Wastewater treatment and land treatment at Jacks Point Development, Queenstown

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ABSTRACT

The Jacks Point development is adjacent to Lake Wakatipu, near Queenstown, in southern New Zealand. It is resort style with several large residential zones, separate individual large house sites, a lodge and restaurant, a golf course and clubhouse, a commercial village. Queenstown has a very high temporary peak population, with permanent residents averaging 1.6 people per household and peaking at around five people per household days during summer. Four of the six soil types underlying the development area were selected as suitable for land treatment, at application rates ranging from 6 to 12 mm/day, via subsurface drip irrigation. Decentralised treatment and land treatment was chosen as the preferred wastewater treatment method using packed bed technology and sub surface drip irrigation. Nitrogen loading was the critical issue when consenting the discharge, with Otago Regional Council wanting to ensure that post-development nutrient leaching from the entire development was significantly less than pre-development. Nutrient budgets were undertaken (using various models) and a post-development total N leached value of 75% of the calculated pre-development value was adopted as a consent condition.

Keywords: Wastewater cluster treatment, land treatment, nitrogen budget, dripline irrigation.

INTRODUCTION

This paper describes the initial concepts, preliminary design and consenting phases of the project and how this was achieved with a very large development located in a potentially sensitive environment. The detailed design and tendering is complete and construction of Stages N1 and N5 (167 and 105 lots) is nearly at the commissioning stage.

GENERAL CONCEPT

"Just 15 minutes away from the centre of Queenstown is Jacks Point, a master plan of complimentary neighbourhoods set within 1,000 acres of unspoilt rolling grasslands, montane highlands and spreading downs" – description taken from Jacks Point web site, www.jackspoint.com

The Jacks Point development is eight kilometres south of Frankton, on the shores of Lake Wakatipu, near Queenstown in southern New Zealand (see Figure 1). The 420 ha site was a stud cattle farm, but is now being transformed into a residential outlier to Queenstown. The development is set in an area of outstanding natural landscapes and panoramic mountain views, which has climatic extremes (hot summers, cold winters including ice and snow).

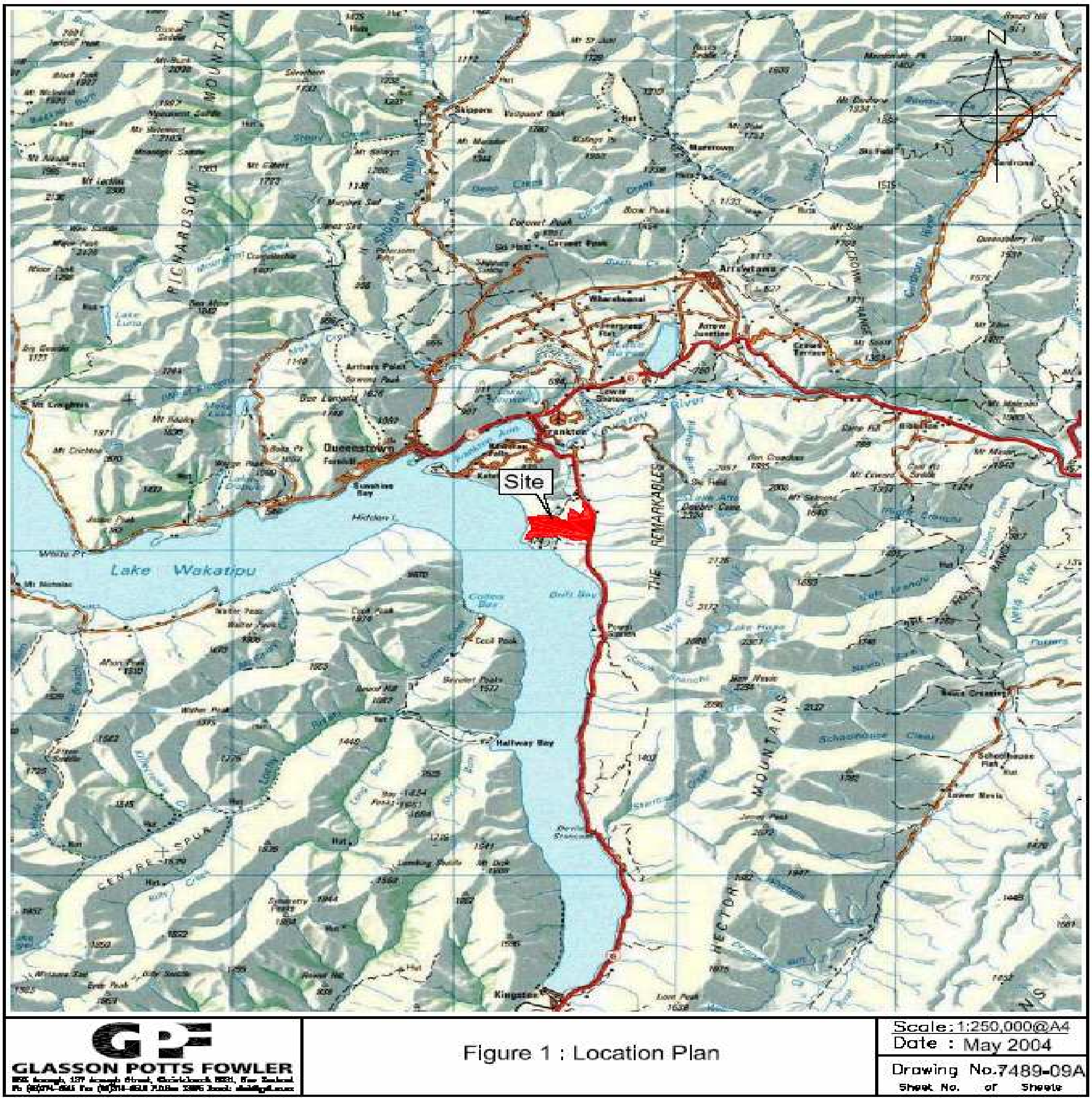

Figure 1. Site location.

