MINERAL RESOURCES TASMANIA

Tasmania

DEPARTMENT *of* INFRASTRUCTURE, ENERGY *and* RESOURCES

NHT Funded Project
NLP 13188

Natural Heritage Trust

Helping Communities Helping Australia

The effects of waste disposal on groundwater quality in Tasmania

Stieglitz sewage lagoons

Tasmanian Geological Survey Record 2002/09

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DEPARTMENT of INFRASTRUCTURE, ENERGY and RESOURCES

Mineral Resources Tasmania
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Groundwater quality investigations at the Stieglitz sewage lagoons

A. R. Ezzy

Abstract

Groundwater was investigated in the area of the Stieglitz sewage lagoons to determine if the lagoons were affecting groundwater quality. The lagoons are situated close to perched shallow water tables. Further investigations are required to refine the hydrogeological model of the site and preferred pathways of flow from groundwater mounding beneath the lagoons.

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 sewage lagoons at Stieglitz were one of these sites.

The objectives of the investigations at the Stieglitz sewage lagoons were to:

- Determine the geological nature of the host materials;
- Identify the depth of the water table;
- Examine the quality of the groundwater;
- Determine the permeability of the host materials; and
- Identify if a potential hydraulic connection exists between the lagoons and the local groundwater system.

SITE DESCRIPTION

The township of Stieglitz is located on the east coast of Tasmania, bordering Georges Bay about four kilometres east of St Helens. The Stieglitz sewage lagoons are located approximately 500 metres southeast of Stieglitz (609 200 mE, 5 423 700 mN) (fig. 1). The lagoons, which have been in operation since about 1983, are currently licensed by the Department of Primary Industries, Water and Environment (DPIWE) while the Break O'Day Council is responsible for maintenance. Engineering consultants Sinclair Knight Merz have supervised additional engineering works undertaken since the initial construction of the lagoons.

During construction both lagoons had a one metre cement wave wall constructed at surface level to prevent wave erosion damage. Post construction, the southern lagoon was lined with geo-fabric material sprayed with bitumen. This liner has since lifted from the base of the lagoon and can been seen floating at the surface (Plate 1). Both lagoons are located in gravelly sand.

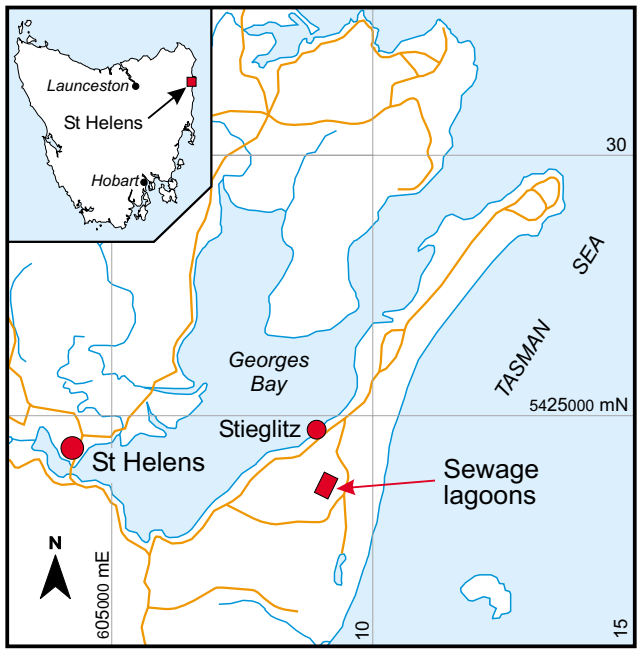


Figure 1
Location of the Stieglitz sewage lagoons.

