



Tasmania

DEPARTMENT of
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The effects of waste disposal on groundwater quality in Tasmania



Chapel Street & Jackson Street waste depots, Glenorchy

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Groundwater quality investigations at the Chapel Street and Jackson Street waste depots, Glenorchy

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Abstract

Groundwater quality near the waste depots at Chapel Street and Jackson Street, Glenorchy, was investigated by Mineral Resources Tasmania and the Glenorchy City Council. Both landfill footprints are located on Permian sedimentary rocks and Jurassic dolerite, which contain heterogenous fractured bedrock aquifers. Groundwater quality at the toe of the Chapel Street landfill footprint is elevated in chloride, ammonia, manganese and total petroleum hydrocarbon fraction C₁₀-C₁₄. Migration rate will be related to the fracture widths within the aquifers. No evidence of major groundwater contamination was identified around the Jackson Street landfill. Geophysical surveys have identified the extent of the Chapel Street waste depot and an area of partial clay capping. Saturation level of fill material within the Chapel Street landfill has on-going risk management implications relating to stability and the local urban environment.

INTRODUCTION

Mineral Resources Tasmania (MRT) initiated a project to investigate the effects of waste disposal on groundwater quality in Tasmania. The project was funded by MRT and the Natural Heritage Trust (NHT) and included a number of sites for detailed study. The Chapel Street and Jackson Street waste depots at Glenorchy were two of these sites.

The Glenorchy City Council provided additional funding for the project at both sites, by meeting the cost of all contract drilling undertaken as part of the investigations.

The objectives of the investigations at the Glenorchy waste depots were to:

- Determine the geological nature of the host materials;
- Identify the depth of the water table for development of a hydrogeological model;
- Examine the quality of the groundwater with respect to leachate generation and migration; and
- Indicate potential future monitoring and/or remediation options for the sites.

SITE DESCRIPTION

Site history – Chapel Street

The Chapel Street waste depot (fig. 1) was in operation between 1975 and 1985 and was re-opened for a short period between 1996 and 1998. No basal clay liner was engineered at the site during either stage of filling.

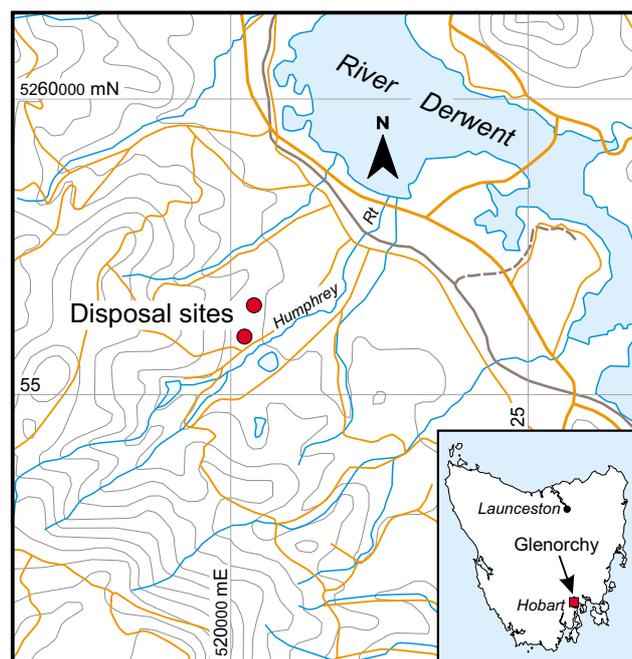
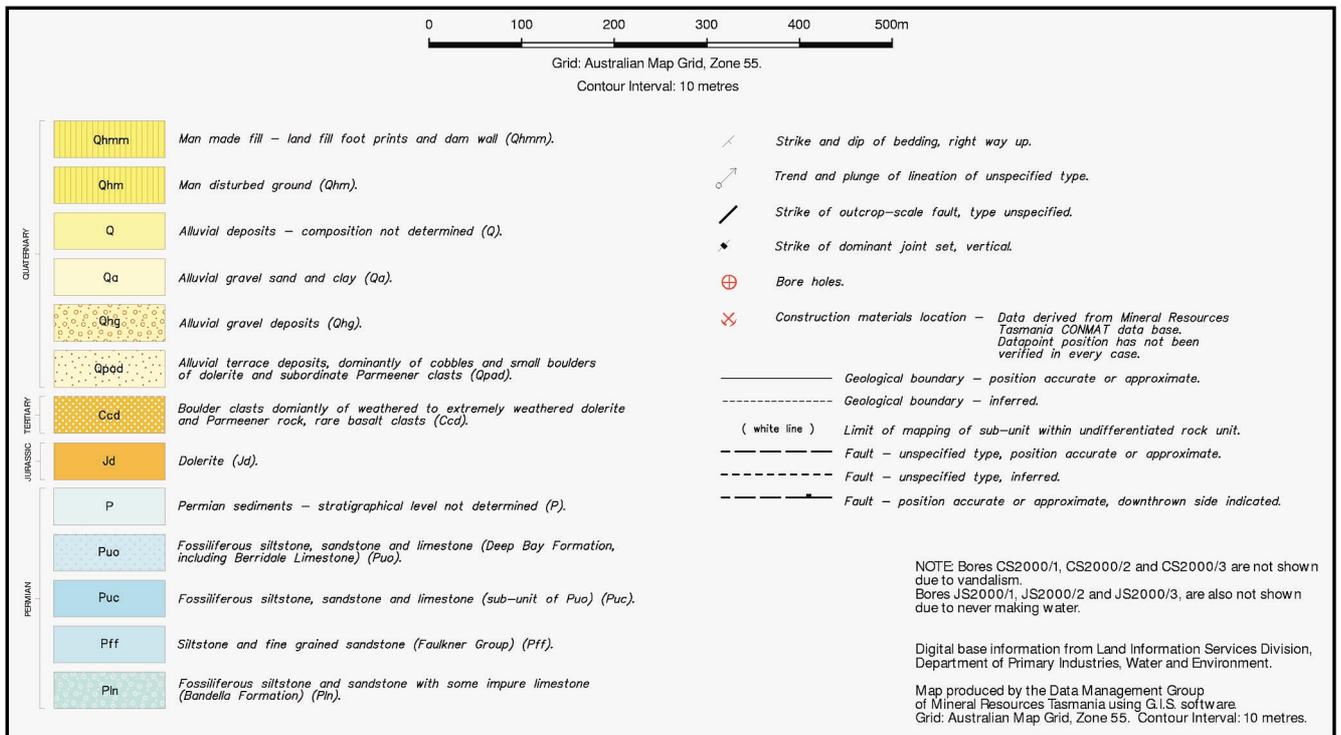


Figure 1. Locations of the Glenorchy waste disposal sites.



The Glenorchy City Council has, at various stages, constructed engineering works at the site, including:

- A leachate collection drainage system that discharges to sewer;
- Stormwater diversion drains;
- Capping of selective areas of the landfill; and
- Passive landfill gas venting infrastructure (Plate 1).

Site history – Jackson Street

The Jackson Street waste depot was in operation between 1985 and 1996 and from 1998 to the present. Stormwater diversion drainage has been constructed at the site. Leachate is collected through various pipes that feed into a sump at the toe of the landfill, which discharges to sewer. Progressive clay capping of the landfill has been occurring for the last five years.

Site management

The Glenorchy City Council manages both sites, which are licensed by the Department of Primary Industries, Water and Environment (DPIWE). In the last decade Council has undertaken a pro-active approach to management, identifying issues that may represent an ecological risk and potentially result in

environmental harm. The construction of engineered infrastructure has been undertaken to manage the stability of the Chapel Street site. An approach to leachate management by leachate minimisation (including appropriate disposal for treatment) has been undertaken at both sites. The GCC has demonstrated a professional approach towards best practice environmental management over the last decade.

Geology

The geology of the Chapel Street–Jackson Street areas is shown in Figure 2. This map was initially produced using geological data from the Hobart 1:25 000 scale MRT geological map sheet. The basic map was modified slightly by new observations made as part of this project near the landfill footprints.



Plate 1

Passive landfill gas venting infrastructure installed at the Chapel Street waste depot.

Both landfill footprints are located on Jurassic dolerite and Permian rocks. A faulted, reactivated contact exists between these two main lithologies. Areas of Quaternary alluvial deposits, derived from the Jurassic dolerite and Permian rocks, exist beneath and in close proximity of the landfill footprints.

Cuttings in the southwest corner of the Jackson Street waste depot indicate that at least two intrusions of magma were associated with the emplacement of the Jurassic dolerite.

Hydrology

The Chapel Street waste depot site is located on a tributary of Humphrey Rivulet which discharges into the River Derwent at Elwick Bay, approximately three kilometres northeast of the waste depot.

The Jackson Street waste depot site is located on Littlejohn Creek, which discharges into Humphrey Rivulet about 1.5 kilometres northwest of the waste depot.

Australian Bureau of Meteorology rainfall station 094030 (Hobart Botanical Gardens) is the closest rainfall station to both sites, with an average annual rainfall of 571.4 mm. The chart of average monthly recorded rainfall is shown in Figure 3.

INVESTIGATION METHODS

Borehole drilling, installation, and test pitting

Seven monitoring bores (CS2000/1-3 and JS2000/1-4) were auger drilled by MRT between 26 and 27 June 2000 for this project (fig. 4). These 120 mm diameter holes were drilled to identify any shallow groundwater in the materials overlying the bedrock. Fifty millimetre PVC casing and slotted screens with bentonite seals were installed in each hole.

Four additional bores were percussion drilled by KMR Drilling Pty Ltd between 28 and 30 May 2001 (Plate 2). All four second phase boreholes were 165 mm diameter and 100 mm PVC casing was installed. All

bores and pits were logged in accordance with AS1726-1993; engineering logs are presented in Appendix 1.

Nine test pits were also excavated at the Chapel Street waste depot using a GCC 20 tonne 320B excavator. Test pits CSTP2001/1, CSTP2001/2 and CSTP2001/3 were excavated to help target the drilling of borehole CS2001/2. Test pits CSTP2001/4 to CSTP2001/9 were excavated to test the engineering integrity of capping materials used in the western area of the Chapel Street landfill footprint. Substantial volumes of landfill gas vented from these test pits. Engineering logs and photos of the test pits are presented in Appendix 2.

No groundwater was encountered in the MRT-drilled boreholes CS2000/1, CS2000/2, CS2000/3, JS2000/1, JS2000/2 and JS2000/3. Some moisture was observed on the faulted contact section of borehole CS2001/2. Groundwater was encountered below ground level in bedrock at 4.5 m in JS2000/4, 18.0 m in JS2001/1, and at 32.0 m in JS2001/2. Plate 3 shows the water strike during the drilling of bore hole JS2001/2. Groundwater was encountered in bedrock at 5.0 m (CS2001/1) below ground level at the toe of the Chapel Street waste depot.

Flow encountered during the drilling of JS2001/1, JS2001/2 and CS2001/1 indicated that the groundwater in these boreholes was unconfined. These boreholes were developed on 1 June 2001; Plates 4 to 6 show the development of each respective borehole.

Groundwater was encountered in test pit CSTP2001/1 at 0.5 and 1.5 m, with flows of 0.005 and 0.036 l/s respectively. Groundwater was also encountered at 1.4 m within the waste fill material in test pit CSTP2001/4.

Between 29 and 30 May 2001 vandals destroyed boreholes CS2000/1, CS2000/2 and CS2000/3 (Tasmania Police offence report number 105395). All future investigation work at this site should take into consideration expected vandalism of infrastructure.



Figure 3
Average monthly rainfall for Australian Bureau of Meteorology rainfall station 094030, Hobart Botanical Gardens.

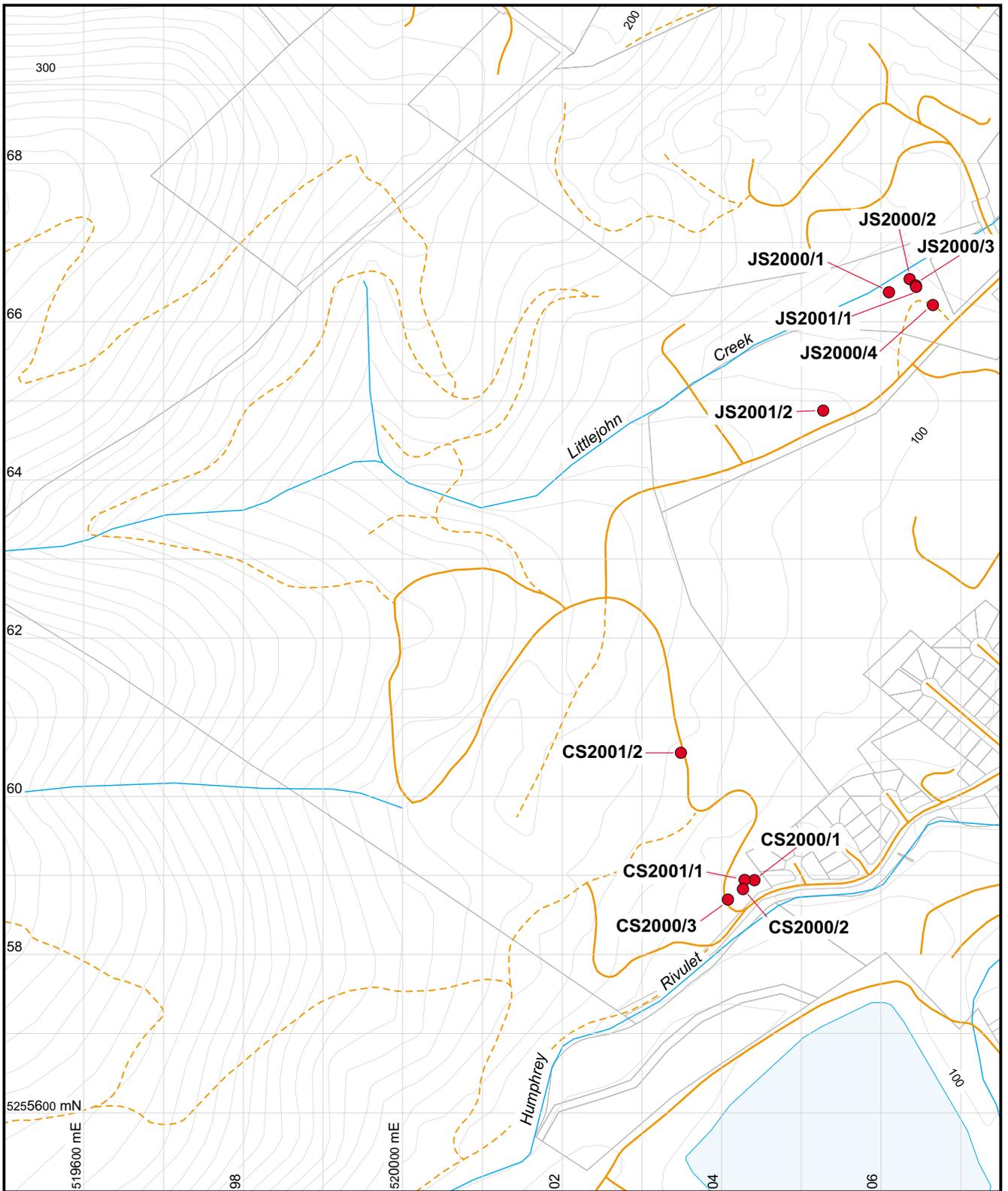


Figure 4
Locations of environmental monitoring bores installed at the Chapel Street and Jackson Street waste depots.



Plate 2

Drilling bore hole JS2001/2 on 28 May 2001.



Plate 3

Initial water strike during the drilling of bore hole JS2001/2 on 28 May 2001.



Plate 4

Developing bore hole JS2001/1.



Plate 5
Developing bore hole JS2001/2.



Plate 6
Developing bore hole CS2001/1. Note discolouration of water compared to Plates 4 and 5.

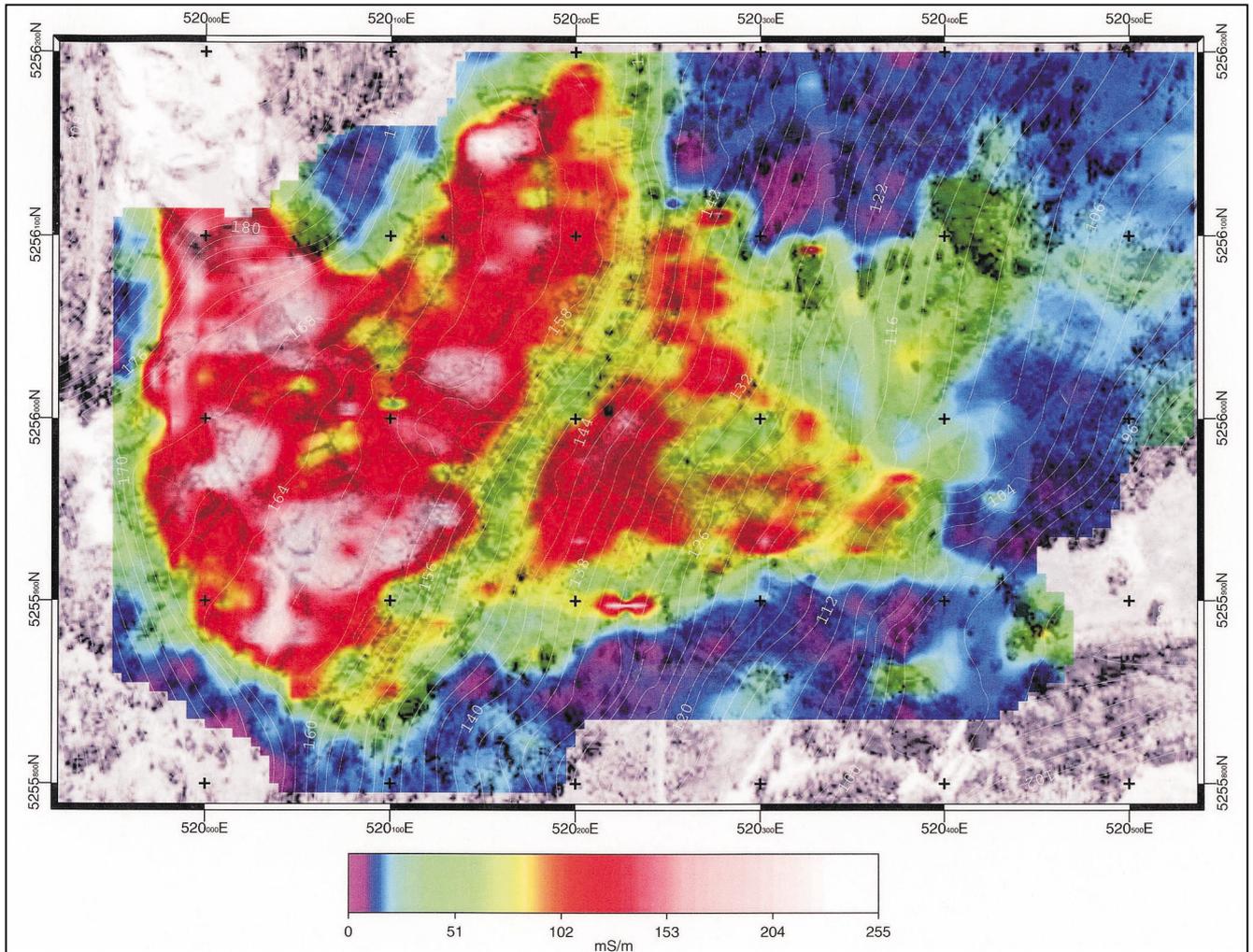


Figure 5

EM31 image of Chapel Street waste depot (image by N. Truchanas, School of Earth Sciences, University of Tasmania).

Geophysical investigations

As part of a postgraduate study undertaken by N. Truchanas, an EM31 geophysical survey was conducted over the Chapel Street waste depot. The survey measured ground conductivity at an approximate depth of three to six metres. The EM31 image (fig. 5) shows the bedrock as being non-conductive (blue) compared to the landfill materials (green, red and white). The high conductivity zone on the eastern side of the landfill footprint relates to an area of clay capping. The green zone to the west of the main landfill footprint is an area of very shallow fill material possibly being recharged by groundwater.

HYDROLOGICAL MODEL

Groundwater occurs in fractured aquifers within the two consolidated rock types that underlie the landfill footprints. Jointing within these rock types provides fracture porosity that assists in the movement of groundwater. The orientation and width of the joint patterns influence the flow rate and the flow vectors within the groundwater system.

Vertical jointing allows groundwater recharge and sub-horizontal joints provide additional groundwater storage capacity. Jointing is heterogeneous in most cuttings in the area of the waste depots. Platy thermal jointing exists in the initial 5 to 10 metres of the dolerite adjacent to the faulted contact with the Permian sedimentary rocks, while the Permian rocks have been contact metamorphosed by the dolerite in the vicinity of the contact. The nature of the jointing associated with the contact appears to create an hydraulic boundary between the two rock types. Outcrops of the contact and the engineering log of JS2001/2 indicate that the attitude of the boundary varies at least 10° from vertical laterally along the contact. Fracture spacing and orientation is also heterogeneous vertically and horizontally along the contact.

The aquifer properties for fractured Jurassic dolerite and Permian sedimentary aquifers (from Hofto, 1990) are shown below.

	<i>Groundwater bore yield (l/sec)</i>	<i>Groundwater quality (TDS ppm)</i>
Jurassic dolerite	0.03–1.0	500–1000
Permian sediments	0.25–1.0	100–2000

Groundwater occurs within the fill materials (most likely perched on the bedrock) as well as in fracture storage and related flow. Because of limited data, no detailed piezometric surface map has been attempted for this site. Existing data implies that unconfined groundwater within the bedrock trends northeast to easterly beneath both landfill foot prints. Possible flow directions from the Chapel Street landfill have been examined in slightly more detail (Ezzy, 2002). The nature of materials in hole CS2001/2, and observed spring locations from the waste fill material, imply a complex groundwater hydraulic system across the Jurassic dolerite/Permian contact. Spring discharges from the fill may be associated with up-slope saturated fill and/or natural springs that were buried by the landfill construction process.

GROUNDWATER CHEMISTRY

Groundwater samples were collected from holes CS2001/1, JS2001/1, CS2000/2 and JS2000/4 at the end of purging each bore on 1 June 2001. Plate 7 shows the sampling of CS2001/1. Table 1 summarises the groundwater sampling capacity of the bores installed during the investigation.

All yielding bores (except JS2000/4) were sampled in accordance with Australian/New Zealand Standard AS/NZS 5667.11:1998 on 5 June 2001. One additional surface water sample was collected from a spring emanating from the fill material at the Chapel Street waste depot (this spring was also sampled on 4 June 2001). The chemical signature of leachate was established by sampling the leachate line at the Chapel Street waste depot. A final water sample was collected from the base of test pit CS2001/4 on 22 June 2001 to confirm water chemistry in the fill.

Analytical Services Tasmania (in accordance with relevant Australian and international standards) carried out laboratory testing of all the surface and groundwater samples. The laboratory reports are presented in Appendix 3.

Groundwater values for pH ranged between 6.5 and 8.0 while conductivity ranged between 1170 and 5590 $\mu\text{S}/\text{cm}$. Analytical results for surface and groundwater samples are presented on site maps in Appendix 4. Figures 6 and 7 are cation Ternary plots for the results of surface and groundwater samples at both the Chapel Street and Jackson Street waste

Table 1

Summary of the groundwater sampling capacity for bores installed during the investigation.

Bore	Total depth (m)	Depth water struck (m)	Current status
CS2000/1	1.5	No water	Destroyed by vandals
CS2000/2	2.0	No water	Destroyed by vandals
CS2000/3	1.7	No water	Destroyed by vandals
CS2001/1	13.0	5.0	Secured groundwater sampling point
CS2001/2	28.0	No water (moisture between 6.5 to 8.0)	Secured groundwater sampling point, however may not always make water
JS2000/1	1.7	No water	Dry hole
JS2000/2	2.5	No water	Dry hole
JS2000/3	4.0	No water	Dry hole
JS2000/4	4.7	4.5	Secured groundwater sampling point
JS2001/1	23.0	18.0	Secured groundwater sampling point
JS2001/2	35.0	32.0	Secured groundwater sampling point



Plate 7

Sampling bore hole CS2001/1 at the completion of developing the bore on 1 June 2001.