The Jacks Point development is resort-style comprising 800 residential lots, 300 to 600 apartments and a 60 room lodge, an 18 hole international standard golf course and clubhouse, and village. Infrastructure planning (especially water supply, roading, gas, power, telecommunications) has also involved two adjoining developments to the north and south (known as "Coneburn") which together may contain up to 3,000 residential lots and apartments.

Detailed geological, soil, topographical, vegetation and visual assessment surveys were undertaken at project commencement. Drilling records from previous site investigations were also sourced.

Infrastructure planning commenced in 2002 to provide the necessary supporting information for an application to vary the District Plan (made by Queenstown Lakes District Council

(QLDC), the district council in the area). This included wastewater treatment and disposal planning. Two options were considered:

- Connection to the local QLDC wastewater treatment plant (WWTP); or
- On-site treatment and disposal.

The QLDC WWTP was somewhat remote from the site, and QLDC was facing the requirement to obtain a new discharge consent for the WWTP. So on-site treatment and disposal was the preferred option and fitted well with the company philosophy.

Ian Gunn of Auckland University was engaged to provide a wastewater concept design report. Decentralised treatment and disposal to ground was chosen as the preferred method.

The maximum built density is 5%, leaving 95% open space (this includes ponds, streams, roads, parking areas, the golf course and landscape planting). Treated effluent use for on-site irrigation was considered, particularly for the golf course. This was later discounted due to concerns over adding complexity to the consent process, particularly if the preferred disposal method (spray irrigation) was used. In addition, subsurface irrigation was known to result in uneven patterns of grass growth that was considered unsuitable for golf course fairways.

Consenting process

Glasson Potts Fowler (GPF) were selected to undertake detailed soil testing, preliminary design, resource consent application and design. Construction Management Services (CMS) role was as infrastructure manager.

Soil testing and preliminary design were completed in April 2004. The preliminary design was peer reviewed by Ian Gunn and the consent application lodged with the Otago Regional Council (ORC) in July 2004.

The application was notified in February 2005. Only three submissions were received, which in itself is of note (compared to other notified land use consent applications in the Queenstown area). One submission was in support, one in opposition and one neither opposed nor supported the application, with no submitters wishing to be heard. The hearing was in June 2005 and the decision issued in July 2005.

Jacks Point Ltd filed an objection to the Environment Court on two points, both of which were subsequently negotiated and agreed to with Otago Regional Council. The final consent was issued in November 2005, for a term of 20 years. The consent permits discharges from seven separate treatment and disposal sites, totalling 844 m^3 wastewater/ day. The consent requires treatment and disposal by:

- Interceptor tanks (STEP/STEG);
- Recirculating packed bed technology;
- Minimum retention of 24 hours; and
- Maximum rate of subsoil irrigation 12 mm per day (6 mm per day for the lodge).

Other conditions specify that the disposal areas may be used for sheep grazing, grass and other landscape planting. No buildings, roading, hardstand, tennis courts, bowling greens or other intensive uses like golf greens and tees are permitted over the disposal areas. Other conditions specify ongoing monitoring and reporting requirements to the Otago Regional Council.

Construction

Construction began in September 2004 on earthworks for the golf course and roading. The golf course construction is essentially complete and is now growing in. Water supply construction (for domestic supply for Jacks Point, the two adjoining developments and golf course irrigation) commenced in July 2005 and was completed in January 2006. A separate consent allows a maximum take from Lake Wakatipu (for water supply purposes) of 225 L/s. Road construction earthworks, drainage and base course is largely complete. The first residential areas are to be completed by May 2006 and the first houses should be completed soon after. The new entry off State Highway 6 will come into use then.

FIELD INVESTIGATIONS

Geological, soil, topographical and vegetation surveys were undertaken at project commencement. Only the investigations relevant to wastewater treatment and land-based disposal are discussed here.

Geology and soils

The area has been influenced by glacial events, some as recent as 18,000 years ago. These have left various glacial deposits, predominantly glacial till, over which recent alluvial and loess material has been deposited. In some locations, the glacial till has been deposited on schist bedrock.

Landcare Research mapped soils on the site in 2001. GPF staff undertook on-site soil investigations in August 2002. The investigation examined soil profiles up to a depth of five metres at 21 locations. A number of shallow holes were also dug to determine variability. The soil groups corresponded with the soil types identified in 2001.

The soil boundaries are presented in Figure 2. Of the six soil types identified, four have been considered suitable for land treatment and these are summarised below.

- *Wanaka* soils cover most of the rolling hill areas, except hilltops and rocky outcrops. They are formed in glacial material, with till more common on the western side and the eastern side formed from alluvial glacial material (glacial outwash). The glacial material is hard/compacted at a depth of about 500 mm and in the case of the western side, overlies schist at about 1,000 to 2,000 mm depth. No bedrock was encountered on the eastern side;

- *Blackstone* soils cover most hilly areas and rocky outcrops. They are confined to the western side. They have a soil covering of typically less than 500 mm over schist. This decreased towards the ridge tops and was deeper in depressions between ridges. The depth is also variable depending on the horizontal bedding plane of the underlying schist;

- *Moke* soils are located at transitions between Wanaka and Frankton soils. This soil type appears to be typical of old lake beaches. They are characterised by relatively free draining gravels. The site visit indicated that their area (at least hydraulic properties) may not be as extensive as that indicated in the 2001 Landcare Research report;

- *Pigburn* soils are located in the two major valley floors on the eastern side of the site. They appear to be productive free draining soils with sandy/gravely lower horizons. Water passing through these soils is likely to recharge groundwater in the area. Soils in the northern valley have a higher gravel/stone content closer to the surface;

Soil infiltration, water retentivity and nutrient characteristics were measured. There had been 42 mm of rainfall in the preceding three days, so infiltration rates stabilised very quickly.

