20	15/03/06 14:45:04	Calcium-Total (ICP) ICP-MS (Referral)	18.2 g/m³	ICP-MS	0.05 g/m³
>> Referral: Hill Laboratories, Hamilton.	5/03/06 13:57:53	15/03/06 14:45:31	Iron-Total (ICP) ICP-MS (Referral)	0.05 g/m³	ICP-MS	0.02 g/m³
>> Referral: Hill Laboratories, Hamilton.	5/03/06 13:57:22	15/03/06 14:45:10	Magnesium-Total (ICP) ICP-MS (Referral)	2.41 g/m³	ICP-MS	0.02 g/m³
>> Referral: Hill Laboratories, Hamilton.	5/03/06 13:57:19	15/03/06 14:45:07	Manganese-Total (ICP) ICP-MS (Referral)	0.0016 g/m³	ICP-MS	0.0005 g/m³
	28/02/06 10:07:54	2/03/06 09:04:34	E. coli (Quanti-Tray)	<1 MPN/100 mL	Inhouse	1.0 MPN/100 mL
	3/03/06 18:27:58	5/03/06 14:11:03	Nitrate (IC) Referral	0.60 g/m³	Ion Chromatography	0.02 g/m³

Analyst's Comments: Units: In accordance with modern practice the previous 'mg/L' is now expressed as the equivalent 'g/m³'.
These samples were collected by yourselves and analysed as received at the laboratory.
The detection limits given are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.
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Dr. Frank Ho
Laboratory Services Manager

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The tests reported here have been performed in accordance with its terms of accreditation - with exception of any marked *, which are not accredited.

Richard Allan
Microbiology Technician

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Telephone (03) 455 7938, Fax (03) 455 7940
Email: mail@citilab.co.nz
Website: www.citilab.co.nz

Citilab
Analysts
Consultants

laboratory

Sample 10059 John Lee - bore water

Batch 25587

Determinants	Results (mg/L or specified)	MAV[1] or GV[2]	Target range	Comments
Acidity	23	-	Low	Ok
Alkalinity	55	-	Low	Ok
Bromide	0.08	-	Low	Ok
Chloride	0.93	250	<250	Ok
Colour	<0.5 CPU	10 (CPU)	<5 (CPU)	Ok
Conductivity	12 mS/m	-	<40, low	Ok
Fluoride	0.10	1.5	<0.75	Ok
Total hardness	55.4	200	<200	Soft
pH	6.81 pH unit	7.0 to 8.0	7.0 to 8.5	Low*
Phosphate	<0.4	-	low	Ok
Sulphate	4.2	250	<125	Ok
Turbidity (1)	0.65 NTU	<2.5 NTU	<2.5 NTU	Ok
Total arsenic	<0.001	0.01	<0.005	Ok
Total calcium	18.2	-	low	Ok
Total iron	0.05	0.2	<0.2	Ok
Total magnesium	2.41	-	low	Ok
Total manganese	0.0016	0.5	<0.5	Ok
E.coli	<1 per 100 mL	<1	<1	Ok
Nitrate	0.60	50	<25	Ok

[1]MAV means Maximum Acceptable Values quoted from Drinking Water Standards for New Zealand 2000. [2]GV means Guideline Values from the same source above.
mg/L equals to g/m³ and is sometimes quoted as ppm (parts per million).

Overall comment:
The water is deemed to be **SUITABLE** for drinking purpose with respect to the tested parameters according to the guideline values in The New Zealand Drinking Water Standards (NZDWS). The pH was below the desirable range and as such may cause corrosion to metals under certain circumstances in the long run.

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