Table 2

Comparison of analytical results against water quality standards (guideline value listed when stated by a relevant standard)

Parameter	CS2001/1 (01/06/01)	CS2001/1 (05/06/01)	JS2001/1 (01/06/01)	JS2001/1 (05/06/01)	JS2001/2 (01/06/01)	JS2001/2 (05/06/01)	JS2001/2 (01/06/01)	JS2001/2 (05/06/01)	Leachate spring (04/06/01)	Leachate spring (05/06/01)	Leachate line (05/06/01)	CSTP2001/4 (22/05/01)	Emission limit
pH	7.5	6.5	8.0	7.1	8.0	6.9	6.8	6.9	7.0	7.7	6.8	6.8	N/A
Conductivity (µS/cm)	5500	5590	1180	1170	1490	1590	1750	7470	7230	6720	7850	7850	N/A: note average seawater value 36 000
TDS (mg/L)	3810	3620	732	753	926	1030	1090	3770	3700	3570	4830	4830	N/A
Bromide (mg/L)	9.9	9.7	0.55	0.57	0.93	0.81	1.7	15	18	14	6.7	6.7	N/A
Chloride (mg/L)	1400	1400	150	170	300	270	240	1300	1300	1400	820	820	250* (mg/L)
Fluoride (mg/L)	<0.02	<0.02	0.24	0.26	0.27	0.16	3.7	0.61	0.21	0.20	36	36	1.5* (mg/L)
Sulphate (mg/L)	28	27	41	40	38	25	120	0.32	2.7	5.1	62	62	250* (mg/L)
Ammonia(mg/L)	1.05	0.85	0.05	0.12	0.54	0.08	0.27	223	170	110	170	170	0.5* (mg/L) nitrogen (as ammonia)
Nitrate + Nitrite (mg/L)	-	-	-	-	-	-	-	0.334	-	-	-	-	10.0* (mg/L) nitrogen (as nitrate or nitrite)
Nitrate (mg/L)	<0.03	<0.03	<0.03	<0.03	0.19	0.08	<0.03	-	0.013	6.4	<0.30	<0.30	10.0* (mg/L) nitrogen (as nitrate or nitrite)
Nitrite (mg-N/L)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.072	<0.10	1.5	0.35	0.35	10.0* (mg/L) nitrogen (as nitrate or nitrite)
Phosphate (mg-P/L)	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	-	<0.10	<0.10	<1.00	<1.00	2.0* (mg/L) as phosphorus
Ortho-P (mg-P/L)	-	-	-	-	-	-	-	0.021	-	-	-	-	2.0* (mg/L) as phosphorus
N (Total) (mg/L)	3.240	3.100	0.137	0.117	1.880	0.706	4.060	-	240	146	142	142	N/A
P (Total) (mg/L)	1.010	0.035	0.074	0.086	19.300	4.590	1.440	-	3.820	0.107	3.660	3.660	N/A
Aluminium (mg/L)	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.277	0.277	N/A
Arsenic (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05* (mg/L)
Cadmium (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	0.004	0.004	0.01* (mg/L)
Cobalt (mg/L)	0.023	0.035	0.001	<0.001	<0.001	0.003	0.006	0.016	0.030	0.012	0.019	0.019	N/A
Chromium (mg/L)	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.006	0.005	0.003	0.009	0.009	0.5* (mg/L)
Copper (mg/L)	0.003	0.002	<0.001	<0.001	<0.001	<0.001	0.013	<0.001	0.016	0.001	0.004	0.004	1.0* (mg/L)
Iron (mg/L)	0.040	0.047	0.037	0.022	0.040	0.027	0.056	0.383	0.380	0.156	44.4	44.4	(Combined iron and manganese total)
Manganese (mg/L)	6.890	13.800	0.094	0.181	0.038	0.090	0.408	0.722	1.470	1.070	1.530	1.530	(1.0* mg/L)
Nickel (mg/L)	0.049	0.039	0.003	0.002	0.003	0.007	0.014	0.021	0.023	0.021	0.068	0.068	0.1** (mg/L)
Lead (mg/L)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	0.009	0.05* (mg/L)
Zinc (mg/L)	<0.001	0.003	0.006	0.005	<0.001	0.003	0.008	0.063	0.960	0.021	1.430	1.430	5.0* (mg/L)
Calcium (mg/L)	308	378	74.1	71.3	100	114	89.4	178	225	176	283	283	N/A
Potassium (mg/L)	2.42	1.97	2.76	2.37	2.17	1.85	10.2	135	150	115	198	198	N/A
Magnesium (mg/L)	303	275	72.5	66.6	88.2	94.7	61.3	161	186	185	308	308	N/A
Sodium (mg/L)	525	504	90.4	82.1	103	94.3	232	846	864	879	584	584	N/A
TPH (mg/L)	0.199	0.058	0.248	<0.040	<0.040	<0.040	0.105	0.092	0.071	0.127	9.990	9.990	N/A
TPH CO ₆ -CO ₉ (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.011	<0.010	0.020	<0.010	3.100	3.100	N/A
TPH CO ₁₀ -C ₁₄ (mg/L)	0.042	0.047	<0.010	<0.010	<0.010	<0.010	<0.010	0.080	0.033	0.092	6.660	6.660	N/A
TPH C ₁₅ -C ₂₈ (mg/L)	0.074	<0.010	0.204	<0.010	<0.010	<0.010	0.076	0.012	<0.010	0.032	0.232	0.232	N/A
TPH C ₂₉ + (mg/L)	<0.010	<0.010	0.040	<0.010	<0.010	<0.010	0.012	<0.010	0.018	<0.010	<0.010	<0.010	N/A

* Environment Protection (Water Pollution) Regulations 1974, emission into inland water.

** Australian Water Quality Guidelines for Fresh and Marine Waters 1992.

N/A – no emission limit available.

Table 3

Comparison of analytical results against the Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000.

Bore hole number	CHAPEL STREET AND JACKSON STREET WASTE DEPOTS							ANZECC 2000		
	CS2001/1 (05/06/01)	Chapel Street leachate line (05/05/01)	Chapel Street leachate spring (05/06/01)	CSTP2001/4 (22/05/01)	JS2001/1 (05/06/01)	JS2001/2 (05/06/01)	JS2000/4 (01/06/01)	IRRIGATION STV (Short-term)	LTV (Long-term)	LIVESTOCK DRINKING
Standing Water Level (m)	2.18	-	-	1.40	14.91	2.20	2.20			
pH (lab)	6.5	7.7	7.0	6.8	7.1	6.9	6.8	**6.0-8.5		
Conductivity (lab) (µS/cm)	5590	6720	7230	7850	1170	1590	1750	(1)(Refer Tables 4.2.3 & 4.2.4)		(2) 2,000-10,000 (Refer Table 4.3.1)
TDS (mg/L)	3620	3570	3700	4830	753	1030	1090			
Bromide (mg/L)	9.7	14	18	6.70	0.57	0.81	1.7			
Chloride (mg/L)	1400	1400	1300	820	170	270	270	(3)MT (Refer Table 4.2.6) MR (Refer Table 4.2.7)		
Fluoride (mg/L)	<0.02	0.20	0.21	36	0.26	0.16	3.7	4	1	
Sulphate (mg/L)	27	5.1	2.7	62	40	25	120			
NH ₃ -N (mg/L)	0.85	110	170	170	0.12	0.08	0.270			
NO ₂ -N (mg/L)	<0.10	1.5	<0.10	0.35	<0.10	<0.10	<0.10			
PO ₄ -P (mg/L)	<0.10	<0.10	<0.10	<1.00	<0.10	<0.10	<0.10			
Calcium (mg/L)	378	176	225	283	71.3	114	89.4			1,000
Potassium (mg/L)	1.97	115	150	198	2.37	1.85	10.2			
Magnesium (mg/L)	275	185	186	308	66.6	94.7	61.3			250-2,000
Sodium (mg/L)	504	879	864	584	82.1	94.3	232	(3)MT (Refer Table 4.2.8)		
Aluminium (µg/L)	<20	<20	<20	277	<20	<20	<20	20,000	5,000	5,000
Arsenic (µg/L)	<5	<5	<5	<5	<5	<5	<5	2000	100	500
Cadmium (µg/L)	<1	<1	2	4	<1	<1	<1	50	10	10
Cobalt (µg/L)	35	12	30	19	<1	3	6	100	50	1,000
Chromium (µg/L)	<1	3	5	9	<1	<1	2	1,000***	100***	1,000
Copper (µg/L)	2	1	16	4	<1	<1	13	5,000	200	400-5,000
Iron (µg/L)	47	156	380	44400	22	27	56	10,000	200	NST
Manganese (µg/L)	13800	1070	1470	1530	181	90	408	10,000	200	NST
Nickel (µg/L)	39	21	23	68	2	7	14	2000	200	1,000
Lead (µg/L)	<5	<5	<5	9	<5	<5	<5	5,000	2,000	100
Zinc (µg/L)	3	21	960	1430	5	3	8	5,000	2,000	20,000

Shading indicates values above relevant guideline levels

Notes:

- ** set to limit potential for corrosion and fouling of pumping, irrigation and stock watering systems. *** Chromium (VI)
- (1) Suitability depends on salt tolerance of crop & calculation of EC_{se}, the average root zone salinity. EC_{se} depends on soil type & average root zone leaching fraction
- (2) Depending on animal type, within this salinity range may be reluctant to drink or may be some scouring but stock should adapt without loss of production
- (3) ES = Suits extremely sensitive crops MS = Suits moderately sensitive crops, may affect sensitive crops MT = Suits moderately tolerant crops
- MR = Medium risk of increasing crop cadmium concentrations MA = may affect crops sensitive to foliar injury through foliar absorption
- STV – Short term trigger value for contaminant in irrigation water (<20 years) use
- LTV – Long term trigger value for contaminant in irrigation water (100 years) use
- NST – Not sufficiently toxic

depots. Tables 2 and 3 compare the analytical results against international standards where a guideline/emission value is stated by the relevant standard.

Chapel Street landfill

Water within the fill, the leachate line and the leachate spring all had high conductivity, TDS, chloride, magnesium, sodium, iron and manganese concentrations. Groundwater sampled from CS2001/1 had a similar chemical signature, including total petroleum hydrocarbons. This implies the migration of leachate from the fill material into the Permian sedimentary aquifer down gradient of the landfill. The water strike one metre above the bedrock in CS2001/1 could indicate that migration is occurring in the base of the Quaternary alluvium as well as within the fractured aquifer system.

Jackson Street landfill

All three bores sampled at the Jackson Street landfill showed no sign of groundwater nutrient enrichment. Bore JS2000/4 contained slightly high sodium, which is most likely associated with groundwater sourced from Jurassic dolerite at shallow depth (see fig. 7 for related Ternary plot). Some degree of hydrocarbon contamination is also present in bore JS2000/4. The drop of pH between the two samples from bores CS2001/1, JS2001/1 and JS2001/2 may be a result of the water being oxygenated from the air lifting process during development of the bores.

CONTAMINATION ASSESSMENT

Chapel Street landfill

Interaction between the bedrock aquifer and perched water within the waste fill may be occurring as either recharge and/or discharge directional flow. Groundwater at the toe of the landfill (seen in CS2001/1) is degraded by the migration of leachate from within the up-slope fill material. This is also seen in the EM31 image of the site (fig. 5, green area at the toe of the landfill). Surface water within the landfill footprint is outside selective guideline limits.

Geomorphological features exist in the landfill footprint that are indicative of land instability. Saturation of the fill could promote instability within the fill material.

Jackson Street landfill

The Ternary plot (fig. 7) shows high magnesium concentrations for all bores at this landfill. This is considered an overprint of the natural dolerite groundwater signature (Ezzy, 1999). No target contamination indicators (e.g. chloride, ammonia and iron) were detected in the area of the Jackson Street landfill. It should be noted that a cluster of local bores (except JS2000/4) on the cation Ternary plot (fig. 7) is distinctly different to the statewide averages for these rock types. This may imply a natural geochemical groundwater signature, or a distinct change in the bedrock aquifer chemistry due to the migration of highly mobile ions from the fill. The total petroleum

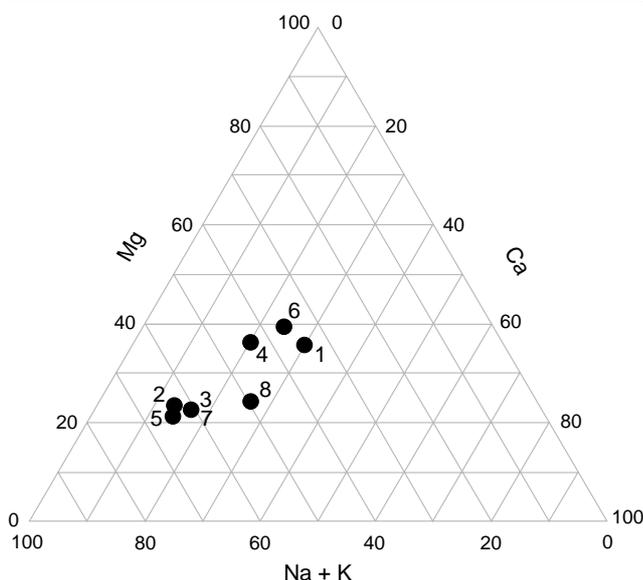


Figure 6

Cation Ternary plot for surface and groundwater samples at the Chapel Street waste depot.

- 1 - CS2001/1 (05/06/01); 2 - leachate line;
- 3 - leachate spring (05/06/01); 4 - CSTP2001/4;
- 5 - leachate spring (04/06/01); 6 - CS2001/1 (01/06/01); 7 - average of all MRT groundwater records for Permian sediments; 8 - average of all MRT groundwater records for Jurassic dolerite.

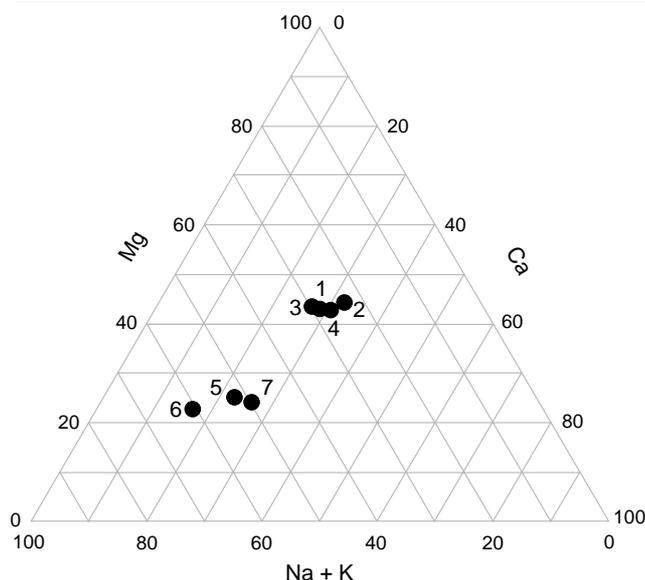


Figure 7

Cation Ternary plot for groundwater samples at the Jackson Street waste depot.

- 1 - JS2001/1 (05/06/01); 2 - JS2001/2 (05/06/01);
- 3 - JS2001/1 (01/06/01); 4 - JS2001/2 (01/06/01);
- 5 - JS2000/4; 6 - average of all MRT groundwater records for Permian sediments; and
- 7 - average of all MRT groundwater records for Jurassic dolerite.

hydrocarbon signature in JS2000/4 may also be sourced from materials in the landfill.

PRINCIPAL CONCLUSIONS

The conceptual hydrogeological model for Chapel Street and the related water storage within the waste fill has implications relating to the on-going management of the risk of stability at the site. Saturation of the fill material should be monitored on an on-going basis, as significant volumes of perched water may accumulate within the fill material.

Degradation of groundwater has occurred at the toe of the Chapel Street waste depot. The extent of this contamination plume is unknown, although the flow rate within the Permian rocks may be as high as 0.1 m/d. The EM31 image in the area of the landfill toe supports the presence of a plume emanating from the site.

No current evidence suggests that there is major groundwater contamination associated with the Jackson Street waste depot. The total petroleum hydrocarbons detected in JS2000/4 require further investigation.

On-going monitoring of water levels (particularly in the fill material) and groundwater quality is seen as a high priority at the Chapel Street and Jackson Street waste depots.

FURTHER WORK

Future monitoring of microbiological water quality parameters would provide further information on groundwater quality at the site. Monitoring of existing and additional hard-rock boreholes, combined with selective surface water sites, would allow a greater understanding of the extent of water quality degradation related to the Chapel Street waste depot.

Background bores are still required to define the local groundwater chemical signatures in the Jurassic dolerite and Permian rock aquifers (and also give greater control on the interpretation of groundwater flow and related gradients). The appropriate siting, drilling, installation and pump testing of a number of monitoring bores within the waste fill material is required to determine the volume of saturated waste fill (and related hydraulic head) and the calculation for a storativity value for the fill material at Chapel Street.

Pump testing is suggested for all yielding bores. Permeabilities calculated from the pump tests, combined with interpreted groundwater gradients, could then be used to estimate the extent of the contamination plume associated with the Chapel Street waste depot. A three-dimensional model should be constructed of any identified migration of contaminated groundwater from the site that is considered to present an ecological risk to the adjacent environs. Modelling of the plume should consider the design and related hydrogeological hydraulic properties of the Tolosa Street reservoir. The extent of natural attenuation should be calculated and calibrated against on-going field data.

REFERENCES

- EZZY, A. R. 1999. *Groundwater resources within Tasmanian Jurassic dolerites*. B.Sc. (Hons) thesis, University of Tasmania.
- EZZY, A. R. 2002. Drilling investigations to identify groundwater flow directions in the area north of the Tolosa Street Reservoir, Glenorchy. *Record Tasmanian Geological Survey* 2002/12.
- HOFTO, P. J. 1990. *Urban geological mapping project series. Map 1. Engineering Geology Greater Hobart Area*. Department of Resources and Energy Tasmania.

[30 May 2002]

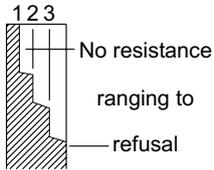
Appendix 1

Engineering logs of boreholes

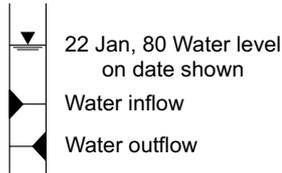
EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration



Water



Notes — samples and tests

U50	Undisturbed sample 50 mm diameter
D	Disturbed sample
N	Standard penetrometer blow count for 300 mm
N*	SPT + Sample

Material classification

Based on Unified Soil Classification System.
In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

Moisture content

D	Dry, looks and feels dry
M	Moist, no free water on hand when remoulding
W	Wet, free water on hand when remoulding
LL	Liquid limit
PL	Plastic limit
PI	Plasticity index

e.g. M>PL — Moist, moisture content greater than the plastic limit

Consistency

		: hand penetrometer
VS	Very soft	<25 (kPa)
S	Soft	25 – 50
F	Firm	50 – 100
St	Stiff	100 – 200
VSt	Very stiff	200 – 400
H	Hard	>400
Fb	Friable	

Notes: X on log is test result
— is range of results

Density index

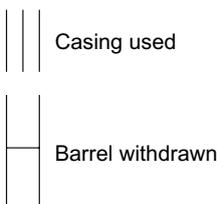
		%
VL	Very loose	0 – 15
L	Loose	15 – 35
MD	Medium dense	35 – 65
D	Dense	65 – 85
VD	Very dense	85 – 100

Fracture description

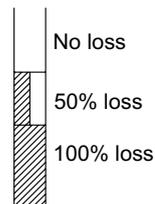
RP	Rough planar
RL	Rough irregular
SP	Smooth planar
SL	Smooth irregular

Cored borehole log

Case - lift



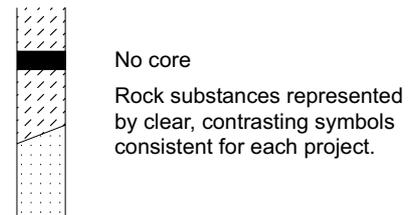
Fluid loss



Lugeons

Lugeon units (uL) are a measure of rock mass permeability. For a 46 to 74 mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of 1×10^{-4} mm / sec.

Graphic log



Weathering

Fr	Fresh
SW	Slightly weathered
HW	Highly weathered
EW	Extremely weathered

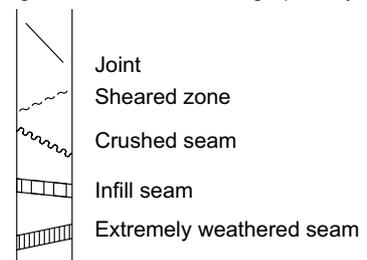
Strength

		point load strength index $1_{5(50)}$ (MPa)
EL	Extremely low	< 0.03
VL	Very low	0.03 – 0.1
L	Low	0.1 – 0.3
M	Medium	0.3 – 1
H	High	1 – 3
VH	Very high	3 – 10
EH	Extremely high	>10

Notes: X on log is test result.

Significant defects

Significant defects shown graphically



ENGINEERING LOG - BOREHOLE

Borehole no.
CS 2000/1
Sheet 1 of 1

Project		Chapel Street waste depot		Location		Chapel Street, Glenorchy				
Co-ordinates		55 520441 mE 5255894 mN		Drill type		Auger				
R.L.				Drill method		Rotary				
Inclination		vertical		Drill fluid		Nil				
Bearing				Hole commenced		27 June 2000				
				Hole completed		27 June 2000				
				Drilled by		Mr Shane Heawood				
				Logged by		Mr Andrew Ezzy				
				Checked by		Mr Adrian Waite				
penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	index	
			D Sample ID 1			OH	CLAY - black, humic	M	St	Soil A horizon
	No screen	Bentonite/Cement	D Sample ID 2	0.5		CL	CLAY - medium plasticity, light grey, silty, hornfels siltstone and sandstone fragments	D	S L	Quaternary alluvial deposit
	1.0 metre N.R.F.S.* screen	7 mm Gravel	D Sample ID 3	1.0		CL	CLAY - medium plasticity, light grey, silty, hornfels siltstone and sandstone fragments	M	S L	Quaternary alluvial deposit
	N/S			1.5			End of hole due to auger refusal at 1.5 m			Auger refusal most likely due to boulder in clay matrix
			Sample ID numbers refer to samples stored in MRT core shed							
			* Nylon Rock Fabric Sock							

ENGINEERING LOG - BOREHOLE

Project	Chapel Street waste depot		Location	Chapel Street, Glenorchy	
Co-ordinates	55 520427 mE 5255883 mN	Drill type	Auger	Hole commenced	27 June 2000
R.L.		Drill method	Rotary	Hole completed	27 June 2000
Inclination	vertical	Drill fluid	Nil	Drilled by	Mr Shane Heawood
Bearing				Logged by	Mr Andrew Ezzy
				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1	2	3	samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
	No screen	Bentonite	D Sample ID 1			OH	CLAY - black, humic, 40% orange clay mottles	M	F	Soil A horizon
			D Sample ID 2	0.5		CL	CLAY - medium plasticity, grey, sandy silt, 20% dolerite, sandstone and siltstone fragments	M	S L	Quaternary alluvial deposit with boulders of dolerite and Permian sedimentary rock
	1.5 metre N.R.F.S.* Screen	7 mm Gravel	D Sample ID 3	1.0		CL	CLAY - medium plasticity, light brown, sandy, 30% dolerite, sandstone and siltstone fragments	M	S L	Quaternary alluvial deposit with dolerite and Pm sedimentary boulders
			D Sample ID 4	1.5		CH	CLAY - medium to high plasticity, orange, 5% dolerite fragments	M	F MD	Quaternary alluvial deposit with dolerite and Pm sedimentary boulders
	N/S		D Sample ID 5	2.0		CH	CLAY - high plasticity, dark brown, 5% grey clay mottles, 5% dolerite fragments	M	St	As above
			Sample ID numbers refer to samples stored in MRT core shed				End of hole due to auger refusal at 2.2 m			Auger refusal most likely due to boulder in clay matrix
							* Nylon Rock Fabric Sock			

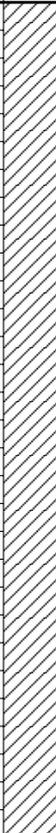
ENGINEERING LOG - BOREHOLE

Project		Chapel Street waste depot		Location		Chapel Street, Glenorchy				
Co-ordinates		55 520408 mE 5255869 mN		Drill type		Auger				
R.L.				Drill method		Rotary				
Inclination		vertical		Drill fluid		Nil				
Bearing				Hole commenced		27 June 2000				
				Hole completed		27 June 2000				
				Drilled by		Mr Shane Heawood				
				Logged by		Mr Andrew Ezzy				
				Checked by		Mr Adrian Waite				
penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	index	
	No screen	Bentonite	D Sample ID 1			OH	CLAY - black, humic	M	St D	Soil A horizon
			D Sample ID 2	0.5		CL	CLAY - medium plasticity, brown, 40% dolerite fragments	M	F D	Quaternary alluvial sediments
	0.5m .Screen	7 mm Gravel	D Sample ID 3	1.0		CH	CLAY - high plasticity, black, 10% dolerite fragments	M	St D	Quaternary alluvial sediments
	N/S			1.5						
Sample ID numbers refer to samples stored in MRT core shed							End of hole due to auger refusal at 1.7 m		Auger refusal most likely due to boulder in clay matrix	

ENGINEERING LOG - BOREHOLE

Borehole no.
CS 2001/1
Sheet 1 of 3

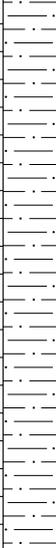
Project	Chapel Street waste depot	Location	Chapel Street, Glenorchy		
Co-ordinates	55 520429 mE 5255894 mN	Drill type	Percussion	Hole commenced	29 May 2001
R.L.		Drill method	Down hole hammer	Hole completed	29 May 2001
Inclination	vertical	Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Bearing				Logged by	Mr Andrew Ezzy
				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
			D Sample ID 1			OH	CLAY - black, humic	D	H	Quaternary alluvial deposits
		Cement		0.5						
				1.0						
		Back in fill		1.5						
				2.0						
		No screen		2.5						
				3.0						
			D Sample ID 2			CH	CLAY - high plasticity, olive, dolerite, siltstone and mudstone chips	M	F	Quaternary alluvial deposits
		Bentonite		3.5						
				4.0						
		Sand pack		4.5						

ENGINEERING LOG - BOREHOLE

Borehole no. CS 2001/1
Sheet 2 of 3

Project	Chapel Street waste depot	Location	Chapel Street, Glenorchy		
Co-ordinates	55 520429 mE 5255894 mN	Drill type	Percussion	Hole commenced	29 May 2001
R.L.		Drill method	Down hole hammer	Hole completed	29 May 2001
Inclination	vertical	Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Bearing				Logged by	Mr Andrew Ezzy
				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
			D Sample ID 3	5.5		CH	CLAY - high plasticity, brown, dolerite and mudstone chips	W	F	Quaternary alluvial deposits
			D Sample ID 4	6.0			SANDSTONE - grey	W		Permian rocks
			D Sample ID 5	8.0			MUDSTONE - grey, brown and green alternating layers of siltstone and sandstone	W		Permian rocks