Using the double-ring infiltrometer falling head method, measurements were taken to determine the soil saturated hydraulic conductivity (K_{sat}). This test provided an indication as to the rate at which water will enter the soil under saturated conditions, mainly through macro-pores. In addition to the double-ring infiltrometer method, percolation rates were assessed within excavated holes. This was undertaken to assess subsoil infiltration characteristics.

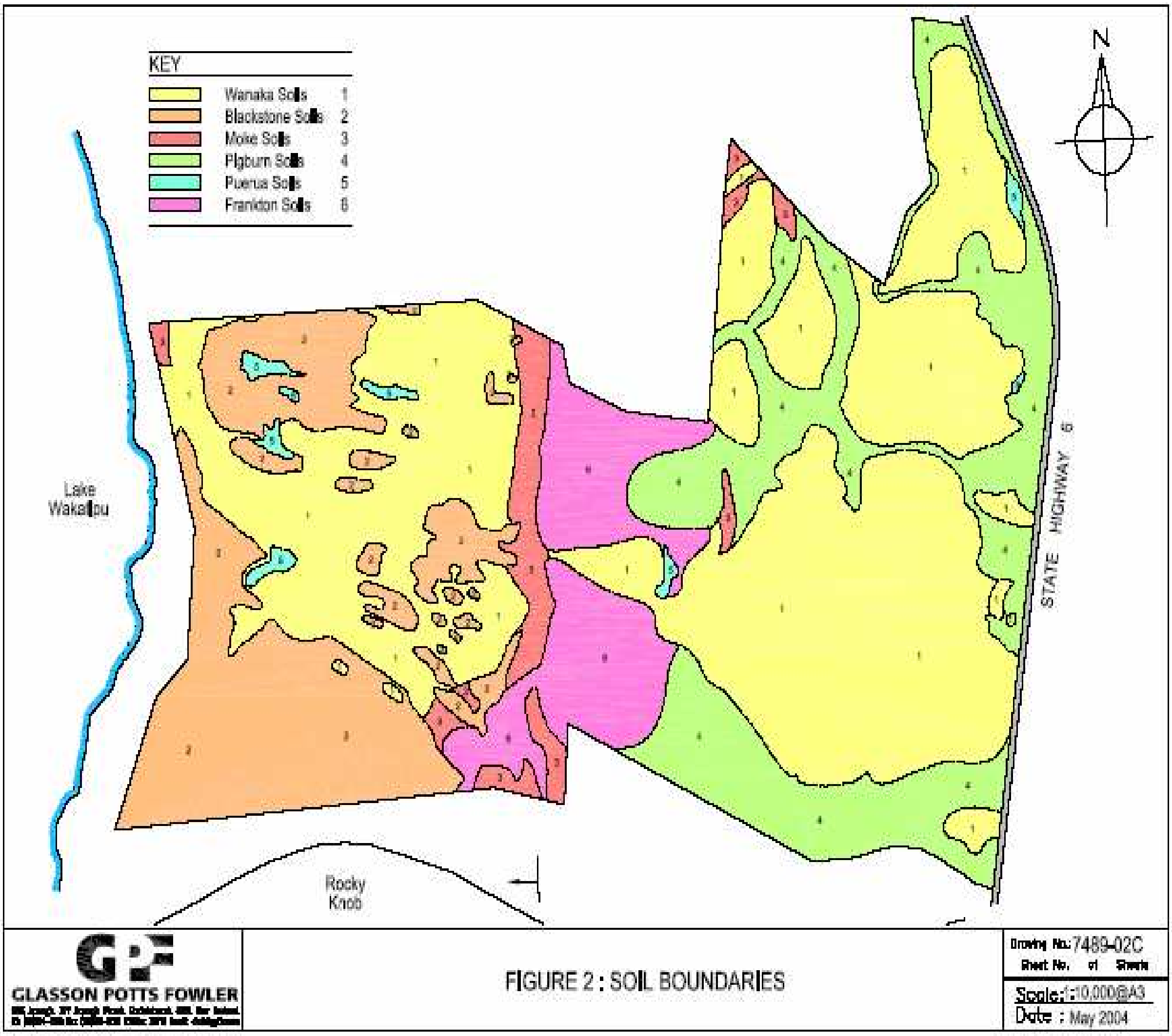

Figure 2. Soil boundaries.

In order to determine soil water-transmitting and water-holding properties, soil retentivity characteristics were assessed in-situ using plate permeameters. The plate permeameter test was considered appropriate for this particular investigation because it indicated the soil's unsaturated hydraulic characteristics. This includes information on the soil's ability to retain water at various levels of suction, or, matrix potential (Ψ_m). In theory, by supplying water to the soil under suction, the soil's macro-pores will not fill with water, so only unsaturated flow can occur. So this test identifies the transition zone between the macro-pore and micro-pore flow, giving an indication of water sorption capabilities. Identifying this transition enables assessment of application rates, which avoid mass flow and/or preferential flow through the soil's larger macro-pores. The intended matrix potentials (Ψ_m) ranged from -100 mm to -20 mm. Other experiments of similar nature have proven that these matrix potentials (Ψ_m) give a good indication of soil-water characteristics, particularly micro-pore, meso-pore, and macro-pore flow respectively.

In addition to using plate permeameters, the gravimetric water content of samples at three matrix potentials was determined. These included field capacity (-10 kPa), stress point (–100 kPa) and permanent wilting point (–1,500 kPa). These parameters, in conjunction with the soil's bulk density, can be used when designing irrigation and land treatment systems to avoid over application/irrigation. It is often recommended that an application should not exceed 50 % of the difference in the soil's saturated capacity and field capacity (NZLTC, 2000).

Soil nutrient analyses was undertaken to provide an indication of the soil's ability to retain contaminants and nutrients discharged in wastewater. High Cation Exchange Capacities (CEC) and organic matter content indicate a high potential to absorb contaminants/nutrients. The ratio of various nutrients also indicates the potential for contaminants/nutrients to be retained, and the potential for nutrient imbalances, which may lead, to poor soil and plant health. Soil nutrient analyses also provided an opportunity to benchmark soil conditions prior to development. Soil samples were typically taken over the top 75 mm (main plant rooting depth). A schematic cross section of how the various soils at the site inter-relate, based on the above mentioned soils report and other reports referenced in it, is indicated in Figure 3.

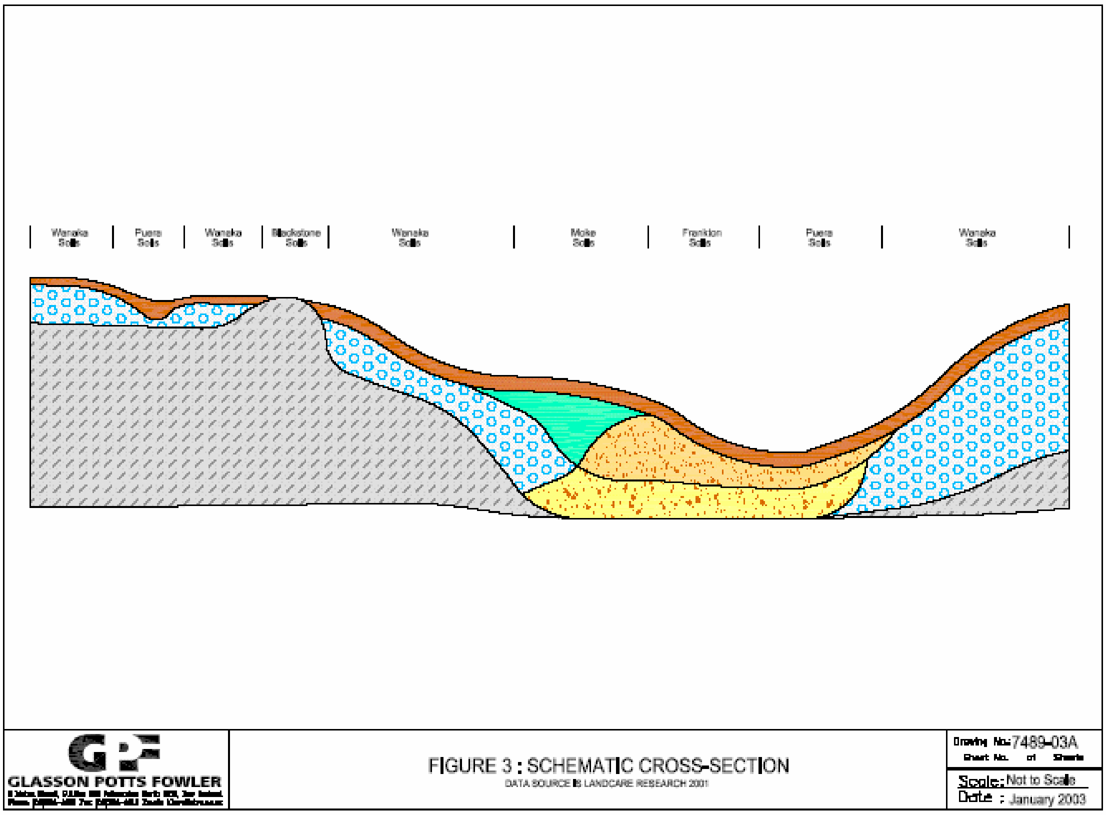

Figure 3. Schematic strata cross section.

RESULTS

The results presented in Table 1 indicate several important features in relation to site infiltration characteristics. The sorbtivity results identifies three distinctive changes in infiltration rates in regard to changes in Ψ_m, giving an indication of the three phases of infiltration – water drainage, water conduction and water retention.

Table 1. Average soil retentivity and infiltration charateristics (mm/hr).

Soil Type	-100 mm	-40 mm	-20 mm	$K_{(sat)}$ Rings
Frankton	0.5	1.0	3.0	3
Moke	4.0	12.0	20.0	18
Pigburn	3.0	17.0	26.5	43
Blackstone	2.5	10.0	30.0	80

In all tests, it appears that at Ψ_m -100mm, the infiltration rate is relatively low. This provides an indication of water retention in micro-pores with slow movement indicating capillary flow. It is possible that recent rain could have resulted in micro-pore volume being occupied and therefore reduced sorption from what may be observed in drier conditions. When the Ψ_m was adjusted to -40 mm, the infiltration rate increased in all of the tests, suggesting a more rapid capillary flow where the transmission pores, or meso-pores, play the dominant role in infiltration. This is the critical phase when assessing the soils ability to absorb water, while retaining it at the same time, as it identifies the transition zone between macro-pore and micro-pore flow.

When the Ψ_m was adjusted to -20mm, the infiltration rate increased significantly, to a rate similar to K_{sat} (measured using the infiltration rings). This suggests that at this Ψ_m, non-capillary porosity plays the major role, where infiltration via macro-pore flow is dependent on gravity.