6 metre 100mm 1mm slotted screen
Sand pack

ENGINEERING LOG - BOREHOLE

Borehole no.
CS 2001/1
Sheet 3 of 3

Project	Chapel Street waste depot		Location	Chapel Street, Glenorchy	
Co-ordinates	55 520429 mE 5255894 mN	Drill type	Percussion	Hole commenced	29 May 2001
R.L.		Drill method	Down hole hammer	Hole completed	29 May 2001
Inclination	vertical	Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Bearing				Logged by	Mr Andrew Ezzy
				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
	6 metre 100mm PVC 1mm slotted screen						(As sheet 2)			Permian rocks
	Back in fill			10.5						
	Back in fill			11.0						
				11.5						
				12.0						
				12.5						
				13.0						
			Sample ID numbers refer to samples stored in MRT core shed				End of hole at 13.0 m			

ENGINEERING LOG - BOREHOLE

Borehole no.
CS 2001/2
Sheet 1 of 6

Project	Chapel Street waste depot	Location	Chapel Street, Glenorchy		
Co-ordinates	55 520349 mE 5256055 mN	Drill type	Percussion	Hole commenced	29 May 2001
R.L.		Drill method	Down hole hammer	Hole completed	30 May 2001
Inclination	vertical	Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Bearing				Logged by	Mr Andrew Ezzy
				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
			D Sample ID 1			CH	CLAY - high plasticity, grey and green, 5% rock chips	M	F	FILL - material disturbed by road construction
				0.5						
				1.0						
				1.5						
				2.0						
			D Sample ID 2				DOLERITE - medium grained	D		
				2.5						
				3.0						
				3.5						
				4.0						
				4.5						

ENGINEERING LOG - BOREHOLE

Borehole no. CS 2001/2
Sheet 2 of 6

Project	Chapel Street waste depot	Location	Chapel Street, Glenorchy		
Co-ordinates	55 520349 mE 5256055 mN	Drill type	Percussion	Hole commenced	29 May 2001
		Drill method	Down hole hammer	Hole completed	30 May 2001
R.L.		Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Inclination	vertical			Logged by	Mr Andrew Ezzy
Bearing				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
							(As sheet 1)			
			D Sample ID 3	5.5 6.0 6.5			DOLERITE - brown, gravelly, hornfelsed mudstone	M		Main contact zone
			D Sample ID 4	7.0 7.5 8.0 8.5 9.0 9.5			MUDSTONE - hornfelsed, light grey, 10% brown gravel	D		

ENGINEERING LOG - BOREHOLE

Borehole no.
CS 2001/2
Sheet 3 of 6

Project	Chapel Street waste depot		Location	Chapel Street, Glenorchy	
Co-ordinates	55 520349 mE 5256055 mN	Drill type	Percussion	Hole commenced	29 May 2001
R.L.		Drill method	Down hole hammer	Hole completed	30 May 2001
Inclination	vertical	Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Bearing				Logged by	Mr Andrew Ezzy
				Checked by	Mr Adrian Waite

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	structure, geology
1 2 3	Screen		Sand pack	10.5		MUDSTONE - hornfelsed, grey	D		
			Bentonite	11.0					
				11.5					
				12.0					
				12.5					
				13.0					
	Back in fill		Back in fill	13.5					
				14.0					
				14.5					

ENGINEERING LOG - BOREHOLE

Borehole no.
CS 2001/2
Sheet 4 of 6

Project	Chapel Street waste depot	Location	Chapel Street, Glenorchy		
Co-ordinates	55 520349 mE 5256055 mN	Drill type	Percussion	Hole commenced	29 May 2001
		Drill method	Down hole hammer	Hole completed	30 May 2001
R.L.		Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Inclination	vertical			Logged by	Mr Andrew Ezzy
Bearing				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
	Back in fill	Back in fill		15.5			MUDSTONE - grey	D		Permian rocks
				16.0						
				16.5						
				17.0						
				17.5						
				18.0						
				18.5						
				19.0						
				19.5						

ENGINEERING LOG - BOREHOLE

Borehole no.
CS 2001/2
Sheet 5 of 6

Project	Chapel Street waste depot	Location	Chapel Street, Glenorchy		
Co-ordinates	55 520349 mE 5256055 mN	Drill type	Percussion	Hole commenced	29 May 2001
		Drill method	Down hole hammer	Hole completed	30 May 2001
R.L.		Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Inclination	vertical			Logged by	Mr Andrew Ezzy
Bearing				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
							(As sheet 4)			Permian rocks
				20.5						
				21.0						
				21.5						
				22.0						
				22.5						
				23.0						
				23.5						
				24.0						
				24.5						

ENGINEERING LOG - BOREHOLE

Borehole no.
CS 2001/2
Sheet 6 of 6

Project	Chapel Street waste depot	Location	Chapel Street, Glenorchy		
Co-ordinates	55 520349 mE 5256055 mN	Drill type	Percussion	Hole commenced	29 May 2001
		Drill method	Down hole hammer	Hole completed	30 May 2001
R.L.		Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Inclination	vertical			Logged by	Mr Andrew Ezzy
Bearing				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
							(As sheet 4)			Permian rocks
	Back in fill	Back in fill		25.5						
				26.0						
				26.5						
				27.0						
				27.5						
				28.0			End of hole at 28.0 m Hole drilled on 29 May 2001 Installation occurred on 30 May 2001			

ENGINEERING LOG - BOREHOLE

Borehole no.
JS 2000/1
 Sheet 1 of 1

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy
Co-ordinates	55 520610 mE 5256637 mN	Drill type	Auger
R.L.		Drill method	Rotary
Inclination	vertical	Drill fluid	Nil
Bearing		Hole commenced	26 June 2000
		Hole completed	26 June 2000
		Drilled by	Mr Shane Heawood
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1	2	3	samples, tests	R.L.	depth	symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
	No screen	Cement	D Sample ID 1			OH	CLAY - black humic	M	St	Reworked Quaternary alluvial deposit
	1.0 metre N.R.F.S. screen	Bentonite	D Sample ID 2	0.5		CI	CLAY - medium plasticity, white and grey, silty, 30% brown clay mottles	D	St	Quaternary alluvium
	7 mm Gravel			1.0						
	No screen		D Sample ID 3	1.5		CH	CLAY - light brown, silty, dolerite fragments up to 60 mm (travertine skins 2 mm) recovered	M	St	Quaternary alluvium
			Sample ID numbers refer to samples stored in MRT core shed				End of hole due to auger refusal at 1.7 m.			

ENGINEERING LOG - BOREHOLE

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy
Co-ordinates	55 520636 mE 5256654 mN	Drill type	Auger
		Drill method	Rotary
R.L.		Drill fluid	Nil
Inclination	vertical	Drilled by	Mr Shane Heawood
Bearing		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
	No screen	Cement	D Sample ID 1			GC	GRAVEL - orange, weathered dolerite	M	L	Fill - Road base
	1.5 metre N.R.F.S. screen	Bentonite		0.5		CI	CLAY - medium plasticity, dark brown, 5% orange and black clay mottles	M	Vst	Quaternary alluvium
	7 mm Gravel		D Sample ID 2	1.0						
	No screen		D Sample ID 3	1.5						
				2.0		CI	CLAY - medium plasticity, black, dolerite fragments up to 80 mm recovered	M	Vst	Quaternary alluvium
			Sample ID numbers refer to samples stored in MRT core shed	2.5			End of hole due to auger refusal at 2.5 m			

ENGINEERING LOG - BOREHOLE

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy
Co-ordinates	55 520643 mE 5256646 mN	Drill type	Auger
		Drill method	Rotary
R.L.		Drill fluid	Nil
Inclination	vertical	Hole commenced	26 June 2000
Bearing		Hole completed	26 June 2000
		Drilled by	Mr Shane Heawood
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1	2	3	samples, tests	R.L.	depth	symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
			D Sample ID 1			GC	GRAVEL - orange, weathered dolerite	M	L	Fill - Road base
						CL	CLAY - low plasticity, black	M	Vst	Quaternary alluvium
				0.5						
						CI	CLAY - medium plasticity, dark brown	M	Vst	Quaternary alluvium
			D Sample ID 2	1.0						
						CL	CLAY - low plasticity, light brown	M	Vst	Quaternary alluvium
			D Sample ID 3	2.0						
						CL	CLAY - low plasticity, dark brown	M	Vst	Quaternary alluvium
			D Sample ID 4	2.5						
						CL	CLAY - low plasticity, black, dolerite fragments up to 55 mm recovered	M	Vst	Quaternary alluvium
			D Sample ID 5	3.0						
						CL	CLAY - low plasticity, black, dolerite fragments up to 55 mm recovered	M	Vst	Quaternary alluvium
			D Sample ID 6	4.0						
							End of hole due to auger refusal at 4.0 m			

ENGINEERING LOG - BOREHOLE

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy
Co-ordinates	55 520665 mE 5256621 mN	Drill type	Auger
		Drill method	Rotary
R.L.		Drill fluid	Nil
Inclination	vertical	Hole commenced	26 June 2000
Bearing		Hole completed	26 June 2000
		Drilled by	Mr Shane Heawood
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology	
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index		
		Cement	D Sample ID 1			GC	GRAVEL - orange, weathered dolerite	M	L	Fill - Road base	
		Bentonite	D Sample ID 2	0.5		CI	CLAY - medium plasticity, light grey, silty, 40% doleritic gravel	M	S	Quaternary alluvium	
		No screen	D Sample ID 3			CL	CLAY - low plasticity, black, humic, slight hydrocarbon odour	M	St	Quaternary alluvium	
		No screen	D Sample ID 4	1.0		CI	CLAY - medium plasticity, mottled orange-brown, 5% dolerite fragments	M	S	Quaternary alluvium	
		No screen		1.5		CI	CLAY - medium plasticity, mottled orange-brown	D	S	Quaternary alluvium	
		7 mm Gravel	D Sample ID 5	2.0		CI	CLAY - medium plasticity, light grey, mudstone, dolerite, sandstone and siltstone fragments	D	St	Quaternary alluvium	
		2.0 metre N.R.F.S. Screen 4x150mm spaced 5mm holes	D Sample ID 6	2.5		CI	CLAY - medium plasticity, light grey, silty, 40% mudstone chips	D	Vst	Quaternary alluvium	
			S.W.L. 26/06/00	3.0							
			D Sample ID 7	3.5							
		No screen	D Sample ID 8	4.0		CI	CLAY - medium plasticity, light grey, silty, 40% mudstone chips	M	Vst	Quaternary alluvium	
				4.5			MUDSTONE - grey	W		Permian rock	
Sample ID numbers refer to samples stored in MRT core shed							End of hole due to auger refusal at 4.7 m				

ENGINEERING LOG - BOREHOLE

Borehole no.
JS 2001/1
 Sheet 1 of 5

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy
Co-ordinates	55 520644 mE 5256644 mN	Drill type	Percussion
R.L.		Drill method	Down hole hammer
Inclination	vertical	Drill fluid	Air
Bearing		Hole commenced	28 May 2001
		Hole completed	28 May 2001
		Drilled by	KMR Drilling Pty Ltd
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
		Cement	D Sample ID 1	0.0 - 2.0		GC	GRAVEL - dark brown, clayey, dolerite cobbles and boulders	M	St	Quaternary alluvium
		Back filled	D Sample ID 2	2.0 - 3.0		CH	CLAY - high plasticity, black humic	M	Vst	Quaternary alluvium
		No screen	D Sample ID 3	3.0 - 4.0			MUDSTONE - grey, weathered	D		Mudstone boulder in Quaternary alluvium
		Bentonite	D Sample ID 4	4.0 - 4.5		CL	CLAY - medium plasticity, orange, dolerite gravel recovered	M	St	Quaternary alluvium

ENGINEERING LOG - BOREHOLE

Borehole no.
JS 2001/1
 Sheet 2 of 5

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy		
Co-ordinates	55 520644 mE 5256644 mN	Drill type	Percussion	Hole commenced	28 May 2001
R.L.		Drill method	Down hole hammer	Hole completed	28 May 2001
Inclination	vertical	Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Bearing				Logged by	Mr Andrew Ezzy
				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
							(As sheet 1)			
			D Sample ID 5	6.0			MUDSTONE - light grey	D		Permian rocks
			D Sample ID 6	7.0						
			D Sample ID 7	8.0						
				9.0				M		Possible fracture zone at 9 metres (damp)

ENGINEERING LOG - BOREHOLE

Borehole no.
JS 2001/1
 Sheet 3 of 5

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy		
Co-ordinates	55 520644 mE 5256644 mN	Drill type	Percussion	Hole commenced	28 May 2001
R.L.		Drill method	Down hole hammer	Hole completed	28 May 2001
Inclination	vertical	Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Bearing				Logged by	Mr Andrew Ezzy
				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
							(As sheet 2)			
				10.5						
				11.0						
				11.5						
				12.0						
			D Sample ID 8	12.5						
				13.0						
			D Sample ID 9	13.5			MUDSTONE - light grey	M		Permian rocks Possible fracture zone (damp)
				14.0						
			D Sample ID 10	14.5			MUDSTONE - light grey	D		Permian rocks

ENGINEERING LOG - BOREHOLE

Borehole no.
JS 2001/1
 Sheet 4 of 5

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy		
Co-ordinates	55 520644 mE 5256644 mN	Drill type	Percussion	Hole commenced	28 May 2001
R.L.		Drill method	Down hole hammer	Hole completed	28 May 2001
Inclination	vertical	Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Bearing				Logged by	Mr Andrew Ezzy
				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
				15.5			(As sheet 3)			
				16.0						
				16.5						
				17.0						
				17.5						
				18.0			MUDSTONE - grey	W		Permian rocks
				18.5						
				19.0						
				19.5						

ENGINEERING LOG - BOREHOLE

Borehole no.
JS 2001/1
 Sheet 5 of 5

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy		
Co-ordinates	55 520644 mE 5256644 mN	Drill type	Percussion	Hole commenced	28 May 2001
		Drill method	Down hole hammer	Hole completed	28 May 2001
R.L.		Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Inclination	vertical			Logged by	Mr Andrew Ezzy
Bearing				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
							(As sheet 4)			
	6 metre 1 mm slotted Screen			20.5						
	2 - 3 mm triple washed sand			21.0						
				21.5						
				22.0						
				22.5						
				23.0						
			Sample ID numbers refer to samples stored in MRT core shed				End of hole at 23.0 m			

ENGINEERING LOG - BOREHOLE

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy
Co-ordinates	55 520528 mE 5256487 mN	Drill type	Percussion
R.L.		Drill method	Down hole hammer
Inclination	vertical	Drill fluid	Air
Bearing		Hole commenced	28 May 2001
		Hole completed	28 May 2001
		Drilled by	KMR Drilling Pty Ltd
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
		Cement	D Sample ID 1	0.5			GRAVEL - light brown, angular rock fragments	M	F	Fill - Road building material
		Back filled	D Sample ID 2	1.0		CL	CLAY - medium plasticity, light grey, orange clay mottles	M	F	Weathered Permian rocks
		Bentonite	D Sample ID 3	2.0			SILTSTONE - light brown	D		Permian rock
	No screen			2.5						
				3.0						
		2 - 3 mm triple washed sand		3.5						
				4.0						
				4.5						

ENGINEERING LOG - BOREHOLE

Borehole no.
JS 2001/2
 Sheet 2 of 7

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy		
Co-ordinates	55 520528 mE 5256487 mN	Drill type	Percussion	Hole commenced	28 May 2001
R.L.		Drill method	Down hole hammer	Hole completed	28 May 2001
Inclination	vertical	Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Bearing				Logged by	Mr Andrew Ezzy
				Checked by	Mr Adrian Waite

penetration	support	water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	structure, geology
1 2 3			D Sample ID 4	5.5			MUDSTONE - light yellow	D		Permian rock
			D Sample ID 5	7.0			MUDSTONE - light brown	D		Permian rock
			D Sample ID 6	8.0						
				8.5						
				9.0						
				9.5						

ENGINEERING LOG - BOREHOLE

Borehole no.
JS 2001/2
 Sheet 3 of 7

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy
Co-ordinates	55 520528 mE 5256487 mN	Drill type	Percussion
R.L.		Drill method	Down hole hammer
Inclination	vertical	Drill fluid	Air
Bearing		Hole commenced	28 May 2001
		Hole completed	28 May 2001
		Drilled by	KMR Drilling Pty Ltd
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
							(As sheet 2)			
			D Sample ID 7	10.5 11.0 11.5 12.0			MUDSTONE - brown, 5% light grey clay	D		Permian rock
			D Sample ID 8	12.5 13.0						
			D Sample ID 9	13.5 14.0 14.5			SILTSTONE - white, 40% medium plasticity light brown clay mottles	D		Permian rock

ENGINEERING LOG - BOREHOLE

Borehole no.
JS 2001/2
 Sheet 4 of 7

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy		
Co-ordinates	55 520528 mE 5256487 mN	Drill type	Percussion	Hole commenced	28 May 2001
		Drill method	Down hole hammer	Hole completed	28 May 2001
R.L.		Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Inclination	vertical			Logged by	Mr Andrew Ezzy
Bearing				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
							(As sheet 3)			
			D Sample ID 10	15.5 16.0			MUDSTONE - light brown	D		Permian rock
				16.5 17.0 17.5 18.0 18.5						
			D Sample ID 11	19.0 19.5		CH	CLAY - high plasticity, orange, 10% grey mudstone chips	M	F	Permian rocks- weathering possibly due to water flow on fractures

ENGINEERING LOG - BOREHOLE

Borehole no. JS 2001/2
Sheet 5 of 7

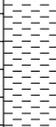
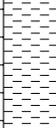
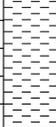
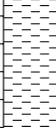
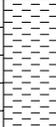
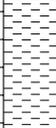
Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy
Co-ordinates	55 520528 mE 5256487 mN	Drill type	Percussion
R.L.		Drill method	Down hole hammer
Inclination	vertical	Drill fluid	Air
Bearing		Hole commenced	28 May 2001
		Hole completed	28 May 2001
		Drilled by	KMR Drilling Pty Ltd
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
			D Sample ID 12				MUDSTONE - light grey, 40% siltstone, light brown	D		Permian rock
	No screen			20.5						
				21.0						
				21.5						
				22.0						
				22.5						
				23.0						
				23.5						
				24.0						
				24.5						

ENGINEERING LOG - BOREHOLE

Borehole no. JS 2001/2
Sheet 6 of 7

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy		
Co-ordinates	55 520528 mE 5256487 mN	Drill type	Percussion	Hole commenced	28 May 2001
R.L.		Drill method	Down hole hammer	Hole completed	28 May 2001
Inclination	vertical	Drill fluid	Air	Drilled by	KMR Drilling Pty Ltd
Bearing				Logged by	Mr Andrew Ezzy
				Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	
			D Sample ID 13	25.5			SILTSTONE - light grey	M		Permian rock
				26.0						
				26.5						
				27.0						
				27.5						
				28.0						
				28.5						
				29.0						
			D Sample ID 14	29.5						

ENGINEERING LOG - BOREHOLE

Borehole no.
JS 2001/2
 Sheet 7 of 7

Project	Jackson Street waste depot	Location	Jackson Street, Glenorchy
Co-ordinates	55 520528 mE 5256487 mN	Drill type	Percussion
R.L.		Drill method	Down hole hammer
Inclination	vertical	Drill fluid	Air
Bearing		Hole commenced	28 May 2001
		Hole completed	28 May 2001
		Drilled by	KMR Drilling Pty Ltd
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	structure, geology
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	index	
			D Sample ID 15	30.5			SILTSTONE - light grey, 20% clay high plasticity orange	M		Permian rock
			D Sample ID 16	31.0		CL	CLAY - medium plasticity, light brown, 10% clay light grey nodules, 10% mudstone light grey recovered	M	F	Permian rocks- weathering possibly due to water flow on fractures
			D Sample ID 17	32.0		CL	CLAY - high plasticity, light brown, 10% siltstone brown-light grey	W	L	Weathered Permian rocks possibly due to palaeo-flow along fractures
				32.5						
				33.0						
				33.5						
				34.0						
				34.5						
							End of hole at 35.0 m			

6 metre 1 mm slotted Screen
 2 - 3 mm triple washed sand

Sample ID numbers refer to
 samples stored in MRT core shed

Appendix 2
Engineering logs and photos of test pits

ENGINEERING LOG - TEST PIT

test pit no.
CSTP 2001/1
 sheet 1 of 1

project	Chapel Street waste depot			location	Chapel Street, Glenorchy		
co-ordinates	55 520351 mE	equipment type	320B 20 tonne Excavator	pit commenced	28 May 2001		
	5256029 mN	bucket size	0.6m	pit completed	28 May 2001		
R.L.		width	0.6m	excavated by	Glenorchy City Council		
		length	2.8m	logged by	Mr Andrew Ezzy		
				checked by	Mr Adrian Waite		

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	field records/comments
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	insitu testing, soil structure, soil origin, additional observations
						CH	CLAY - high plasticity, brown	D	St	Reworked weathered Permian rocks
				0.5			Refusal on grey mudstone at 0.35 m			



ENGINEERING LOG - TEST PIT

test pit no.
CSTP 2001/2
 sheet 1 of 1

project	Chapel Street waste depot			location	Chapel Street, Glenorchy		
co-ordinates	55 520350 mE	equipment type	320B 20 tonne Excavator	pit commenced	28 May 2001		
	5256037 mN	bucket size	0.6m	pit completed	28 May 2001		
R.L.		width	0.6m	excavated by	Glenorchy City Council		
		length	3.3m	logged by	Mr Andrew Ezzy		
				checked by	Mr Adrian Waite		

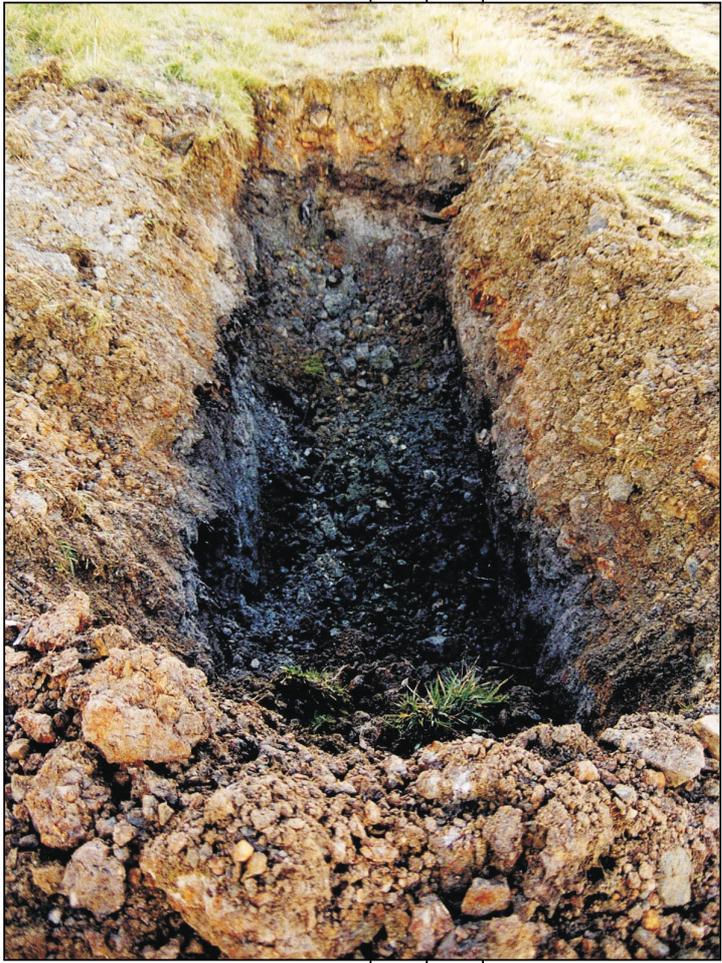
penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	field records/comments
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	insitu testing, soil structure, soil origin, additional observations
			Minor (flow 0.005 l/s)	0.5		CL	CLAY - medium plasticity, grey and brown, 10% dolerite cobbles	M	F	Road materials
			Main (flow 0.036 l/s)	1.5			Refusal on grey mudstone at 1.5 m			Flow of water across bedrock surface at base of unconsolidated material



ENGINEERING LOG - TEST PIT

test pit no.
CSTP 2001/3
 sheet 1 of 1

project	Chapel Street waste depot			location	Chapel Street, Glenorchy		
co-ordinates	55 520345 mE	equipment type	320B 20 tonne Excavator	pit commenced	28 May 2001		
	5256054 mN	bucket size	0.6m	pit completed	28 May 2001		
R.L.		width	0.6m	excavated by	Glenorchy City Council		
		length	3.2m	logged by	Mr Andrew Ezzy		
				checked by	Mr Adrian Waite		

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	field records/comments
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	insitu testing, soil structure, soil origin, additional observations
							MUDSTONE - grey	D		Road base
				0.5		CH	CLAY - high plasticity, dark grey	M	F	Reworked weathered Permian rocks
				1.0			Refusal on grey mudstone at 1.1 m			
										

ENGINEERING LOG - TEST PIT

test pit no.
CSTP 2001/4
 sheet 1 of 1

project	Chapel Street waste depot			location	Chapel Street, Glenorchy		
co-ordinates	55 520039 mE	equipment type	320B 20 tonne Excavator	pit commenced	22 June2001		
	5255989 mN	bucket size	0.6m	pit completed	22 June2001		
R.L.		width	0.6m	excavated by	Glenorchy City Council		
		length	3.6m	logged by	Mr Andrew Ezzy		
				checked by	Mr Adrian Waite		

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	field records/comments
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	insitu testing, soil structure, soil origin, additional observations
						OH	CLAY - black, humic	M	L	Soil cover over main clay capping
				0.5		CL	CLAY - medium plasticity, light brown, sedimentary rock fragments up to 7 mm	M	F	Main landfill capping cover
				1.0			WASTE fill - domestic refuse	W		Pit venting very large volumes of landfill gas
				1.5			WASTE fill - domestic refuse	W		
							Water sampled and analysed for metals, nutrients, total petroleum hydrocarbons and other general parameters			
							End of hole in WASTE fill at 1.5 m			