The gravimetric results indicate that at field capacity, there is the potential for about 36 mm of water to be stored in every 100 mm depth of soil, with all soil groups being very similar. The calculated values for Total Water Holding Capacity (TWHC) and Plant Available Water Holding Capacity (PAWHC) are typical of silt loam material (McLaren and Cameron, 1996).

Silt loam soils similar to those observed at the site typically have a soil porosity of 60 % (McLaren and Cameron, 1996) and a bulk density of about 1.2 g/cm^3 has been reported from the retentivity analyses. Assuming the soil is fully saturated, this would mean that the soil was able to store 72 mm of water per 100 mm of soil depth. Based on this recommendation, a single application should not exceed 18 mm.

AS/NZS 1547 (2000) recommends daily loading rates of 1 to 10 % of the soil's saturated hydraulic conductivity (K_{sat}). These rates make some allowance for effluent quality, soil conditions and site conditions. GPF have adopted an arbitrary rate of 5 % of the clean water loading be used to determine wastewater application rates. In addition to infiltration characteristics, this recommendation takes into account the soil's AWHC. Design loading rates are presented in Table 2.

Table 2. Potential wastewater hydraulic loading for drip irrigation system.

Soil Type	Summer Loading mm/day	Winter loading mm/day
Frankton Soils	6	0
Blackstone Soils	12	6
Moke Soils	18	12
Pigburn Soils	18	12

As there will be seasonal variation in wastewater production at Jacks Point, then higher rates can be used in summer compared to winter. But to be conservative and to allow for similar wastewater generation rates in winter, the winter loading has been used for system design.

OPTIONS AND CONCEPTUAL DESIGN

Population and flows

Statistics New Zealand state that the population size in Otago is 2.5 people per dwelling and QLDC use design average wastewater flows of 220 L/p/day (excluding infiltration) with an average of three people per household. In peak periods with high visitor numbers, additional flows are assumed at 150 L/p/day. A population survey (150 houses – about 10 % of total properties) was carried out over the peak summer weeks in Wanaka for QLDC in 1995/1996 (Kingston Morrison, 1996). This survey showed permanent residents averaged 1.6 people per household and occupancy peaked at just over five people per household for five days and over four people per household for 16 days. Queenstown and Wanaka were considered to have similar occupancy figures.

The Jacks Point design figure was based on a peak occupancy ratio of five people per household and a ratio of average occupancy vs peak occupancy of 3 : 5 people per household. This gives an average flow of 192 L/p/day during peak periods (this is the design dry weather flow for five people per dwelling based on three people at 220 L/p/d and two people at 150 L/p/d). Table 3 gives projected wastewater volumes for each proposed treatment plant, according to residential zone groupings.

Climate

Queenstown is in southern New Zealand. It experiences hot summers and cold winters, with frequent low temperatures (including below zero), ground frosts, ice and snow during winter. These extreme winter conditions can occur at other times of the year. Mean annual rainfall data for the Queenstown meteorological station (for the period 1960-2004) is 888 mm and the mean annual evapotranspiration figure is 615 mm (NIWA, 2005).

There is potential for short-term frozen ground to occur during extreme winter conditions in the Queenstown area. Grass temperatures are measured at Queenstown airport. Comparing the average airport grass temperature (Station I58061) with a fully recorded site such as Earnscleugh (Station I59232), the Earnscleugh site has more extreme winters, with an average July grass temperature of –6.1°C (compared with the Queenstown Airport July grass average of –4.2°C). The average 10 cm soil temperature at Earnscleugh is 0.9°C and 30 cm soil temperature of 2.0°C for July (the coldest month).

Table 3. Projected wastewater volumes per proposed treatment plant.

Zones	Number of lots [c]	Design number of people [a]	Wastewater L/p/day	Volume m^3/day
R(JP)1	174	870	192	167.0
R(JP)2+3	147	735	192	141.1
R(JP-SH)1 north	153	765	192	146.9
R(JP-SH)1 south	125	625	192	120.0
R(JP-SH)2	158	790	192	151.7
R(JP-SH)3+4	89	445	192	85.4
Tablelands HS	18 individual sites	6 per lot [b]	180[b]	1.08 per site
Lodge + staff + restaurant	60 rooms + 6 staff + 60 dining seats	150[c] + 6[c] + 120[c]	as in Table 1[b]	30.84
TOTAL	864 + lodge etc	4,614		862

[a] *No. of people per dwelling is based on Kingston Morrison survey of Wanaka resident and visitor populations (three weeks over the 1995/1996 summer) for QLDC, assuming peak of five people per dwelling.*

[b] AS/NZS 1547:2000 On Site Domestic Wastewater Management Standard

[c] *Figures as provided by Jacks Point Project Manager*

As the 10 cm soil temperature at Earnscleugh shows that the risk of dripper lines freezing is low, then the site at Queenstown should also be at low risk. Sub-surface drip irrigation lines are generally installed 10 – 15 cm deep. To minimise any potential problems, the driplines will be installed at 15 cm and will be the standard Raam (rather than UniRaam) to allow some drainage at cycle completion to avoid rupture (an additional safety measure). In addition, potential dripline freezing was discussed with Dr Richard Otis, from the University of Wisconsin. He said that, in Wisconsin, they have seasonally frozen ground (much more extreme than Queenstown) and that freezing is not a problem, due to the wastewater temperature.

Groundwater resources

There are no bores within three kilometres of the site. Piezometers installed for geological investigations indicate water levels at 18 - 19 metres below ground level.

Lake Wakatipu

Schedule 1A of the ORC Regional Water Plan sets out: (a) ecosystem values; (b) outstanding features or landscape; and (c) significant indigenous vegetation and habitat of indigenous fauna for Lake Wakatipu. Lake Wakatipu is listed in Schedule 2 of the Water Conservation (Kawarau) Order 1997, which sets out the characteristics of the waters to be protected because they are considered outstanding. Restrictions and prohibitions include: fish passage to be maintained; and water quality to be managed to Class AE (for aquatic ecosystem purposes), CR (for contact recreation purposes), F (for fishery purposes), and FS (for fish spawning purposes) standards.

There is a Statutory Acknowledgement for Whakatipu Wai Maori (Lake Wakatipu) under the Ngai Tahu Claims Settlement Act 1998.

Lake Wakatipu has excellent water quality. Otago Regional Council water quality data (39 samples between February 1999 and June 2004) for the sampling site ‘Outlet at Falls Bridge’ is summarised in Table 4.

Table 4. Lake Wakatipu water quality.

Data	NH4-N g/m^3	TON g/m^3	TN g/m^3	Black Disk 60 mm dia m	Chlorophyll a mg/m^3	DO g/m^3	DRP g/m^3	TP g/m^3	TOC g/m^3	FC cfu /100mL	Turbidity NTU
Min	< 0.01	0.005	<0.05	1.5	< 1	8.3	<0.005	<0.005	0.4	< 1	0.1
Max	0.04	0.054	2.29	9	2.4	11.9	0.005	0.028	0.9	1400	1.8

Preferred treatment option

After an extensive option assessment, the selected wastewater treatment and land application system is:

- Primary treatment of raw wastewater, via individual on-site interceptor tanks and filter systems, with reticulation (either pumped or by gravity) via small diameter pipes to;
- A recirculating textile packed bed reactor (rtPBR) treatment plant for each cluster; and
- Sub-surface drip irrigation, at a maximum rate of either 6 or 12 mm/day.

The selected reticulation, treatment and disposal technologies will provide a high quality effluent, cope with fluctuating loadings and treat the effluent in a culturally acceptable manner under demanding climatic conditions. Effluent can be applied within the overall site and should meet the expectations of future regulatory bodies.

Use of interceptor tanks at individual residential lots has advantages over traditional raw sewage gravity flow and pump station systems, which are more difficult to engineer over undulating ground, with shallow bedrock (as is the case at Jacks Point). Effluent is pretreated and can be easily pumped though small diameter pipes installed in a common service trench to the wastewater treatment plant. Sludge production at the treatment plant is reduced and there is greater capacity in the system to store wastewater if a breakdown occurs.

Recirculating packed bed reactor technology is robust to varying inflows and provides high quality effluent, using simple systems that require low operation and maintenance requirements. The textile treatment system is modular and can be installed incrementally as development within the residential zones progresses. Other technologies considered (sequencing batch reactors, other aerated systems) require higher levels of operator input, produce significant quantities of sludge that requires disposal and are not as robust with regard to treating varying hydraulic loadings.

Sub-surface drip irrigation was the preferred discharge option as it is easy to install on uneven ground and provides good treatment for nutrients and pathogen reduction.

ENVIRONMENTAL EFFECTS

A healthy soil environment can assimilate up to 600 kg BOD/ha/day. The loading following the rtPBR will be 0.84 kg/ha/day. Anaerobic slimes and odours are therefore highly unlikely to occur.

From the NZ Guidelines for the Utilisation of Sewage Effluent on Land (NZLTC, 2000), the sodium adsorption ratio is likely to be in the order of 4 – 7. This will not result in sodium toxicity problems and nor will it result in loss of soil structure with the soil types proposed to be irrigated.

Groundwater protection will be ensured by wastewater treatment within the soil profile and underlying gravels, before discharge to groundwater (and ultimately Lake Wakatipu). Results from various studies show virus reductions of 99.99% through 0.6 m of 0.12 mm sand and bacteria reductions of 99.998% through 0.9 m of 0.15 mm dune sand, with 92 to 97% reduction in the top one centimetre (Crane & Moore, 1984; Gunn, 1997). Fietje (1991) concluded that where wastewater is passed through at least 600 mm of unsaturated sand, at a loading rate of up to 50 mm/day, faecal coliform (FC) numbers should be reduced to 10-100/100 mL. It is predicted that after passage through soil, sand and gravel underneath the disposal area, at the low rate of 12 mm/day, that FC will be less than 100/100mL, and a high level of pathogen removal will be achieved.

Nitrogen balance

Nitrogen removal in the packed bed reactor (PBR) is estimated to vary depending on the loading, with effluent concentration ranging from 10–15 g/m^3 in winter to 25 g/m^3 in summer. Nitrogen removal mechanisms post-treatment in the PBR are considered to be soil microbe use, short-term soil storage, gaseous losses (volatilisation and denitrification) and pasture utilisation.

Based on the assumed nitrogen concentration throughout the year and a loading of 12 mm/day during the peak season, the nitrogen loading is calculated at about 467 kg/ha/year, applied over a total of 7.6 ha of land treatment area. The land treatment area will be mown four to six times per year, with clippings generally left where they are cut.

The land treatment areas are interspersed over the total site area of 420 ha. A total mass nitrogen balance has been carried out to determine the change in nitrogen leaching from the site as a result of the proposed landuse change and to assess the combined effect of the discharges on the environment. The nitrogen mass leached per year for each land use (dryland farming predevelopment and a combination of dryland farming, golf course and wastewater land treatment areas post development) was then calculated using NUTMOD (an in-house soil nutrient balance model). The validity of NUTMOD's predictions was compared against the AgResearch "Overseer Model" simulating the same land management scenarios, and also discussed with Dr Hong Di from Lincoln University. From this, it was concluded that nitrogen leaching predictions by NUTMOD were reasonably conservative and generally within the ranges that one could expect from the different land use options under investigation.