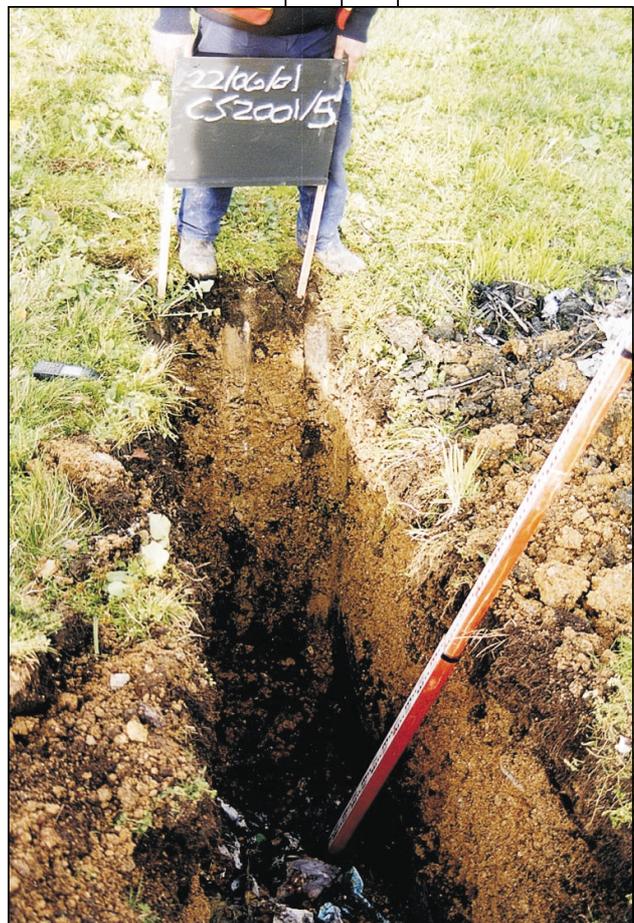
ENGINEERING LOG - TEST PIT

test pit no.
CSTP 2001/5
 sheet 1 of 1

project	Chapel Street waste depot			location	Chapel Street, Glenorchy		
co-ordinates	55 520052 mE	equipment type	320B 20 tonne Excavator	pit commenced	22 June2001		
	5255940 mN	bucket size	0.6m	pit completed	22 June2001		
R.L.		width	0.6m	excavated by	Glenorchy City Council		
		length	3.5m	logged by	Mr Andrew Ezzy		
				checked by	Mr Adrian Waite		

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	field records/comments
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	insitu testing, soil structure, soil origin, additional observations
						OH	CLAY - black, humic	M	L	Soil cover
				0.5		CL	CLAY - medium plasticity, light brown, sedimentary rock fragments up to 7 mm	M	F	Main landfill capping cover
						CH	CLAY - high plasticity, green	M	F	
				1.0			WASTE fill- domestic refuse	W		Pit venting large volumes of landfill gas

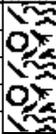
End of hole in WASTE fill at 1.3 m



ENGINEERING LOG - TEST PIT

test pit no.
CSTP 2001/6
 sheet 1 of 1

project	Chapel Street waste depot			location	Chapel Street, Glenorchy		
co-ordinates	55 520010 mE	equipment type	320B 20 tonne Excavator	pit commenced	22 June2001		
	5255968 mN	bucket size	0.6m	pit completed	22 June2001		
R.L.		width	0.6m	excavated by	Glenorchy City Council		
		length	3.8m	logged by	Mr Andrew Ezzy		
				checked by	Mr Adrian Waite		

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	field records/comments
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	insitu testing, soil structure, soil origin, additional observations
						OH	CLAY - black, humic	M	L	Soil cover
				0.5		CL	CLAY - medium plasticity, light brown, sedimentary rock fragments up to 7 mm	M	F	Main landfill capping cover
				1.0		CH	CLAY - high plasticity, mottled grey and brown	M	St	
				1.5			WASTE fill - domestic refuse	D		Pit venting large volumes of landfill gas
				1.5			End of hole in WASTE fill at 1.5 m			



ENGINEERING LOG - TEST PIT

test pit no.
CSTP 2001/7
 sheet 1 of 1

project	Chapel Street waste depot			location	Chapel Street, Glenorchy		
co-ordinates	55 520064 mE	equipment type	320B 20 tonne Excavator	pit commenced	22 June2001		
	5256016 mN	bucket size	0.6m	pit completed	22 June2001		
R.L.		width	0.6m	excavated by	Glenorchy City Council		
		length	3.7m	logged by	Mr Andrew Ezzy		
				checked by	Mr Adrian Waite		

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	field records/comments
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	insitu testing, soil structure, soil origin, additional observations
						OH	CLAY - black humic	M	L	Soil cover
				0.5		CL	CLAY - medium plasticity, light brown, sedimentary rock fragments up to 7 mm	M	F	Main landfill capping cover
				1.0		CH	CLAY - high plasticity, black	M	F	
							WASTE fill- domestic refuse	D		Pit venting large volumes of landfill gas

End of hole in WASTE fill at 1.3 m



ENGINEERING LOG - TEST PIT

test pit no.
CSTP 2001/8
 sheet 1 of 1

project	Chapel Street waste depot			location	Chapel Street, Glenorchy		
co-ordinates	55 520103 mE	equipment type	320B 20 tonne Excavator	pit commenced	22 June2001		
	5256063 mN	bucket size	0.6m	pit completed	22 June2001		
R.L.		width	0.6m	excavated by	Glenorchy City Council		
		length	3.5m	logged by	Mr Andrew Ezzy		
				checked by	Mr Adrian Waite		

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	field records/comments
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	insitu testing, soil structure, soil origin, additional observations
						OH	CLAY - black humic	M	L	Soil cover
				0.5		CL	CLAY - medium plasticity, light brown, sedimentary rock fragments up to 7 mm	M	F	Main landfill capping cover
				1.0		CL	CLAY - low plasticity, black, dolerite fragments up to 12 mm	D	Vst	
							WASTE fill - domestic refuse, dark grey soil	D		Pit venting large volumes of landfill gas

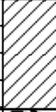
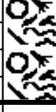
End of hole in WASTE fill at 1.3 m



ENGINEERING LOG - TEST PIT

test pit no.
CSTP 2001/9
 sheet 1 of 1

project	Chapel Street waste depot			location	Chapel Street, Glenorchy		
co-ordinates	55 520131 mE	equipment type	320B 20 tonne Excavator	pit commenced	22 June2001		
	5256104 mN	bucket size	0.6m	pit completed	22 June2001		
R.L.		width	0.6m	excavated by	Glenorchy City Council		
		length	3.7m	logged by	Mr Andrew Ezzy		
				checked by	Mr Adrian Waite		

penetration	support	water	notes	metres	graphic log	classification	material	moisture	consistency	field records/comments
1 2 3			samples, tests	R.L. depth		symbol	soil type: plasticity or particle characteristics, colour, secondary and minor components.	condition	density index	insitu testing, soil structure, soil origin, additional observations
						OH	CLAY - black humic	M	L	Soil cover
				0.5		CL	CLAY - medium plasticity, light brown, sedimentary rock fragments up to 7 mm	M	F	Main landfill capping cover
				1.0		OH	CLAY - dark grey, various rock fragments up to 8 mm	D	Vst	
				1.5			WASTE fill- domestic refuse, dark grey soil	D		Pit venting large volumes of landfill gas
							End of hole in WASTE fill at 1.6 m			



Appendix 3

Analytical Services Tasmania — Laboratory reports



ANALYTICAL SERVICES TASMANIA
Sandy Bay Laboratory
c/- Chemistry Department University of Tasmania
Sandy Bay Tasmania 7005
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NATA Accreditation
Number: 5589

Laboratory Report

Report No: 15088 *Please quote this number when making enquiries about this report*
Submitted By: Andrew Ezzy (Mineral Resources Tasmania)
Client: E&P Division MRT Groundwater
Site Description:
Received: 05-Jun-01 **Client Order No:**
Report Date: 22-Jun-2001 15:17
Report To: Andrew Ezzy (Mineral Resources Tasmania)
Address: Gordons Hill Road Rosny TAS 7018

Test Method(s) :

1001-Water: pH in Water by APHA Method 4500-H
1002-Water: Conductivity by APHA Method 2510
1004-Water: Solids, Total Dissolved by APHA Method 2540C
1103-Water: Anions by Ion Chromatography APHA Method 4110C
1202-Water: Total N & P by APHA Method 4500
1204-Water: Ammonia by Ion Selective Electrode APHA Method 4500-NH3 *
1301-Water: Metals in Water by APHA Method 3030/3120
1302-Water: Major Cations in Water by APHA Method 3030/3120
1406-Water: TPH and BTEX in Water by GC-FID *



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Mike Johnson
Manager

Page 1 of 2

Report No: 15088

Report Date: 22-Jun-2001 15:17

Method	Analyte	Units / Sampled On :	Lab.No.: 21670	21671	21672	21673	21674
			Sample Id.: CS2001/1	Leachateline	Spring1	JS2001/1	JS2001/2
			05/06/01 12:30	05/06/01 11:55	05/06/01 15:45	05/06/01 10:40	05/06/01 15:30
1001-Water	pH		6.5	7.7	7.0	7.1	6.9
1002-Water	Conductivity	µS/cm	5590	6720	7230	1170	1590
1004-Water	TDS	mg/L	3620	3570	3700	753	1030
1103-Water	Bromide	mg/L	9.7	14	18	0.57	0.81
	Chloride	mg/L	1400	1400	1300	170	270
	Fluoride	mg/L	<0.02	0.20	0.21	0.26	0.16
	Nitrate	mg-N/L	<0.03	6.4	13	<0.03	0.08
	Nitrite	mg-N/L	<0.10	1.5	<0.10	<0.10	<0.10
	Phosphate	mg-P/L	<0.10	<0.10	<0.10	<0.10	<0.10
	Sulphate	mg/L	27	5.1	2.7	40	25
	1202-Water	N (Total)	µg/L	3100	146000	240000	117
	P (Total)	µg/L	35	107	3820	86	4590
1204-Water	Ammonia	mg-N/L	0.85	110	170	0.12	0.08
1301-Water	Al (Dissolved)	µg/L	<20	<20	<20	<20	<20
	As (Dissolved)	µg/L	<5	<5	<5	<5	<5
	Cd (Dissolved)	µg/L	<1	<1	2	<1	<1
	Co (Dissolved)	µg/L	35	12	30	<1	3
	Cr (Dissolved)	µg/L	<1	3	5	<1	<1
	Cu (Dissolved)	µg/L	2	1	16	<1	<1
	Fe (Dissolved)	µg/L	47	156	380	22	27
	Mn (Dissolved)	µg/L	13800	1070	1470	181	90
	Ni (Dissolved)	µg/L	39	21	23	2	7
	Pb (Dissolved)	µg/L	<5	<5	<5	<5	<5
	Zn (Dissolved)	µg/L	3	21	960	5	3
	1302-Water	Ca (Dissolved)	mg/L	378	176	225	71.3
K (Dissolved)		mg/L	1.97	115	150	2.37	1.85
Mg (Dissolved)		mg/L	275	185	186	66.6	94.7
Na (Dissolved)		mg/L	504	879	864	82.1	94.3
1406-Water	TPH	µg/L	58	127	71	<40	<40
	TPH C06-C09	µg/L	<10	<10	20	<10	<10
	TPH C10-C14	µg/L	47	92	33	<10	<10
	TPH C15-C28	µg/L	<10	32	<10	<10	<10
	TPH C29+	µg/L	<10	<10	18	<10	<10



ANALYTICAL SERVICES TASMANIA
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NATA Accreditation
Number: 5589

Laboratory Report

Report No: 15070 *Please quote this number when making enquiries about this report*
Submitted By: Andrew Ezzy
Client: E&P Division MRT Groundwater
Site Description:
Received: 01-Jun-01 Client Order No:
Report Date: 21-Jun-2001 11:59
Report To: Andrew Ezzy (Mineral Resources Tasmania)
Address: Gordons Hill Road Rosny TAS 7018

Test Method(s) :

1001-Water: pH in Water by APHA Method 4500-H
1002-Water: Conductivity by APHA Method 2510
1004-Water: Solids, Total Dissolved by APHA Method 2540C
1103-Water: Anions by Ion Chromatography APHA Method 4110C
1202-Water: Total N & P by APHA Method 4500
1204-Water: Ammonia by Ion Selective Electrode APHA Method 4500-NH3 *
1301-Water: Metals in Water by APHA Method 3030/3120
1302-Water: Major Cations in Water by APHA Method 3030/3120
1406-Water: TPH and BTEX in Water by GC-FID *

This report replaces the report(s) issued on : 05-Jun-2001 16:48, 21-Jun-2001 11:57, 21-Jun-2001 11:58



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Greg Hince
Senior Chemist

Page 1 of 2

Report No: 15070

Report Date: 21-Jun-2001 11:59

Method	Analyte	Units / Sampled On :	Lab.No.:	21570	21571	21572	21573
			Sample Id.:	JS2001/2	JS2001/1	JS2001/4	CS2001/1
			01/06/01 13:40	01/06/01 11:10	01/06/01 11:00	01/06/01 11:50	
1001-Water	pH			8.0	8.0	6.8	7.5
1002-Water	Conductivity	µS/cm		1490	1180	1750	5550
1004-Water	TDS	mg/L		926	732	1090	3810
1103-Water	Bromide	mg/L		0.93	0.55	1.7	9.9
	Chloride	mg/L		300	150	240	1400
	Fluoride	mg/L		0.27	0.24	3.7	<0.02
	Nitrate	mg-N/L		0.19	<0.03	<0.03	<0.03
	Nitrite	mg-N/L		<0.10	<0.10	<0.10	<0.10
	Phosphate	mg-P/L		<0.10	<0.10	<0.10	<0.10
	Sulphate	mg/L		38	41	120	28
	1202-Water	N (Total)	µg/L		1880	137	4060
	P (Total)	µg/L		19300	74	1440	1010
1204-Water	Ammonia	mg-N/L		0.54	0.05	0.27	1.05
1301-Water	Al (Dissolved)	µg/L		<20	<20	<20	<20
	As (Dissolved)	µg/L		<5	<5	<5	<5
	Cd (Dissolved)	µg/L		<1	<1	<1	<1
	Co (Dissolved)	µg/L		<1	1	6	23
	Cr (Dissolved)	µg/L		<1	<1	2	1
	Cu (Dissolved)	µg/L		<1	<1	13	3
	Fe (Dissolved)	µg/L		40	37	56	40
	Mn (Dissolved)	µg/L		38	94	408	6890
	Ni (Dissolved)	µg/L		3	3	14	49
	Pb (Dissolved)	µg/L		<5	<5	<5	<5
	Zn (Dissolved)	µg/L		<1	6	8	<1
	1302-Water	Ca (Dissolved)	mg/L		100	74.1	89.4
K (Dissolved)		mg/L		2.17	2.76	10.2	2.42
Mg (Dissolved)		mg/L		88.2	72.5	61.3	303
Na (Dissolved)		mg/L		103	90.4	232	525
1406-Water	TPH	µg/L		<40	248	105	119
	TPH C06-C09	µg/L		<10	<10	11	<10
	TPH C10-C14	µg/L		<10	<10	<10	42
	TPH C15-C28	µg/L		<10	204	76	74
	TPH C29+	µg/L		<10	40	12	<10



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NATA Accreditation
Number: 5589

Laboratory Report

Report No: 15200 *Please quote this number when making enquiries about this report*
Submitted By: Andrew Ezzy (Mineral Resources Tasmania)
Client: E&P Division MRT Groundwater
Site Description:
Received: 22-Jun-01 **Client Order No:**
Report Date: 12-Jul-2001 14:00
Report To: Andrew Ezzy (Mineral Resources Tasmania)
Address: Gordons Hill Road Rosny TAS 7018

Test Method(s) :

1001-Water: pH in Water by APHA Method 4500-H
1002-Water: Conductivity by APHA Method 2510
1004-Water: Solids, Total Dissolved by APHA Method 2540C
1103-Water: Anions by Ion Chromatography APHA Method 4110C
1202-Water: Total N & P by APHA Method 4500
1204-Water: Ammonia by Ion Selective Electrode APHA Method 4500-NH3 *
1301-Water: Metals in Water by APHA Method 3030/3120
1302-Water: Major Cations in Water by APHA Method 3030/3120
1406-Water: TPH and BTEX in Water by GC-FID *



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Greg Hince
Senior Chemist

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 Sandy Bay Tasmania 7005



NATA Accreditation
 Number: 5589

Report No: 15200

Report Date: 12-Jul-2001 14:00

Method	Analyte	Units / Sampled On :	Lab.No.: Sample Id.: 22/06/01 14:00
1001-Water	pH		22162 TPCS2001/4
1002-Water	Conductivity	µS/cm	6.8
1004-Water	TDS	mg/L	7850
1103-Water	Bromide	mg/L	4830
	Chloride	mg/L	6.7
	Fluoride	mg/L	820
	Nitrate	mg-N/L	36
	Nitrite	mg-N/L	<0.30
	Phosphate	mg-P/L	0.35
	Sulphate	mg/L	<1.00
1202-Water	N (Total)	µg/L	62
	P (Total)	µg/L	142000
1204-Water	Ammonia	mg-N/L	3660
1301-Water	Al (Dissolved)	µg/L	170
	As (Dissolved)	µg/L	277
	Cd (Dissolved)	µg/L	<5
	Co (Dissolved)	µg/L	4
	Cr (Dissolved)	µg/L	19
	Cu (Dissolved)	µg/L	9
	Fe (Dissolved)	µg/L	4
	Mn (Dissolved)	µg/L	44400
	Ni (Dissolved)	µg/L	1530
	Pb (Dissolved)	µg/L	68
	Zn (Dissolved)	µg/L	9
1302-Water	Ca (Dissolved)	mg/L	1430
	K (Dissolved)	mg/L	283
	Mg (Dissolved)	mg/L	198
	Na (Dissolved)	mg/L	308
1406-Water	TPH	µg/L	584
	TPH C06-C09	µg/L	9990
	TPH C10-C14	µg/L	3100
	TPH C15-C28	µg/L	6660
	TPH C29+	µg/L	232
			<10



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NATA Accreditation
Number: 5589

Laboratory Report

Report No: 14873 *Please quote this number when making enquiries about this report*
Submitted By: A. Ezzy
Client: E&P Division MRT Groundwater
Site Description: Chapel Street Waste Depot
Received: 04-May-01 Client Order No:
Report Date: 22-May-2001 13:40
Report To: A. Ezzy
Address: C/- MRT

Test Method(s) :

1001-Water: pH in Water by APHA Method 4500-H
1002-Water: Conductivity by APHA Method 2510
1004-Water: Solids, Total Dissolved by APHA Method 2540C
1103-Water: Anions by Ion Chromatography APHA Method 4110C
1201-Water: Nutrients by APHA Method 4500
1301-Water: Metals in Water by APHA Method 3030/3120
1302-Water: Major Cations in Water by APHA Method 3030/3120
1406-Water: TPH and BTEX in Water by GC-FID *



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Manager

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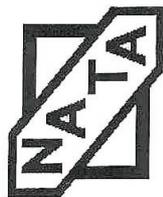
Tasmania

ANALYTICAL SERVICES TASMANIA

Sandy Bay Laboratory

c/- Chemistry Department University of Tasmania

Sandy Bay Tasmania 7005



NATA Accreditation Number: 5589

Report No: 14873

Report Date: 22-May-2001 12:10

Method	Analyte	Units / Sampled On :	Lab.No.:	Sample Id.:
1001-Water	pH	6.9	20544	Surface 1
1002-Water	Conductivity	7470		
1004-Water	TDS	3770		
1103-Water	Bromide	15		
	Chloride	1300		
	Fluoride	0.61		
	Sulphate	0.32		
1201-Water	Ammonia	223000		
	Nitrate+Nitrite	334		
	Nitrite	72		
	Ortho-P	21		
1301-Water	Al (Dissolved)	<20		
	As (Dissolved)	<5		
	Cd (Dissolved)	<1		
	Co (Dissolved)	16		
	Cr (Dissolved)	6		
	Cu (Dissolved)	<1		
	Fe (Dissolved)	383		
	Mn (Dissolved)	722		
	Ni (Dissolved)	21		
	Pb (Dissolved)	<5		
	Zn (Dissolved)	63		



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Sandy Bay Laboratory

c/- Chemistry Department University of Tasmania

Sandy Bay Tasmania 7005



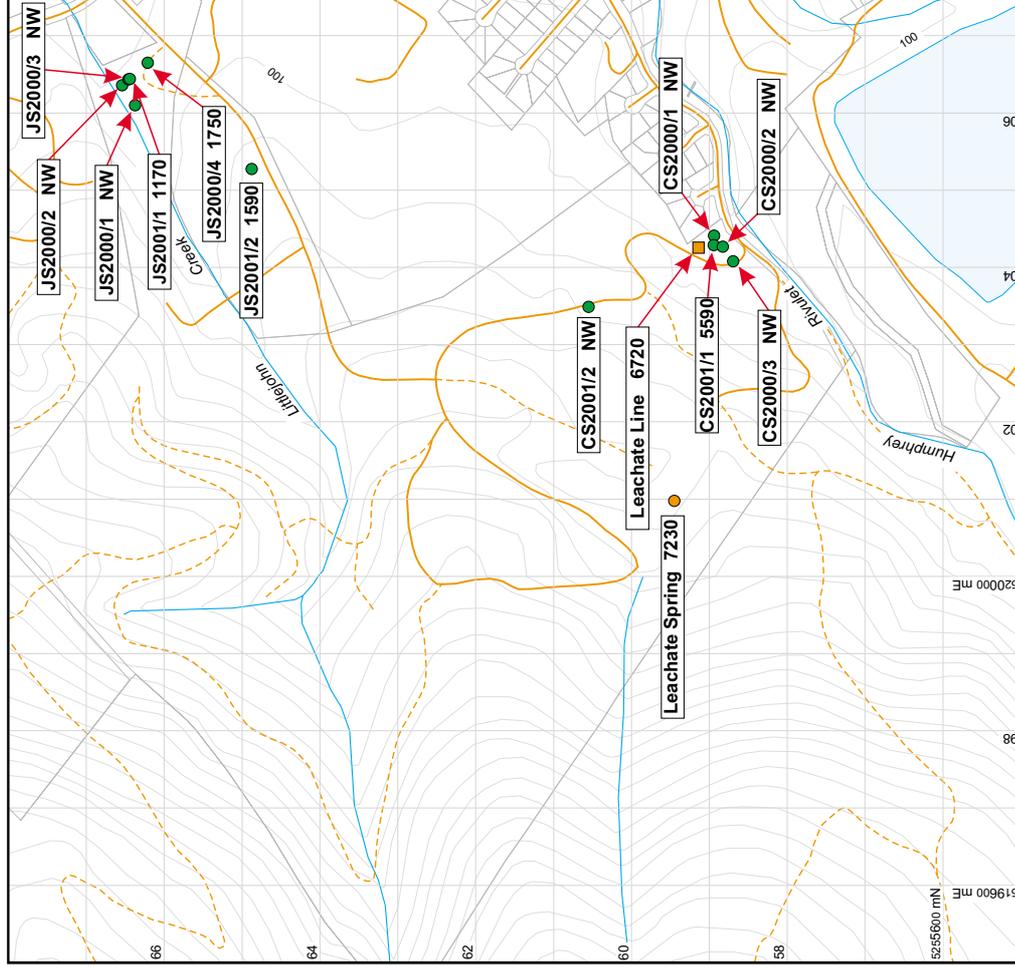
NATA Accreditation Number: 5589

Report No: 14873 Report Date: 22-May-2001 12:10

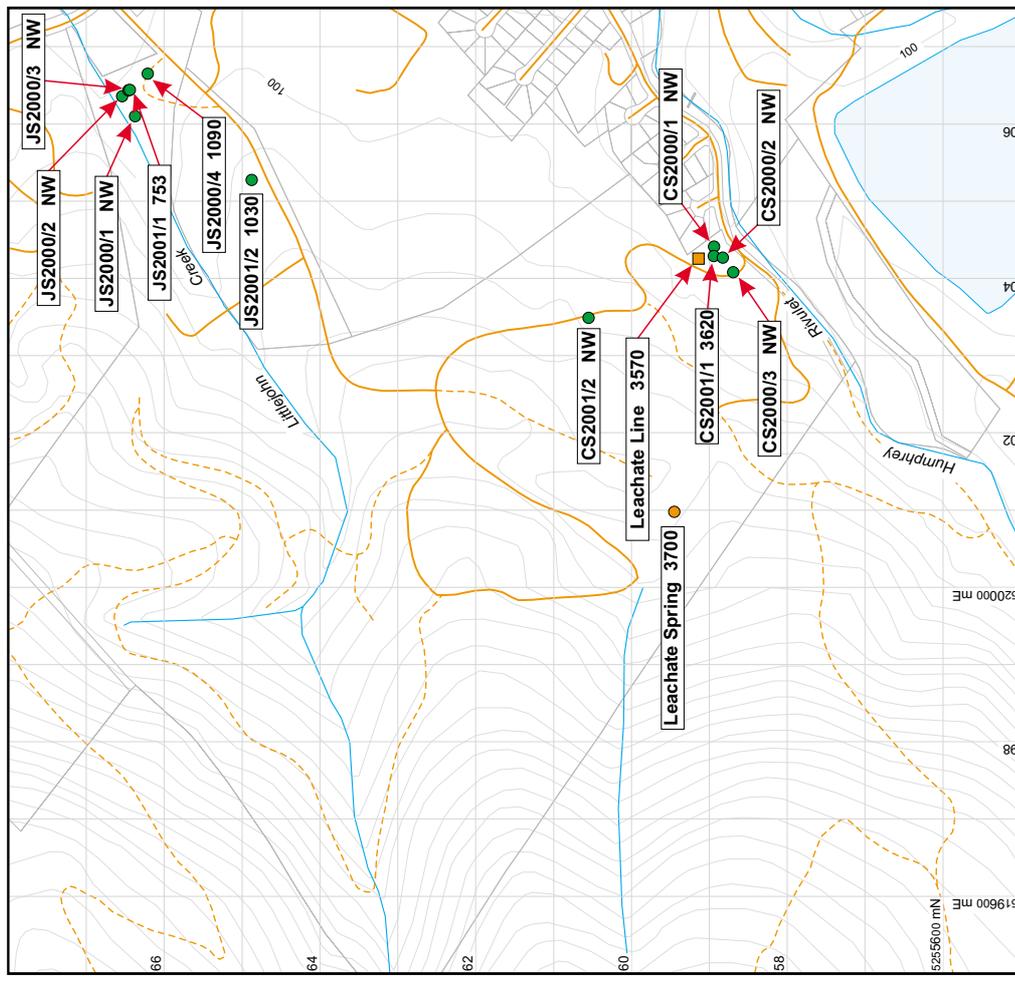
Method	Analyte	Units / Sampled On :	Lab.No.:	Sample Id.:
1302-Water	Ca (Dissolved)	mg/L	20544	Surface 1
	K (Dissolved)	mg/L		
	Mg (Dissolved)	mg/L		04/05/01 14:30
	Na (Dissolved)	mg/L	178	
	TPH	µg/L	135	
1406-Water	TPH C06-C09	µg/L		
	TPH C10-C14	µg/L		
	TPH C15-C28	µg/L	161	
	TPH C29+	µg/L	846	
			92	
		<10		
		80		
		12		
		<10		