The golf course will be managed similar to Millbrook (Queenstown) and Hills (Arrowtown). Irrigation and fertilisation will occur on greens (0.84 ha), tees (0.704 ha) and fairways (13.912 ha). Grass clippings will be left where they fall on the fairways and removed from the tees and greens and spread in bare areas of rough. The rough will not be fertilised or irrigated. Based on fertiliser applications at Hills, the following was adopted for Jacks Point:

• Greens	177 kg N/ha/year N
• Tees	68 kg N/ha/year
• Fairways	78 kg N/ha/year

It is not possible to calculate the increase in nitrate-N in groundwater at the property boundary, due to a lack of groundwater quality and hydraulic parameter data. So the basis of the design (agreed to with ORC) is to ensure that post-development N leaching is equal to or less than pre-development N leaching.

Results from the simulations (shown in Table 5) show that post-development land use for the "cut and leave" scenario is likely to result in about 28% less nitrogen being leached than pre-development farming practices. This was agreed to with ORC and the consent conditions imposed reflect this. A consent requires that an annual nitrogen budget is carried out and the post-development leaching shown to be less than 2,800 kg N.

Effect on groundwater and Lake Wakatipu

The consent also requires the installation of one upgradient and two downgradient bores to monitor groundwater nitrates, and four piezometers to assist in assessing groundwater flow direction and depth. Bores are to be monitored monthly with an allowable increase downgradient to upgradient of 3 g/m3. These have now been installed and testing is about to commence.

There is a large dilution available in the lake from receiving groundwater with elevated nutrient loadings. Based on the mean flows through the lake (5,238.5 million m^3/year), this would result in an increase in lake N concentration of 0.00036 g/m^3 based on the values in Table 5. But as the mass leaching from the overall site is to decrease, there should be a net decrease in lake N concentration than what presently occurs.

Groundwater protection and water quality protection in Lake Wakatipu is ensured by treatment of the wastewater within the soil profile and underlying gravels, before discharge to groundwater and (ultimately) into the lake water column (as discussed in the Environmental Effects section).

Table 5. Nitrogen balance.

	Landuse	Area	Leaching Estimates	
		ha	kg N/ha	Kg N/year
Pre-development	Dryland Farming	420	9	3,780
	Total			3,780
Post-development Scenario 1 (cut and leave for both golf course and land treatment areas)	Dryland Farming	70	9	630
	Land Treatment (C-L)	7.6	246	1,870
	Golf course (C-L)	15.5	15	233
	Total	93.1		2,733
	Change in N leaching post development (%)		-28	
Post-development Scenario 2 (cut and leave for golf course and cut and carry for land treatment areas)	Dryland Farming	70	9	630
	Land Treatment (C-C)	7.6	44	333
	Golf course (C-L)	15.5	15	233
	Total	93.1		1,196
	Change in N leaching post development (%)		-68	

i. Leaching estimates for the dryland farming area are as agreed with ORC and Ross Monaghan assuming no fertiliser applications. Sheep have been grazed all year round, with cattle stocked mainly in the spring and summer. Feed crops (grass, silage and hay) have been harvested for winter feed;
ii. The adopted leaching loss for the golf course was provided by Ross Monaghan is consistent to that reported in papers (Balogh and Walker, 1992);
iii. Leaching estimates for land treatment areas are from the NUTMOD model and are considered conservative. C-L is cut and leave and C-C is cut and carry;
iv. Post-development dryland farming on the block will be sheep just to keep the grass down rather than for optimised farming. The stocking rate will be significantly less than that used before (i.e. << 4 SU/ha), but leaching of 9 kg/ha is still assumed to be conservative.
v. Pasture dry matter yields for grazed dryland in the area averaged 8,000 kg DM ha/year and with wastewater land application at 10,000 kg DM ha/year. These figures were based on pasture growth simulations using the GROW pasture growth predictor model (Onstream Systems Ltd)..

CONSULTATION/ HEARING AND APPEAL

Consultation was undertaken with ORC, QLDC, Kai Tahu ki Otago Ltd (KTKO Ltd), Te Ao Marama Inc. and Te Runanga O Ngai Tahu, Public Health South and neighbouring developers.

No major issues were raised by any parties consulted with, but the application was still publicly notified due to the significant interest in Lake Wakatipu and the development's scale. One submission was received from a neighbour who uses shallow groundwater. It was agreed with him to monitor his bore, even though it was considered to be in a separate catchment to most of the activities. The application was decided upon at an internal ORC hearing.

Consent was granted but some of the conditions appealed by Jacks Point Ltd. Conditions that were discussed during the hearing and the appeal and finally agreed on were:

- Requirement for a 50 metre buffer from land treatment areas (LT) to ephemeral water courses – a buffer size of 20 metres was settled on;
- Requirement that no grazing be undertaken on the LT areas – agreed that up to 10 SU/ha of sheep would be allowed;
- Clarification that in future that the fairway component of the golf course could be used for effluent application; and
- Requirement that the allowable leaching from the entire site be 1,200 kg/year – the predevelopment leaching was assessed and agreed as 3,780 kg N/year, but it was agreed that it is likely to be variable from year to year and although a best estimate, the value was uncertain, so caution was required. To allow some flexibility in management, and to provide a level of safety below the background value of 3,780 kg N/year, a figure of 2,800 kg N/year was considered acceptable by both parties.

DETAILED DESIGN, TENDERING AND CONSTRUCTION

The reticulation system was designed based on STEP/STEG and this has now been installed by the main civil contactor.

A design build contact was selected, as the chosen treatment system was based on a package plant packed bed textile filter. In addition, a five year operation and management component was built into the tender for the treatment/LT system. Tenders and specifications for the on-site tanks were kept separate to the treatment/LT systems and two contracts awarded, both being won, after much internal deliberation, by Innoflow Technologies of Auckland. Their packed textile has heated air running through it which resulted in the potential for better nitrogen reductions in winter when hydraulic loading was lighter.

Prices for the treatment/LT systems varied by nearly 100%. The treatment technologies put forward included fixed media activated sludge, packed bed reactors and membrane bioreactors. The likely effluent quality ranged between the plants but offered guarantees regarding total nitrogen in the effluent were very similar (<25 g/m^3). Considering the technologies being offered, we were disappointed with the guarantees offered by the suppliers, most of which had tags.

The treatment systems for the first stage are now under construction, with completion expected in April (N1) and May (N5). The LT areas for the N1 residential are within the fairways of a proposed family style 9 hole golf course and in an area to be grazed by sheep (Figure 4).

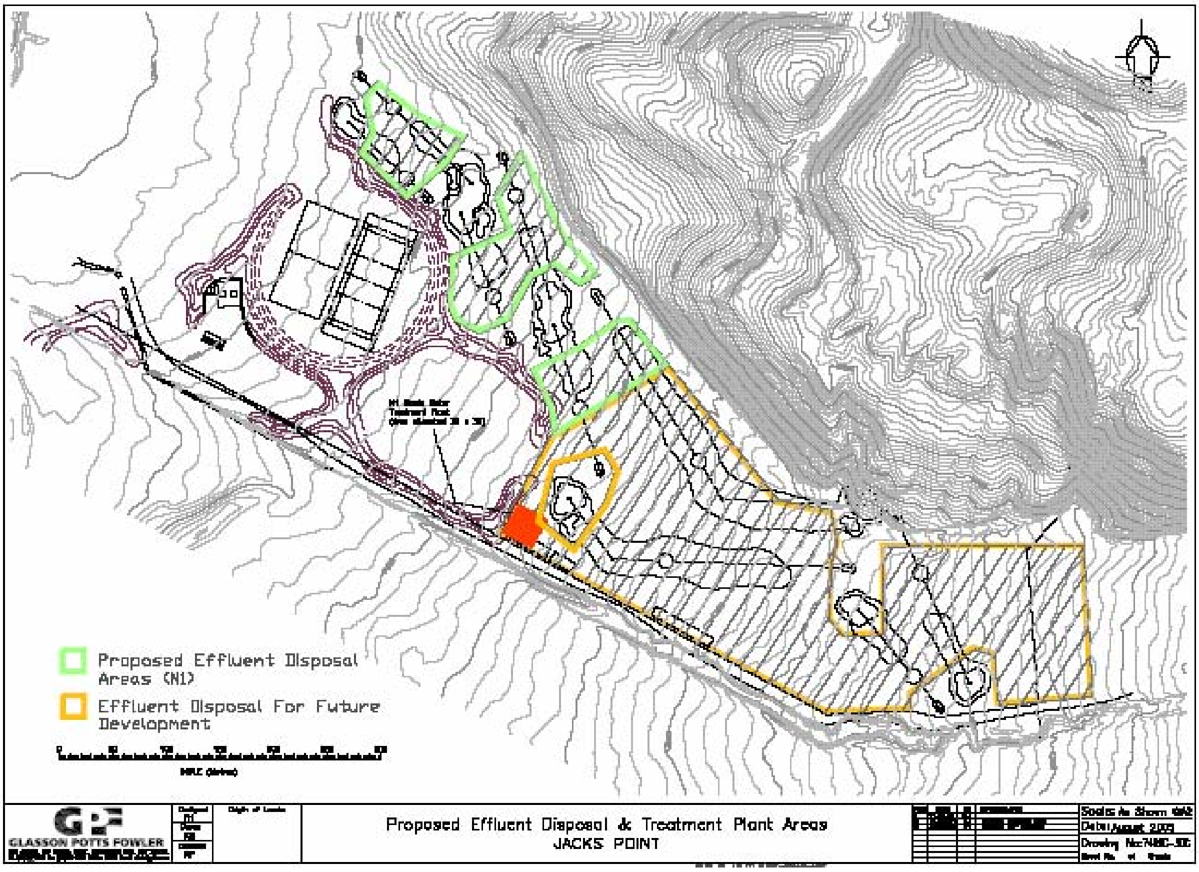

Figure 4. N1 land treatment area.

CONCLUSIONS

The assessment of wastewater loading in resort areas is difficult and not yet well understood. Design practices focus on designing for worst case loading conditions. This does not allow any buffering within the treatment or soil system and thus may not be cost effective. Some allowance was made in the nitrogen loading calculations for the lighter winter loading, with lower concentrations expected from the heated treatment units.

The assessment of likely effects in an relatively undeveloped/pristine area was difficult, as there was very little information on environmental parameters and background levels of contaminants, i.e. what depth and flow direction of groundwater, levels of nitrates in groundwater, etc.

The approach taken with ORC was very pragmatic, particularly as there was no detailed groundwater information. Discussions with ORC involved accepting leachate rates and concentrations that both parties considered to be conservative and realistic. A full assessment of environmental effects was not possible due to lack of information, hence effects on the environment is based on a nutrient budget and limiting post development leaching to less than pre-development levels. In setting conditions, ORC have required piezometers to be installed to assess groundwater flow direction and depth, and installation of up and downgradient monitoring bores to assess performance of the system and underlying soils, i.e. a “monitor and manage” approach.

The loading to the land treatment areas (12 mm/day peak summer) is considered high for a “cut and leave” management regime. This loading was proposed due to the availability of the better soils for land treatment for future development of a village containing commercial and apartments being limited in the future. A “cut and carry” approach and further denitrification within the treatment systems will be considered at this stage.

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