Appendix 4
Analytical results on site maps

Jackson Street & Chapel Street waste depots
June 2001
Conductivity ($\mu\text{S}/\text{cm}$)



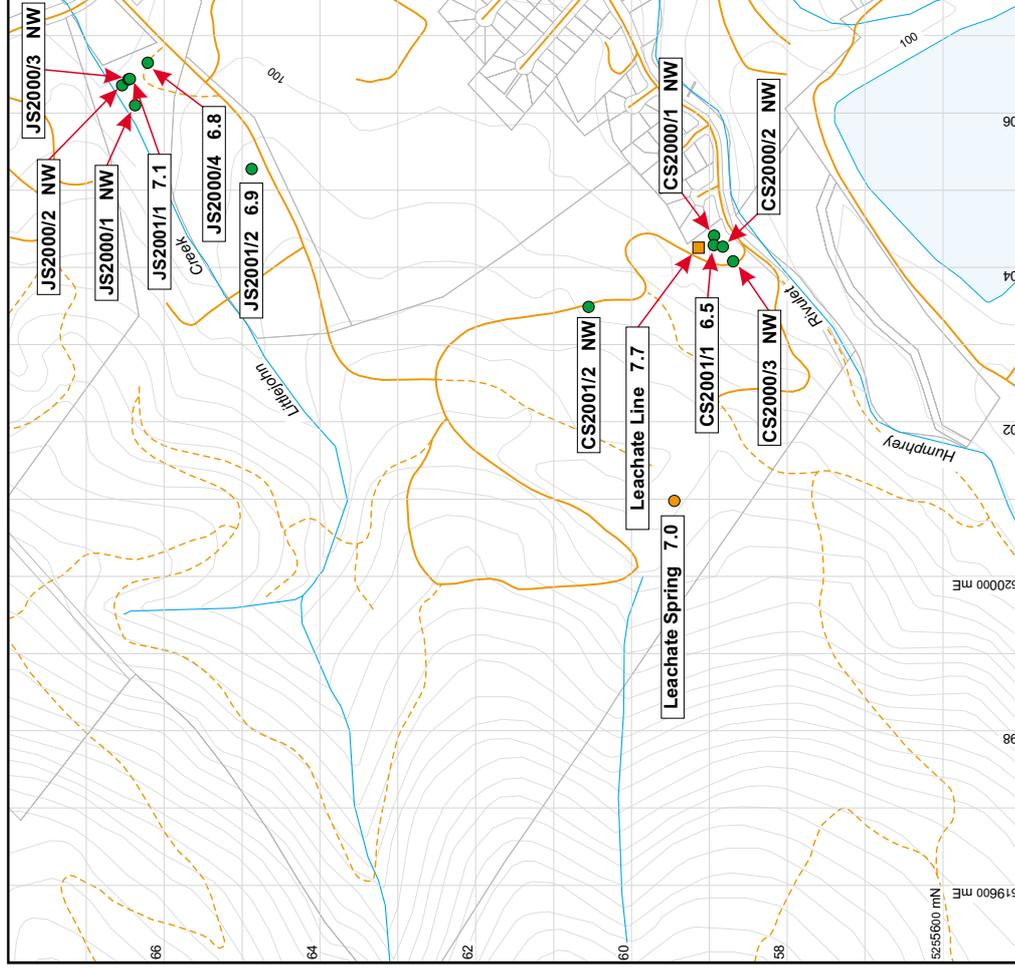
Jackson Street & Chapel Street waste depots
June 2001
TDS (mg/L)



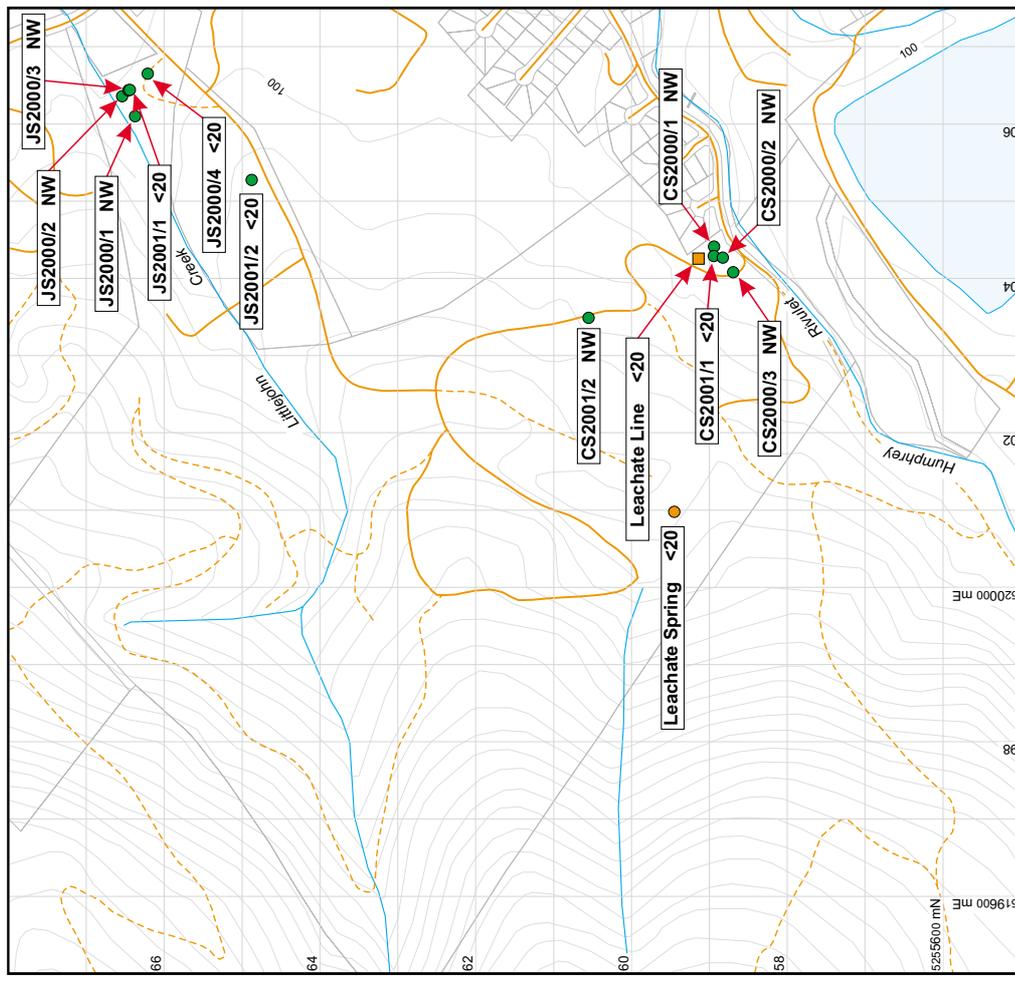
Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

Jackson Street & Chapel Street waste depots June 2001 pH



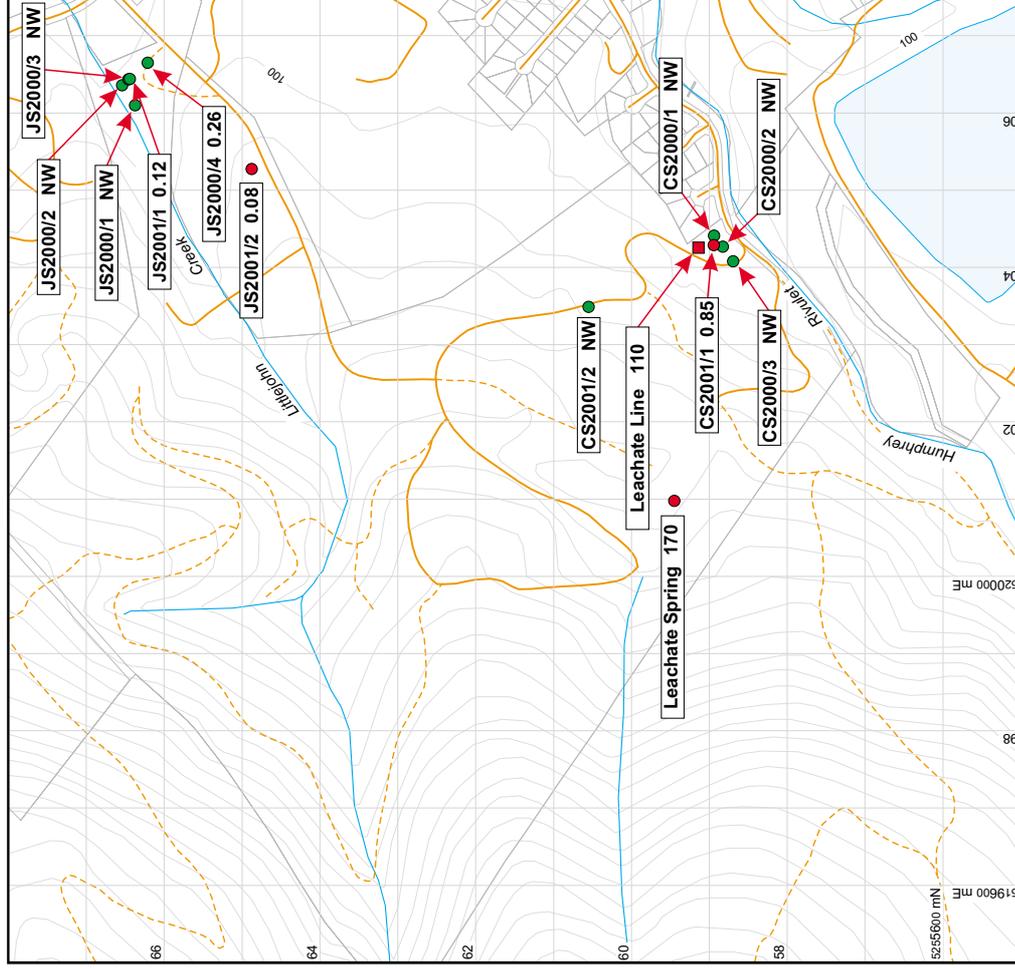
Jackson Street & Chapel Street waste depots June 2001 Al ($\mu\text{g/L}$)



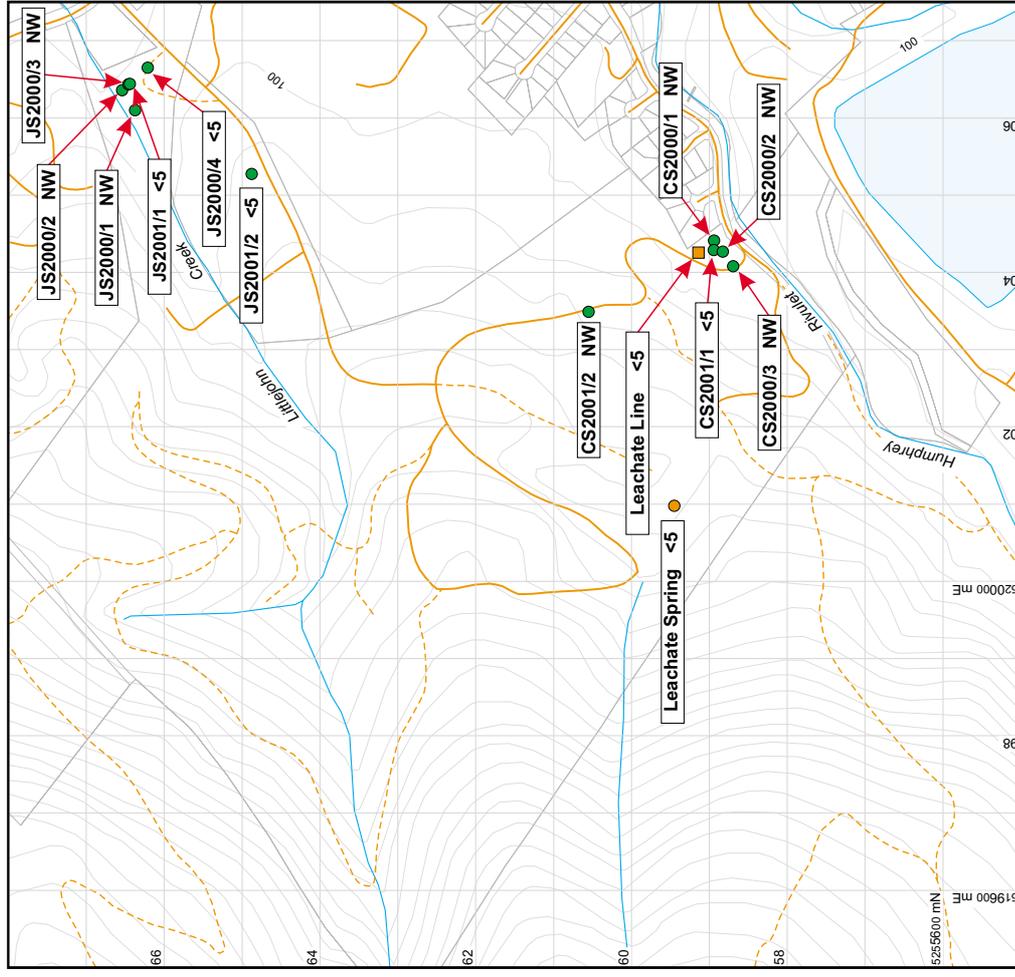
Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

**Jackson Street & Chapel Street waste depots
June 2001
Ammonia (mg-N/L)**



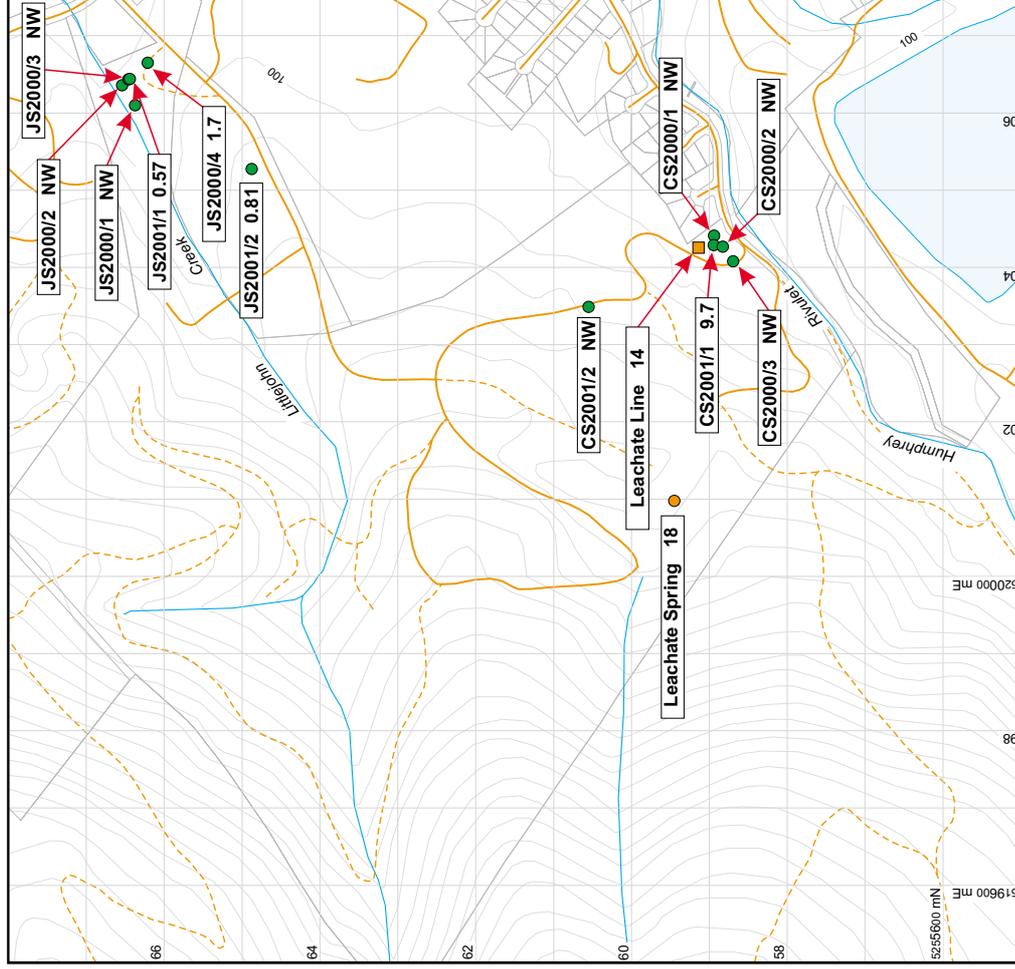
**Jackson Street & Chapel Street waste depots
June 2001
As ($\mu\text{g/L}$)**



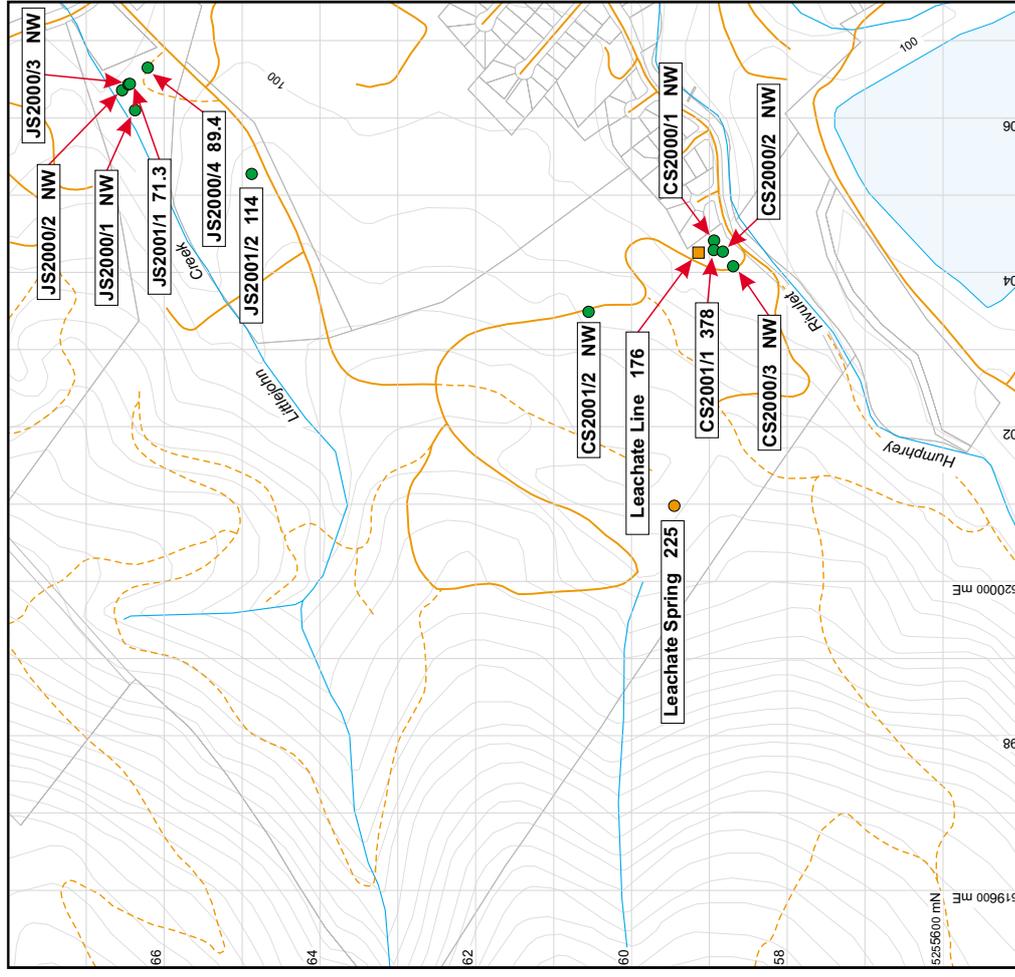
Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

**Jackson Street & Chapel Street waste depots
June 2001
Bromide (mg/L)**



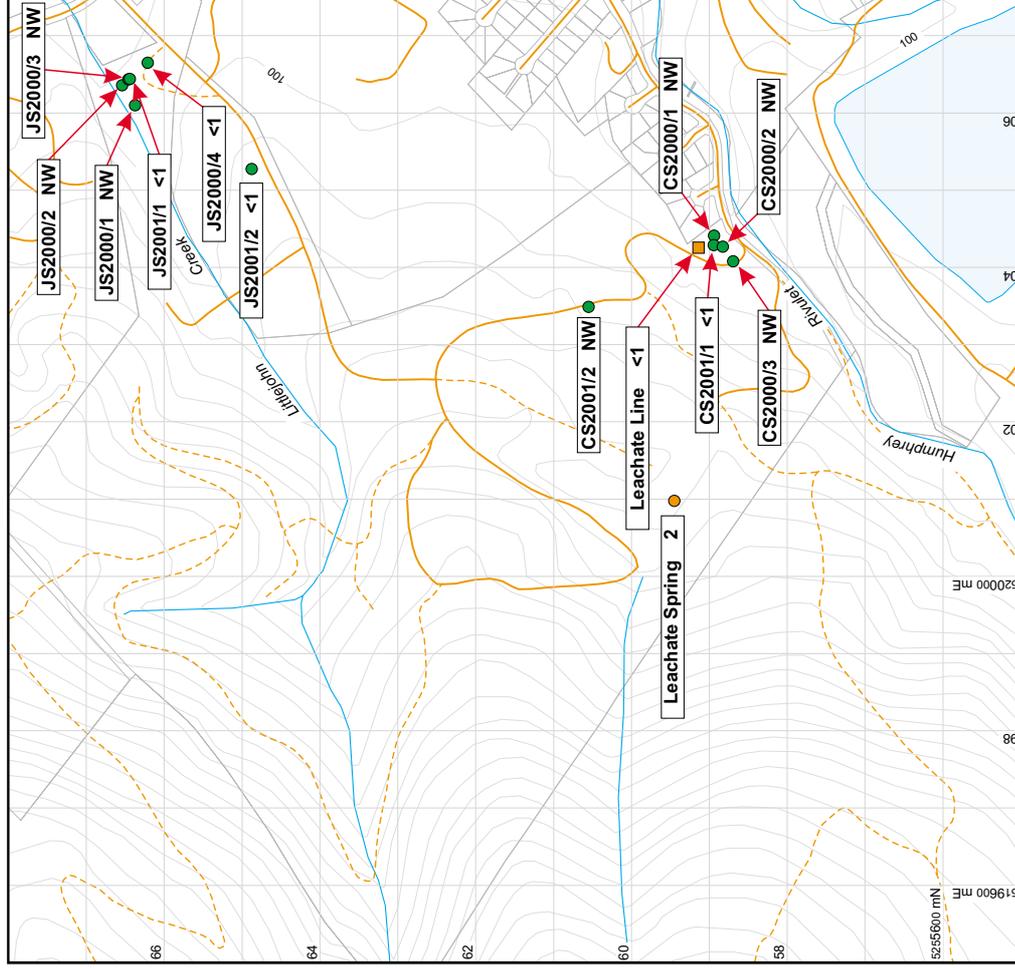
**Jackson Street & Chapel Street waste depots
June 2001
Ca (mg/L)**



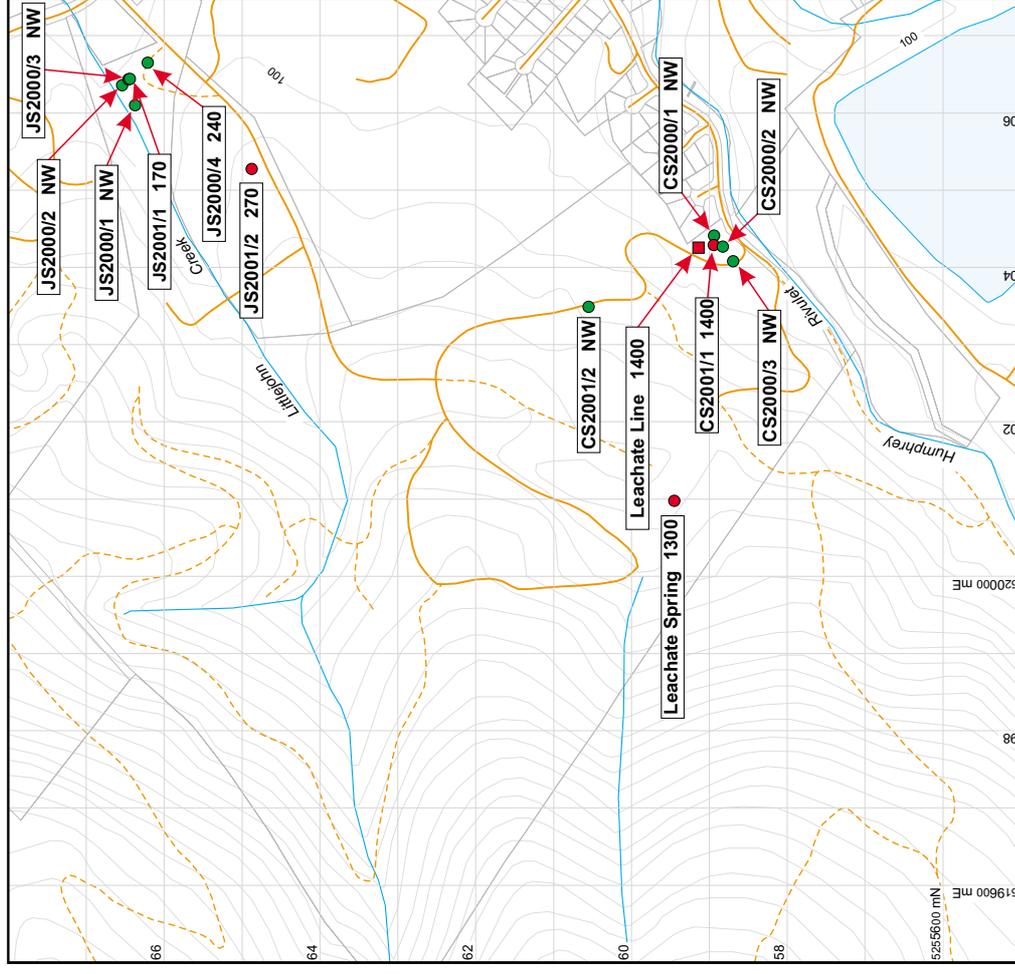
Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

**Jackson Street & Chapel Street waste depots
June 2001
Cd ($\mu\text{g/L}$)**



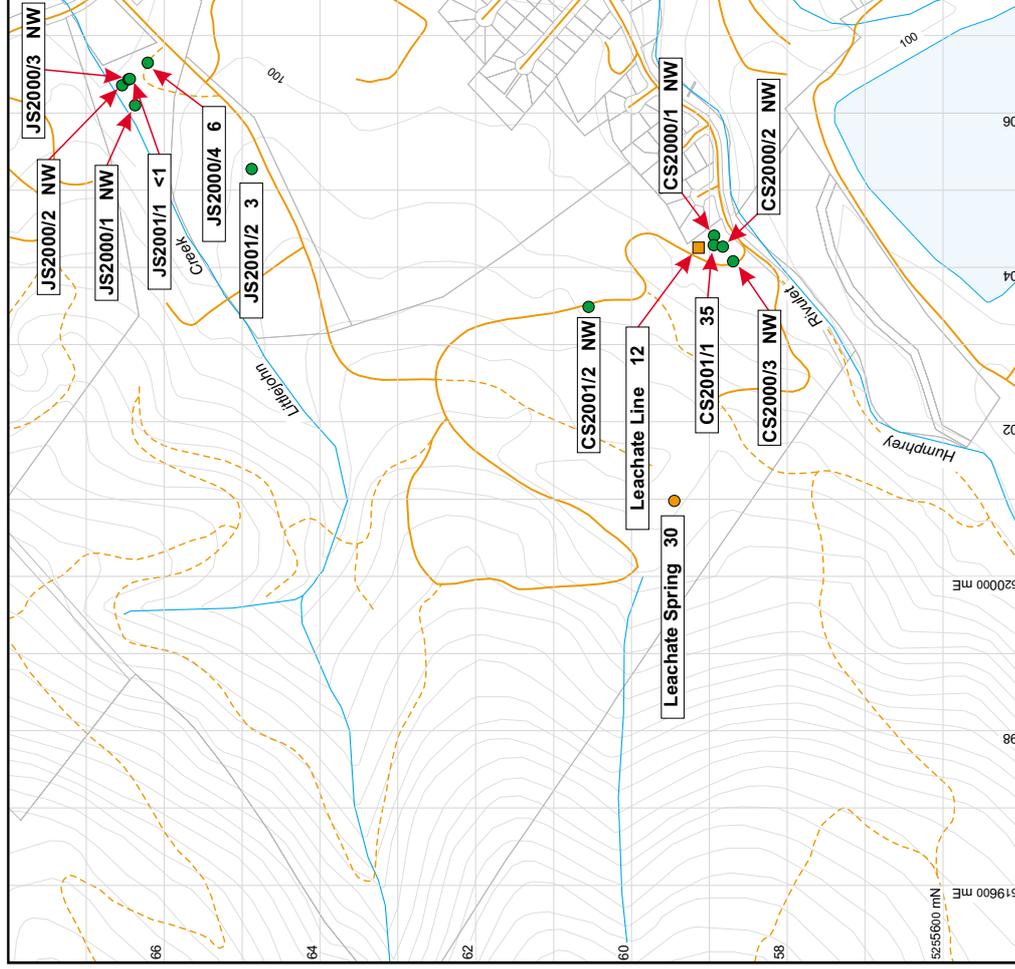
**Jackson Street & Chapel Street waste depots
June 2001
Chloride (mg/L)**



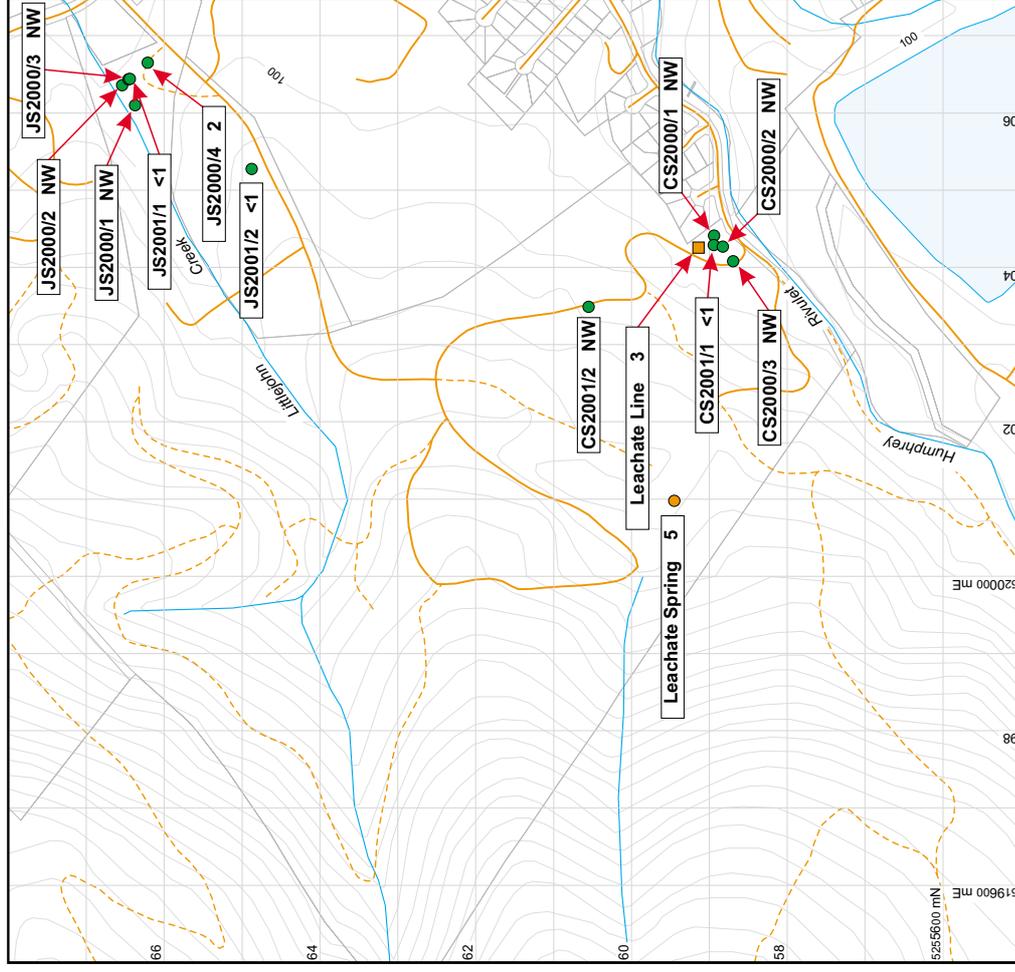
Note: Bore CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

**Jackson Street & Chapel Street waste depots
June 2001
Co ($\mu\text{g/L}$)**



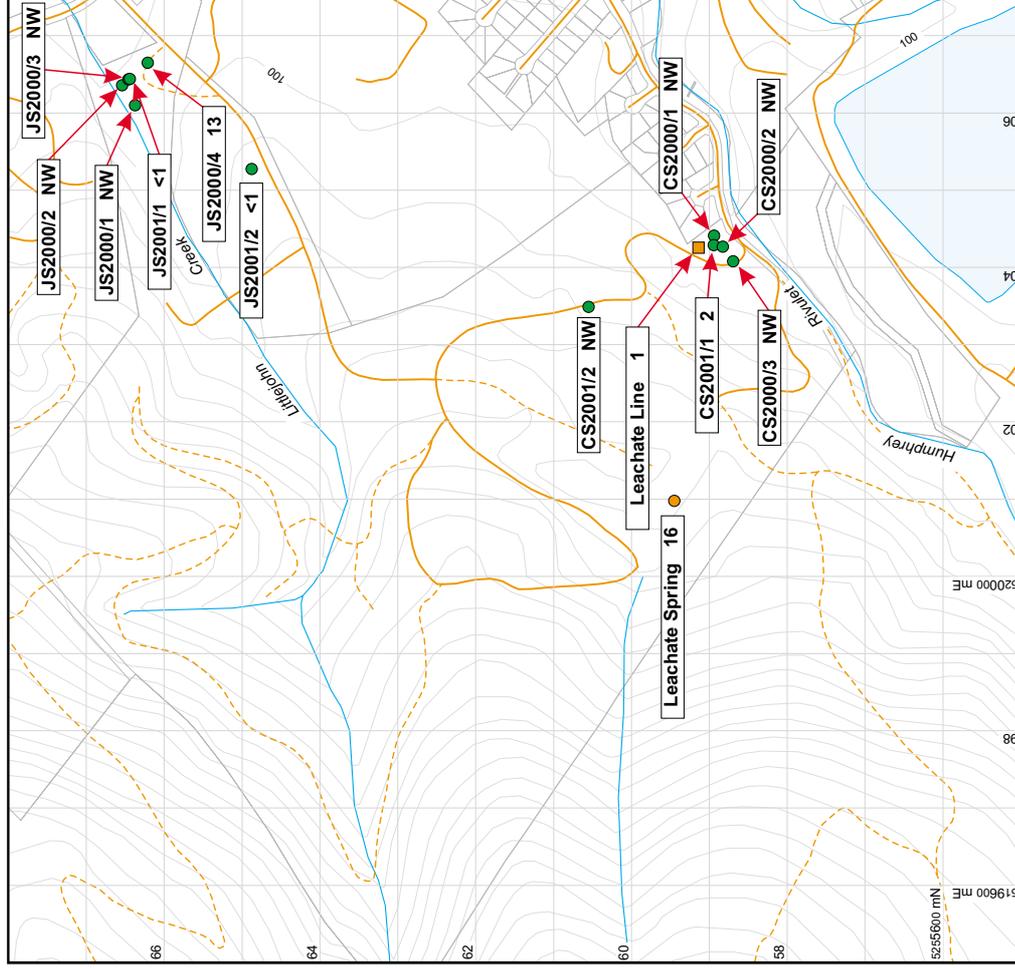
**Jackson Street & Chapel Street waste depots
June 2001
Cr ($\mu\text{g/L}$)**



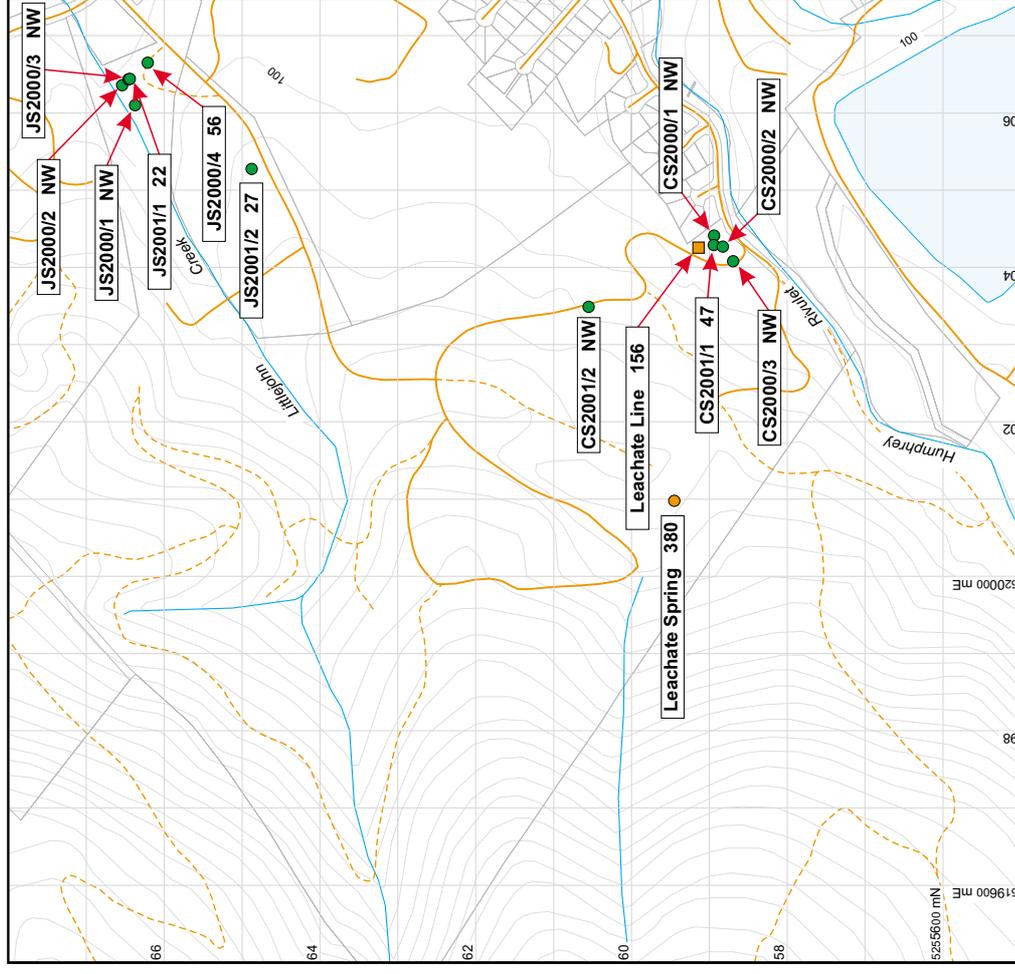
Note: Bore CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

Jackson Street & Chapel Street waste depots
June 2001
Cu ($\mu\text{g/L}$)



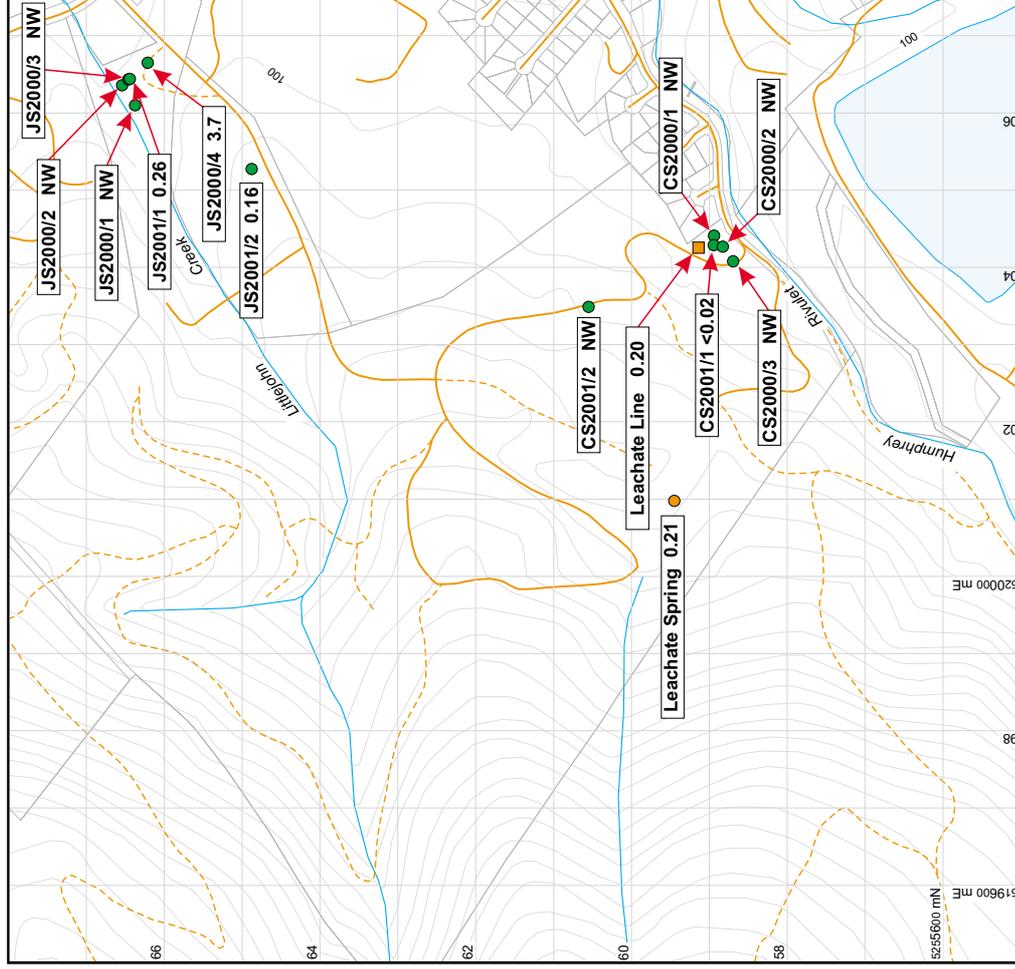
Jackson Street & Chapel Street waste depots
June 2001
Fe ($\mu\text{g/L}$)



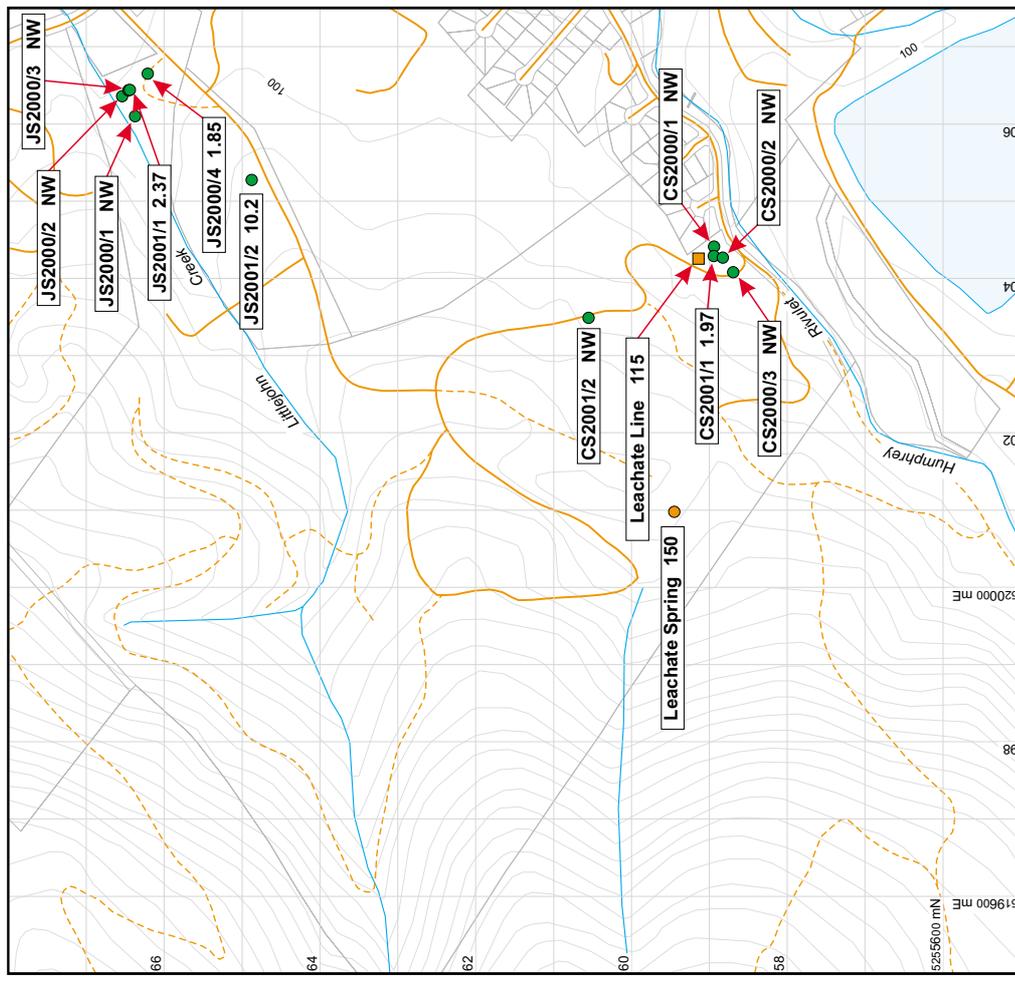
Note: Bore CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

**Jackson Street & Chapel Street waste depots
June 2001
Fluoride (mg/L)**



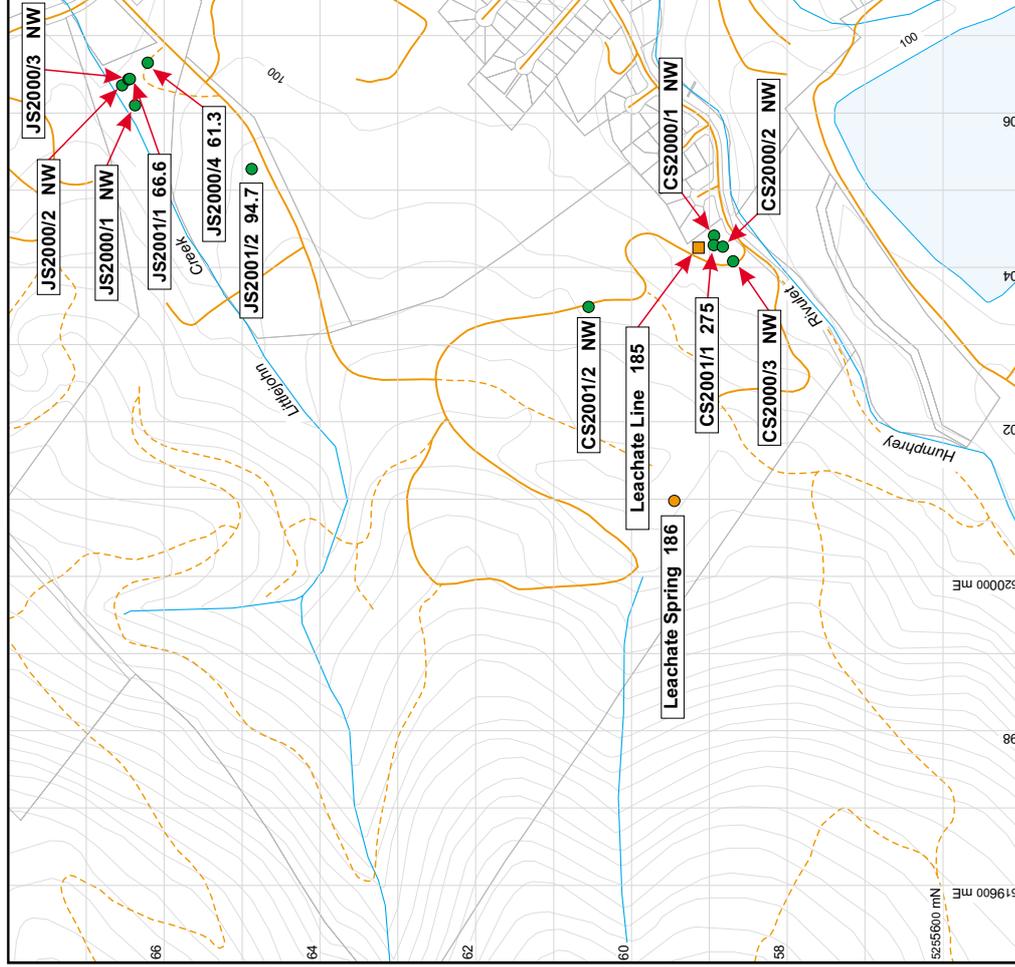
**Jackson Street & Chapel Street waste depots
June 2001
K (mg/L)**



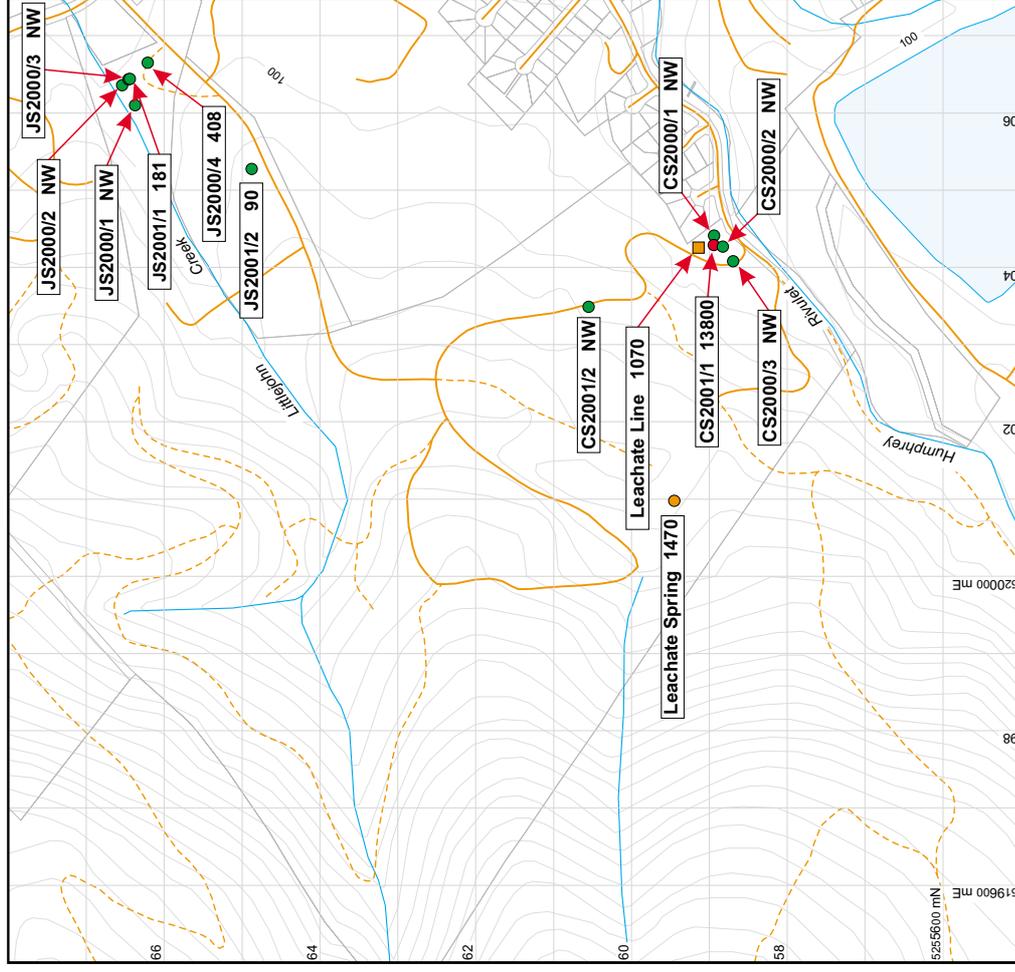
Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

**Jackson Street & Chapel Street waste depots
June 2001
Mg (mg/L)**



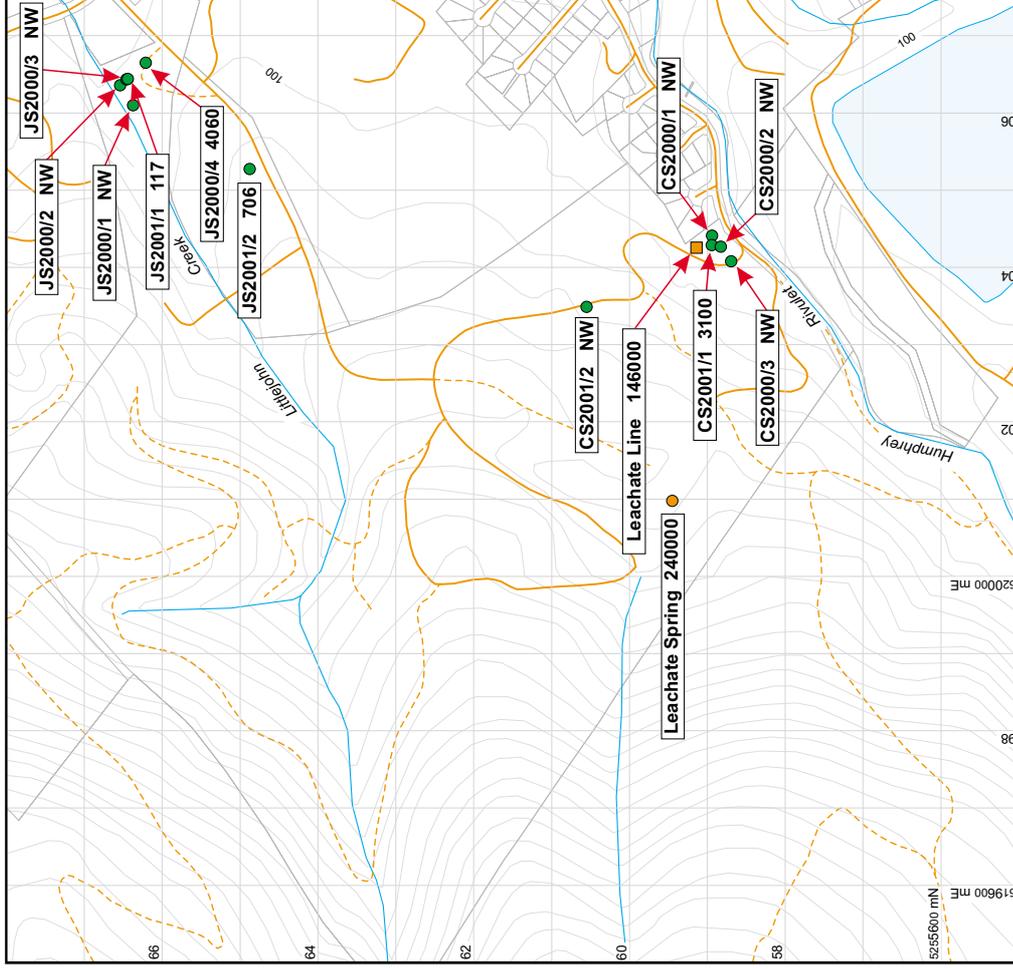
**Jackson Street & Chapel Street waste depots
June 2001
Mn ($\mu\text{g/L}$)**



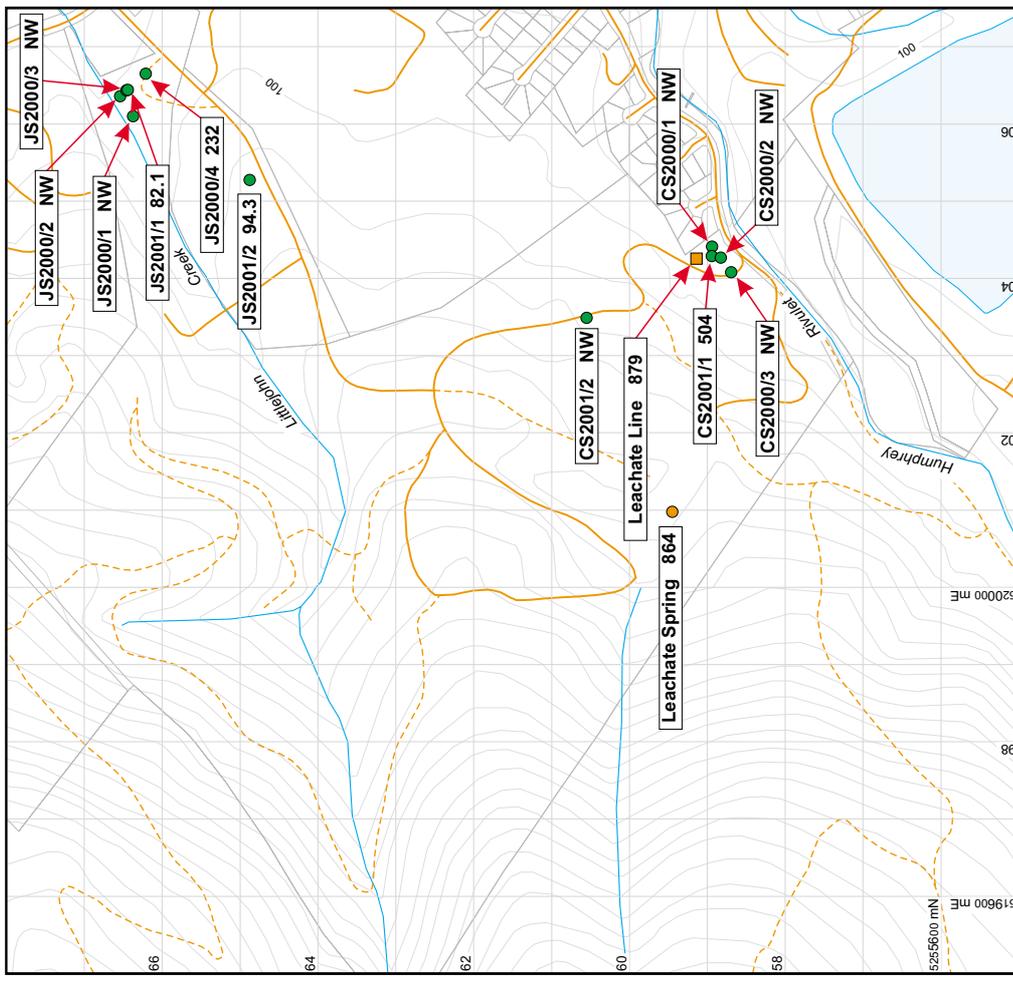
Note: Bore CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

Jackson Street & Chapel Street waste depots
June 2001
Total N ($\mu\text{g/L}$)



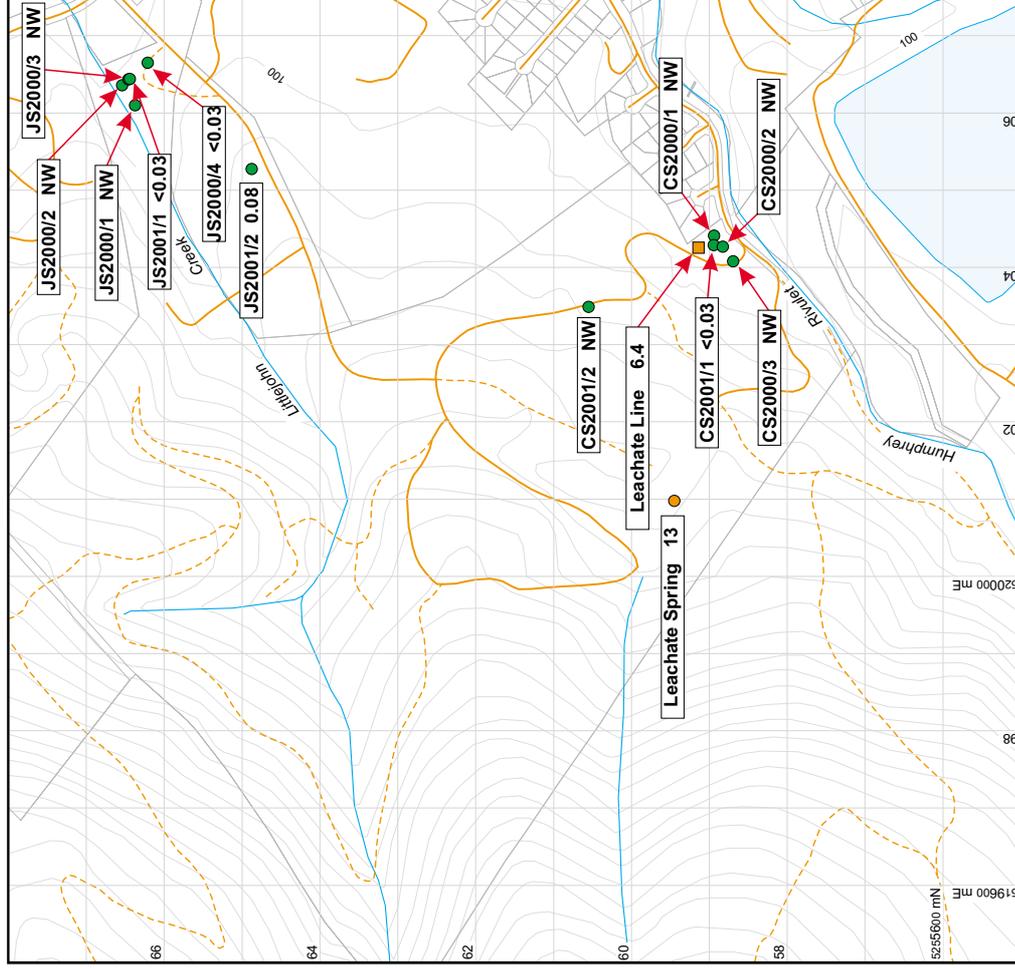
Jackson Street & Chapel Street waste depots
June 2001
Na (mg/L)



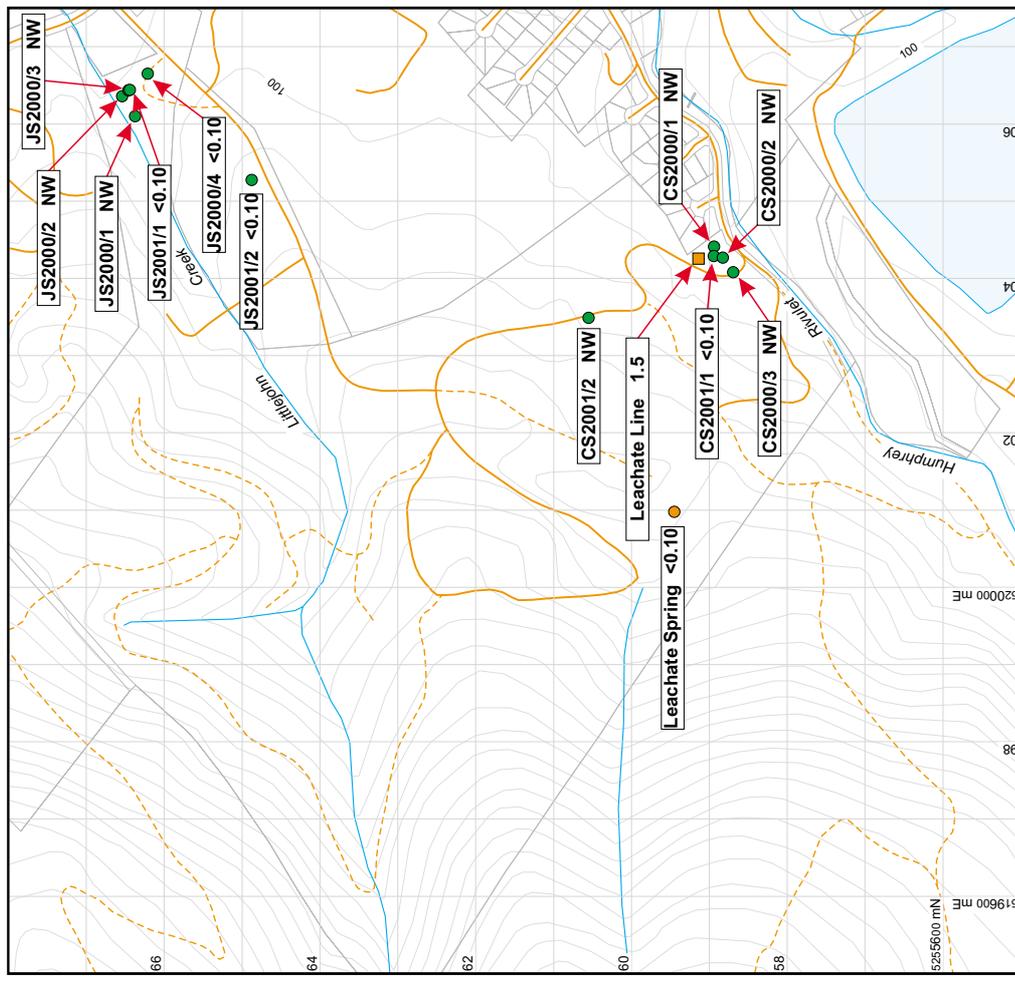
Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

**Jackson Street & Chapel Street waste depots
June 2001
Nitrate (mg-N/L)**



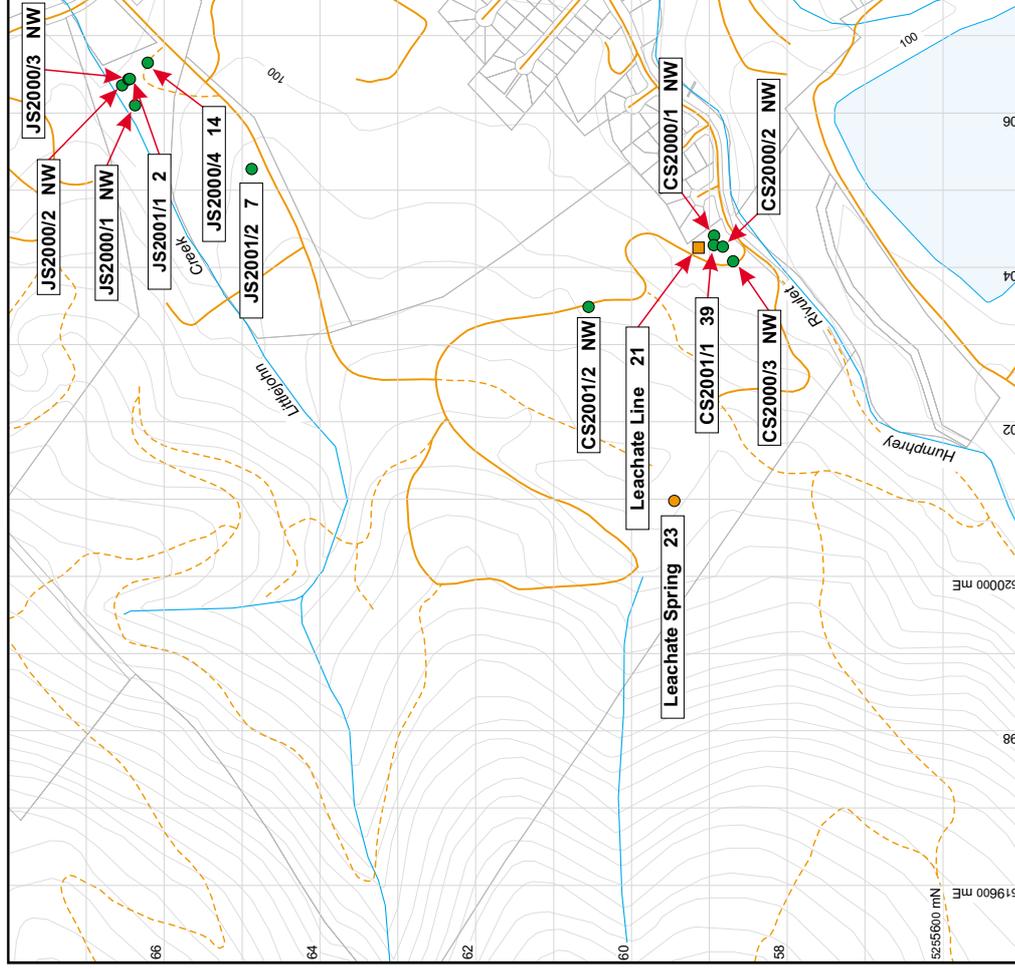
**Jackson Street & Chapel Street waste depots
June 2001
Nitrite (mg-N/L)**



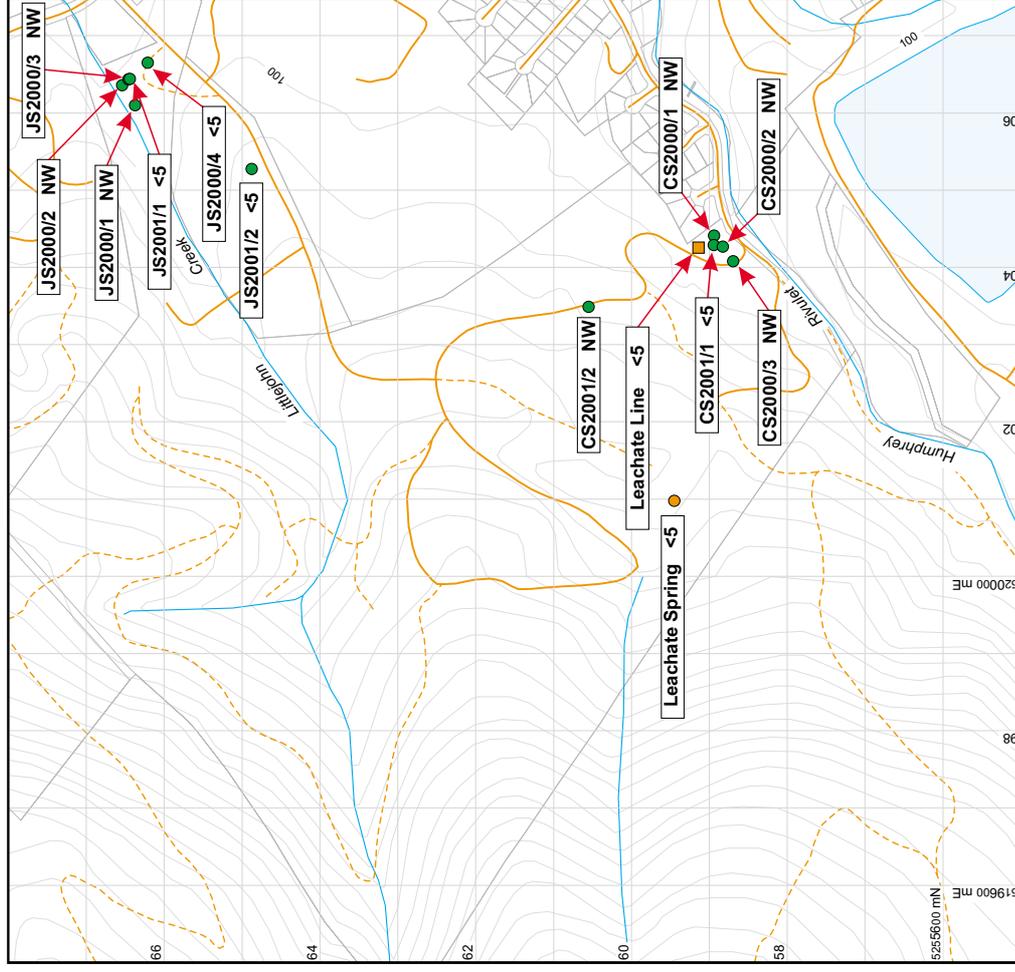
Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

**Jackson Street & Chapel Street waste depots
June 2001
Ni (µg/L)**



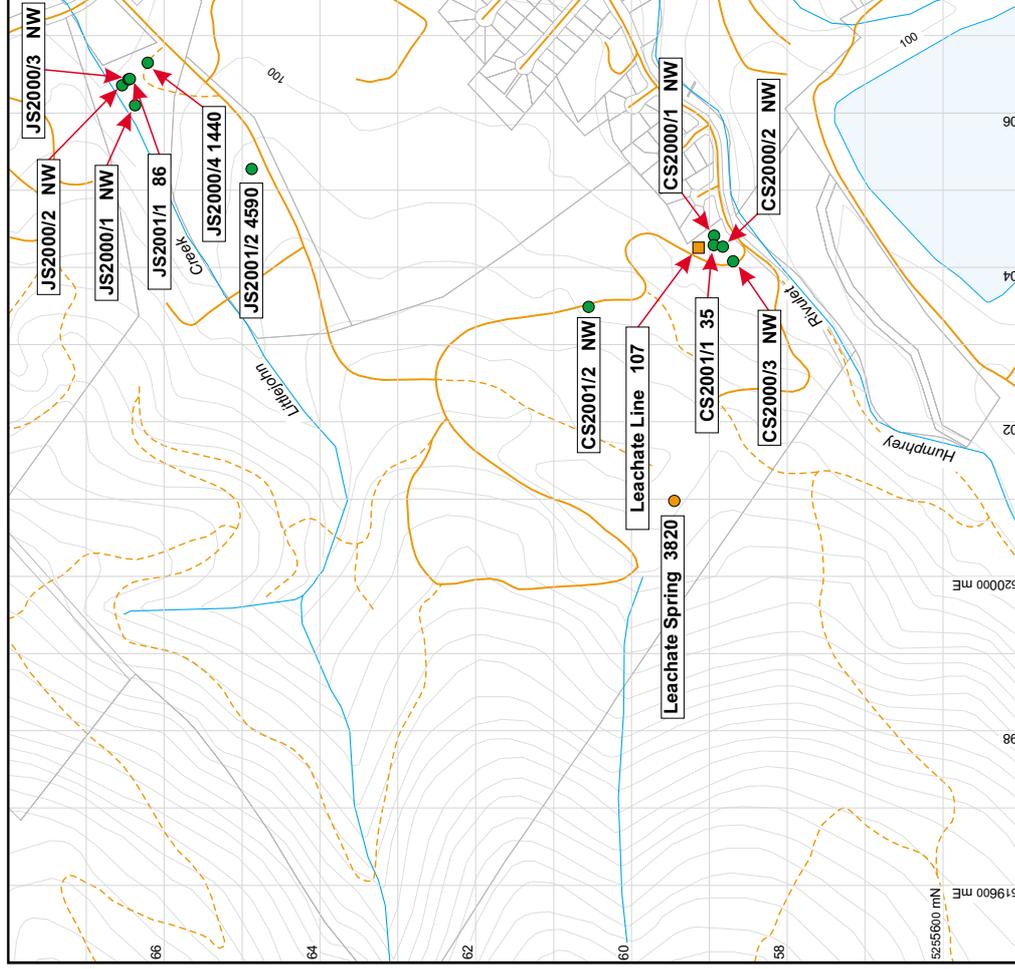
**Jackson Street & Chapel Street waste depots
June 2001
Pb (µg/L)**



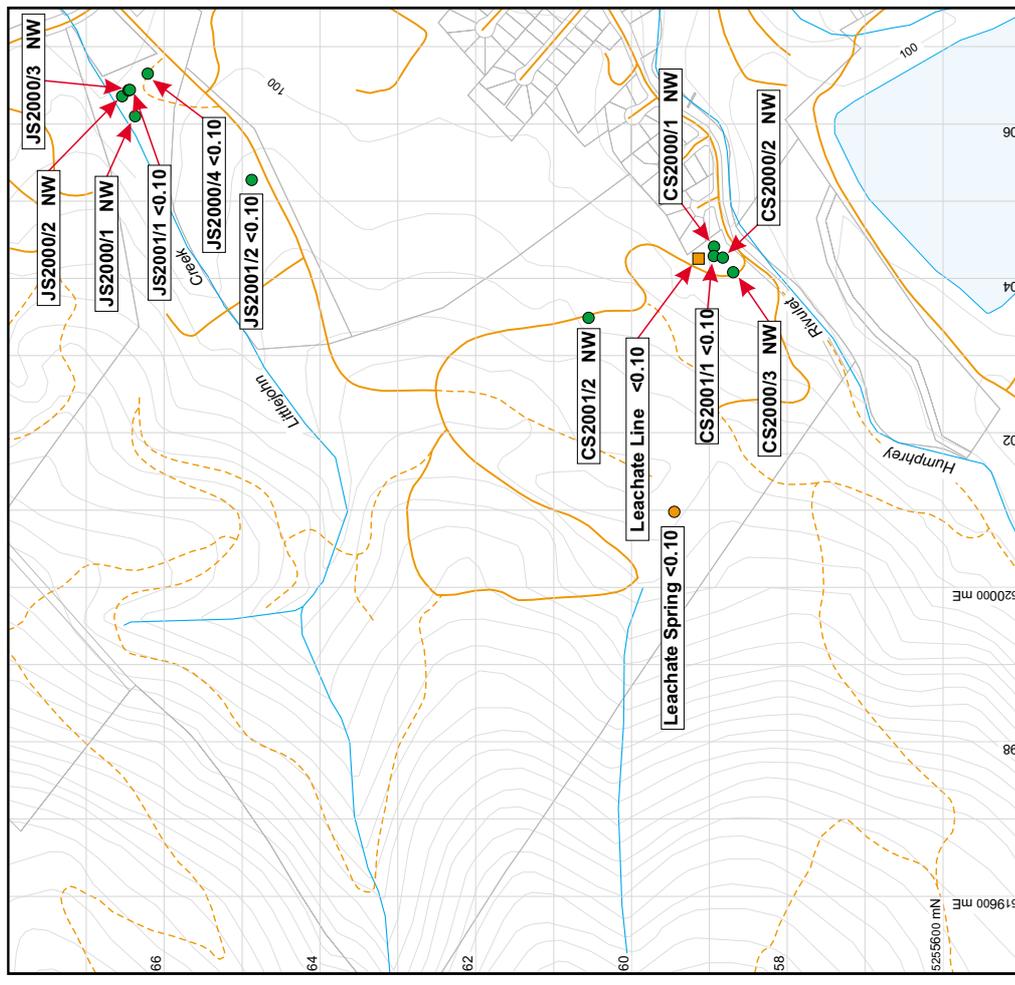
Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

**Jackson Street & Chapel Street waste depots
June 2001
Total P ($\mu\text{g/L}$)**



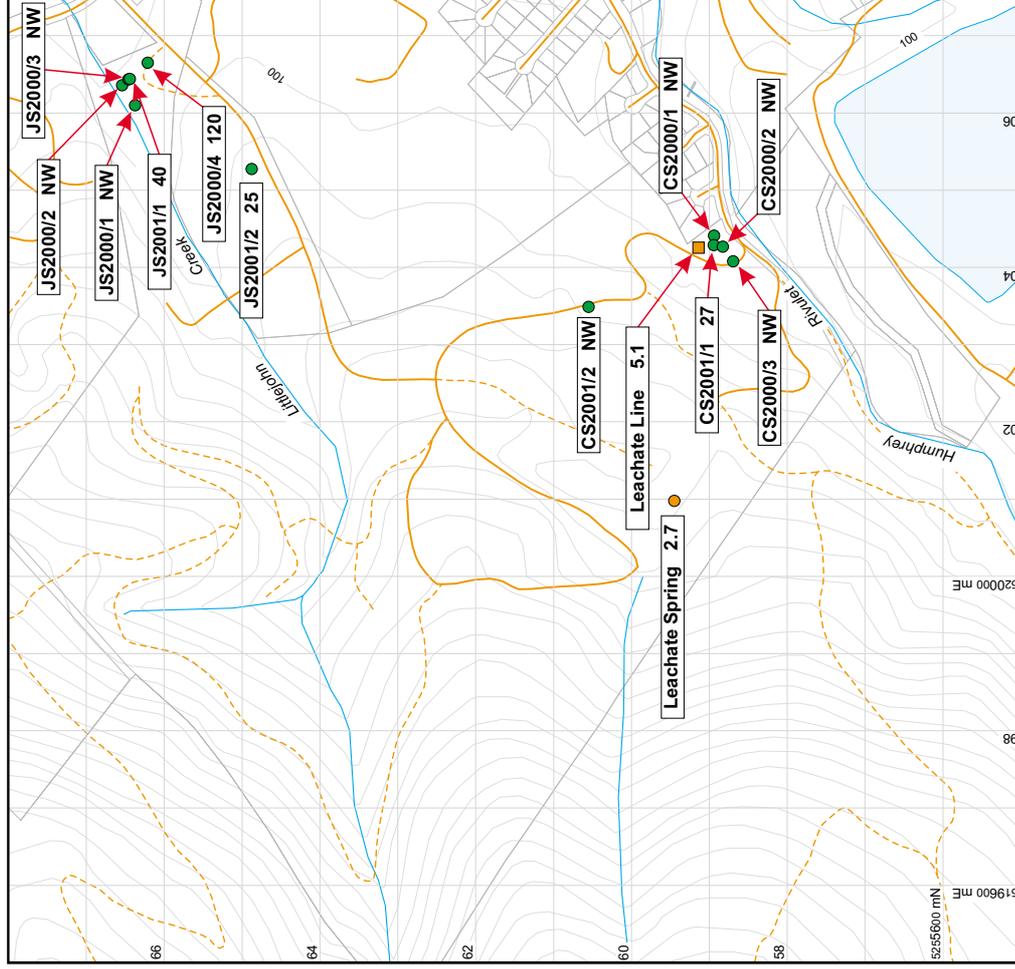
**Jackson Street & Chapel Street waste depots
June 2001
Phosphate (mg-P/L)**



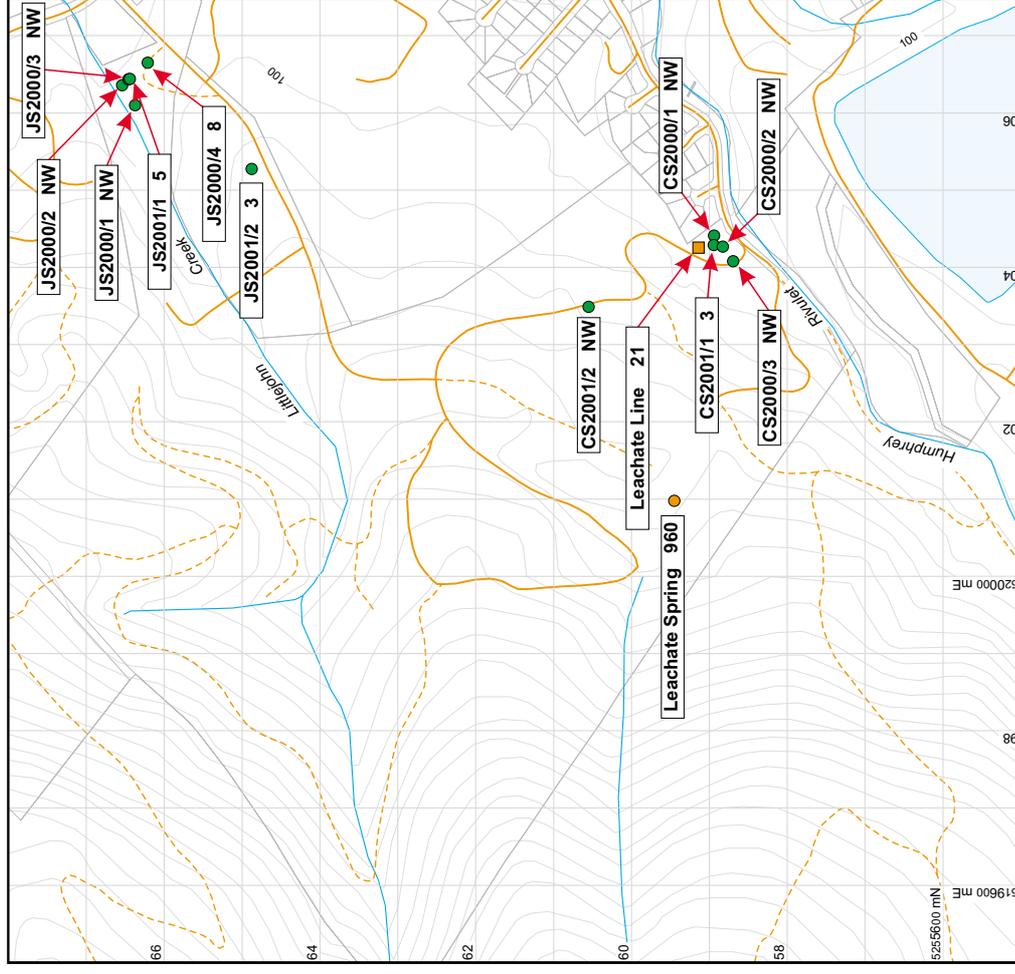
Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

Jackson Street & Chapel Street waste depots
June 2001
Sulphate (mg/L)



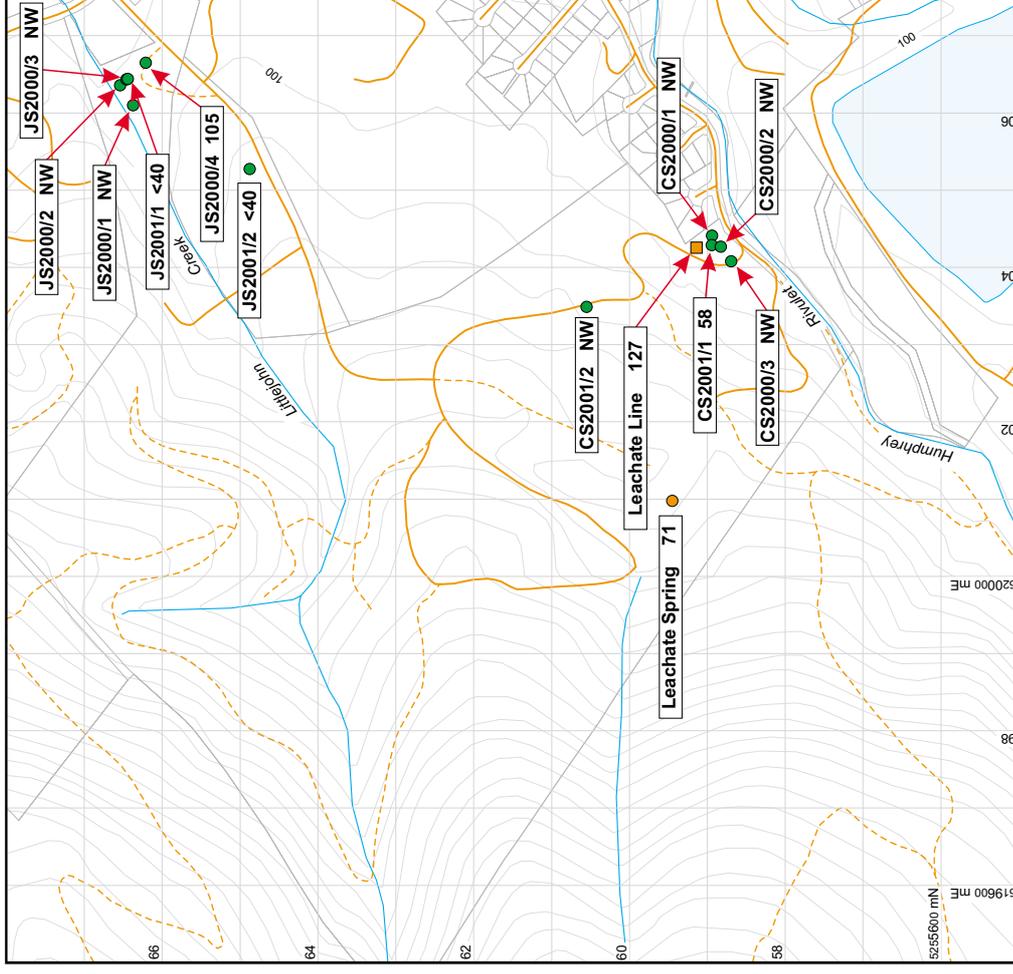
Jackson Street & Chapel Street waste depots
June 2001
Zn ($\mu\text{g/L}$)



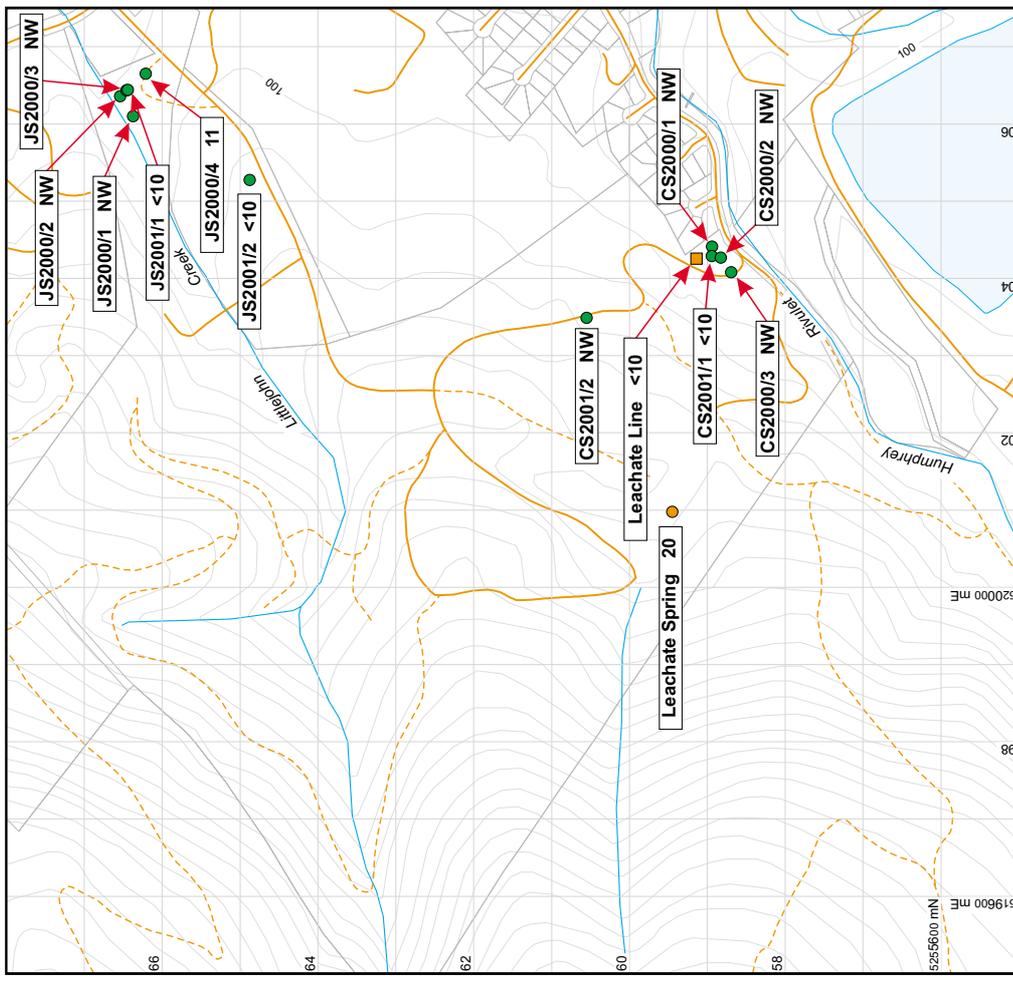
Note: Bore CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

Jackson Street & Chapel Street waste depots
June 2001
TPH ($\mu\text{g/L}$)



Jackson Street & Chapel Street waste depots
June 2001
TPH C06-09 ($\mu\text{g/L}$)

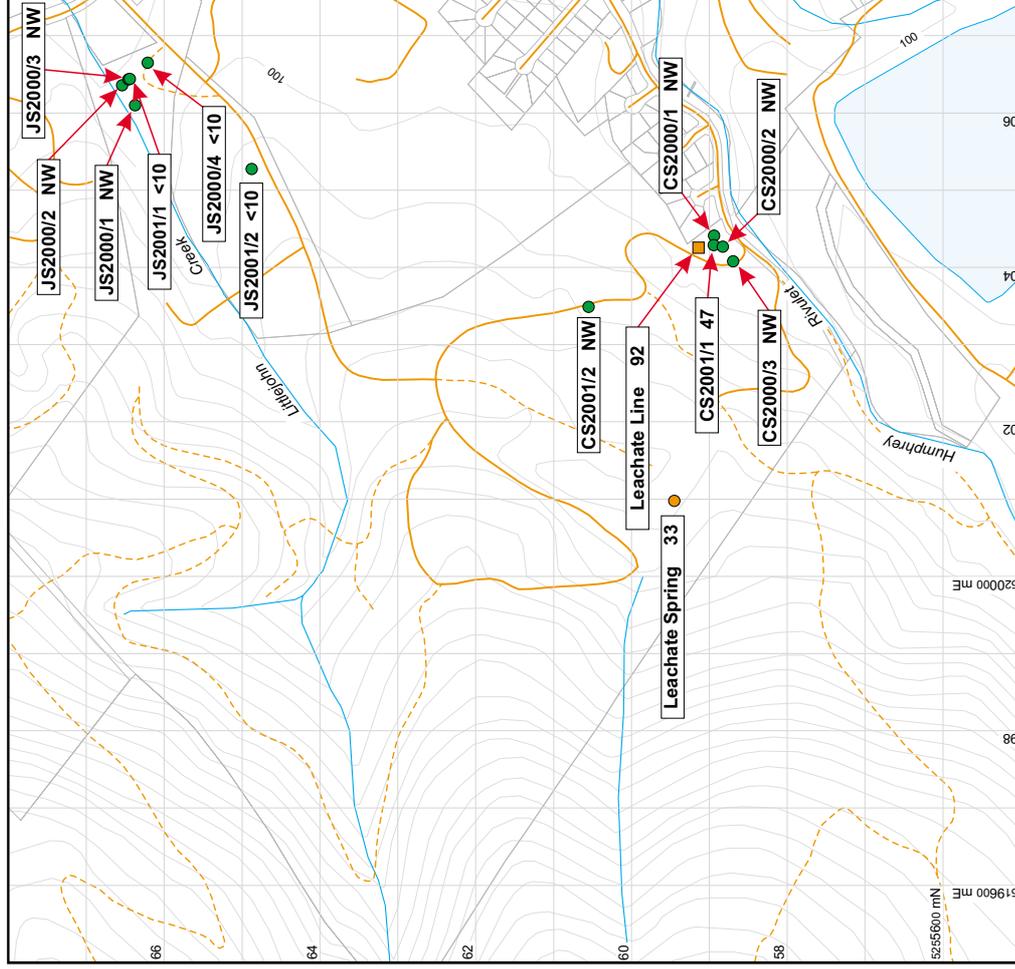


Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

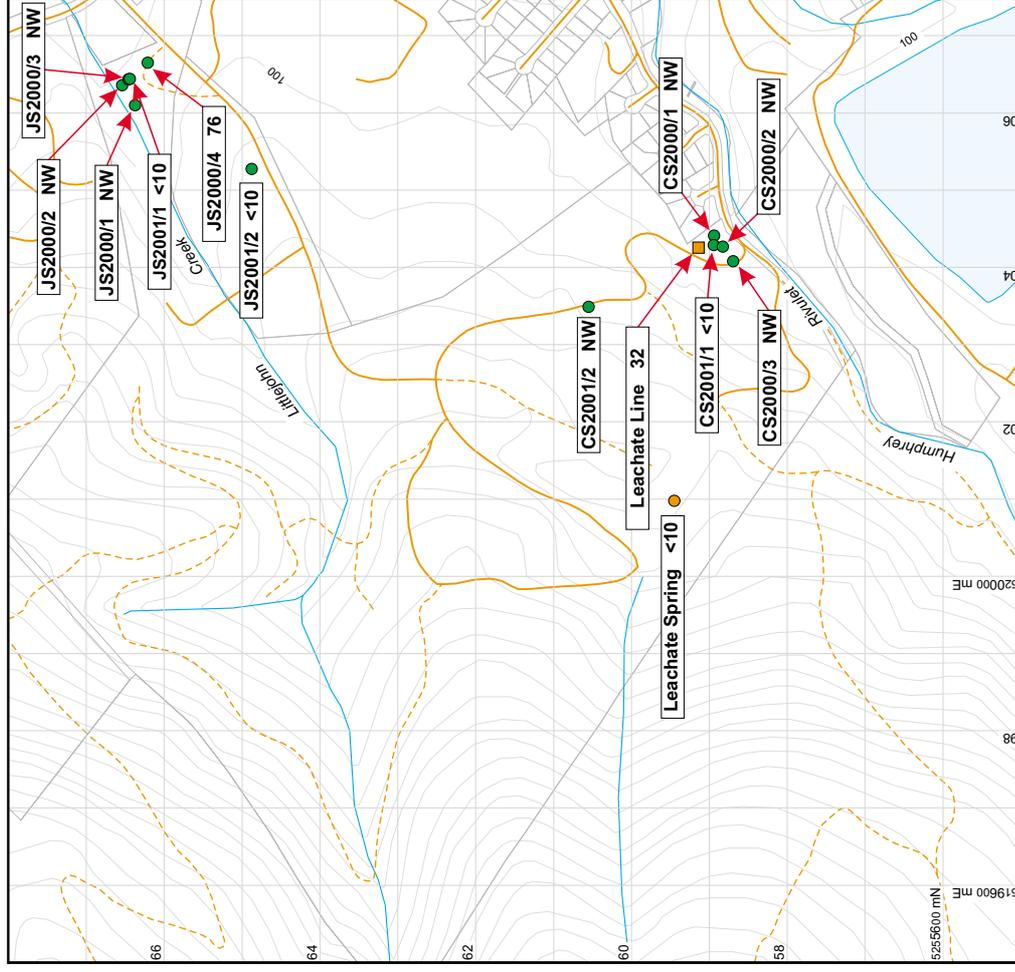
Jackson Street & Chapel Street waste depots
June 2001

TPH C10-14 ($\mu\text{g/L}$)



Jackson Street & Chapel Street waste depots
June 2001

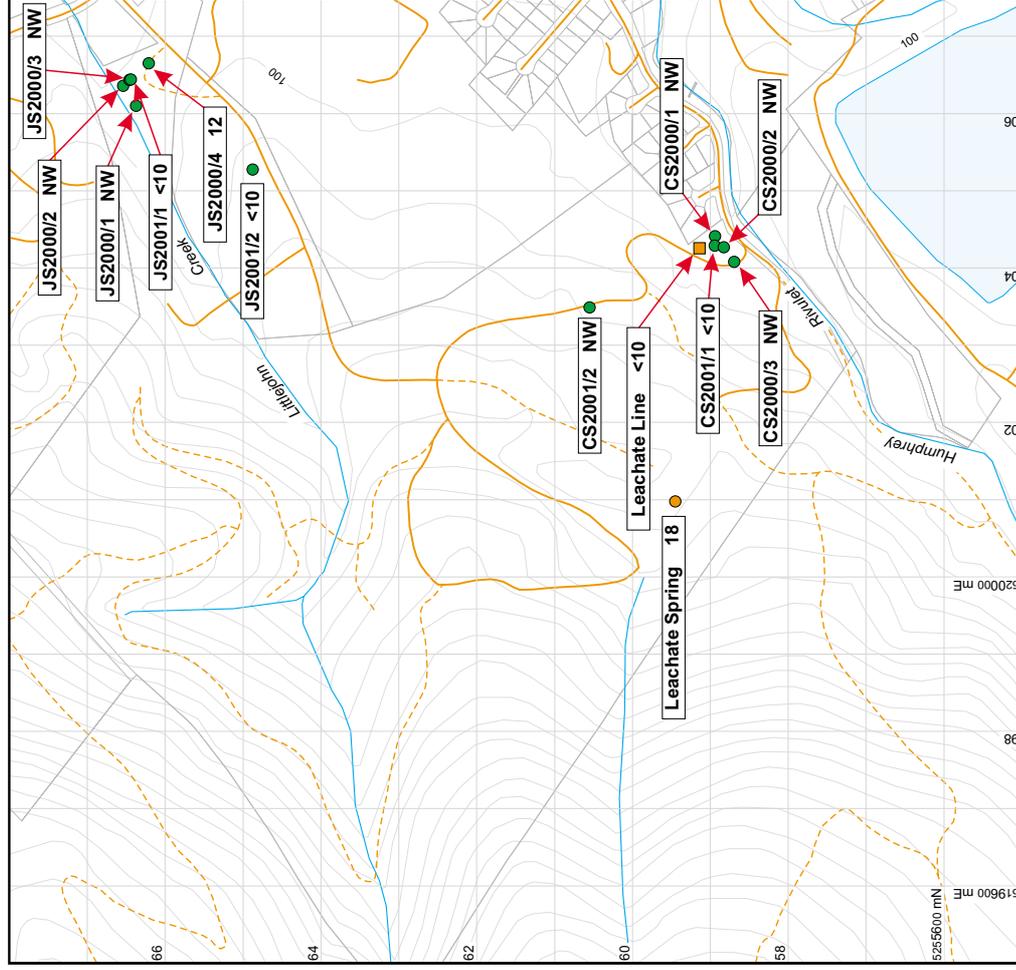
TPH C15-28 ($\mu\text{g/L}$)



Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water

Jackson Street & Chapel Street waste depots June 2001 TPH C29+ ($\mu\text{g/L}$)



Note: Bores CS2000/1, CS2000/2 and CS2000/3 were destroyed by vandals in late June 2001

NW = No water