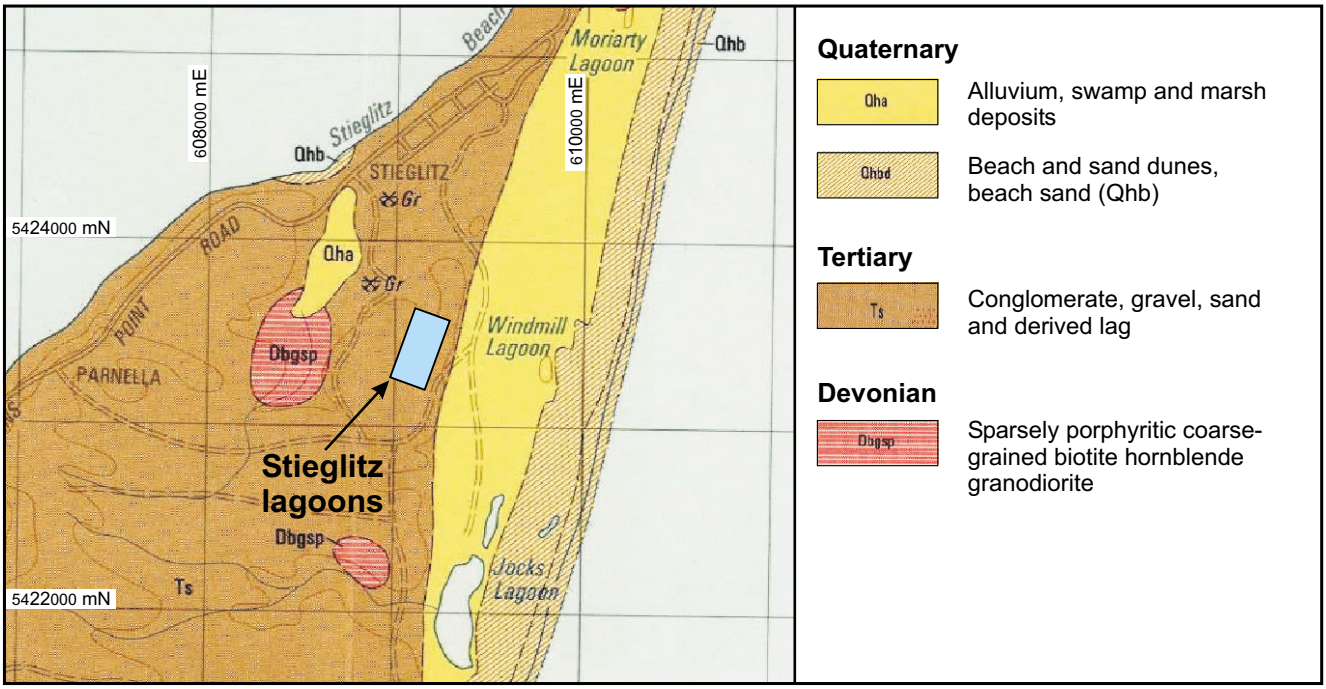


Figure 2

Extract from the St Helens geological map (McClenaghan et al., 1987) of the local area and related geology.

Plate 1

Geo-fabric liner sprayed with bitumen floating in the southern lagoon.

Plate 2

Drainage line west of the sewage lagoons with bore hole SZSL2001/2 in the foreground.

Geology

The Tasmania Department of Mines 1:50 000 scale geological map of the St Helens area (McClenaghan *et al.*, 1987) indicates that the geology of the lagoon footprints comprises Tertiary-aged conglomerate, gravel and sand (fig. 2). Quaternary-aged alluvial, swamp and marsh deposits are indicated to the east of the lagoons.

Geological mapping during the current study indicated that the site is dominated by gravel and sand deposits within 80 m of the lagoons in all directions. Occasional small pods of high plasticity white clay were observed in the area of an old landfill southwest of the lagoons. Dark brown hard pans of iron-enriched material were also observed in the area.

Hydrology

The lagoons are located within 100 m of a drainage line to the west that discharges into Chimneys Lagoon (Plate 2). Windmill Lagoon is located approximately 250 m to the east of the lagoons. Australian Bureau of Meteorology rainfall station 092033 (St Helens Post Office) is the closest rainfall station to the site. The chart of average monthly recorded rainfall (fig. 3) shows that the average annual rainfall of 774.6 mm is evenly distributed over the year. The average annual rainfall is low when regarded in a statewide perspective.

INVESTIGATION METHODS

Borehole drilling and installation

Five 120 mm diameter monitoring bores were auger drilled on 8 March 2001 for this project (fig. 4). All bores (except SZSL2001/4) were drilled to the maximum depth capacity of the drilling rig. Fifty millimetre PVC casing and slotted screens with bentonite seals were installed in each hole. All bores were logged in accordance with AS 1726-1993; engineering logs are presented in Appendix 1.

Groundwater was encountered between 3.2 m (SZSL2001/4) and 7.1 m (SZSL2001/3) depth below ground level across the site. Flow during drilling indicated that the groundwater in all boreholes was unconfined. Recorded yields of bores ranged between 0.012 to 0.033 l/s. Figure 5 shows a cross-section and the standing water level on 19 August 2001.

Both the unsaturated and saturated zones mainly consist of heterogenous layers of clay, fine to coarse-grained sand and gravel. Layers of low to medium plasticity clay were intercepted in boreholes SZSL2001/2 and SZSL2001/3. A strong organic odour was observed on the returns of SZSL2001/1 between 2.3 and 8.3 metres. Rounded quartzite pebbles were intercepted in bore SZSL2001/4 and indicate reworking and imported material in this area.

SZSL2001/4 was drilled as a potential up-gradient background bore. Several months after the installation of the bores, the Break O'Day Council undertook earthworks to control surface water run off in the vicinity of the southwest corner of the southern lagoon. Hole SZSL2001/4 failed to make water after these earthworks were undertaken.

Engineering logs of the boreholes indicate that the bund walls overlying the Tertiary sediments consist of reworked clayey sandy gravelly material.

In situ permeability testing

A slug extraction test on bore SZSL2001/3 was carried out on 17 August 2001. Data collected during this test is presented in Appendix 2.

The slug extraction test data was analysed in the software package *AquiferWin32* (Version 2.17, Environmental Simulations Inc.). The Bouwer and Rice (1976, Unconfined Aquifer) solution was used to calculate the hydraulic conductivity value for SZSL2001/3 (fig. 6). This method was selected as the most appropriate available within the software package.

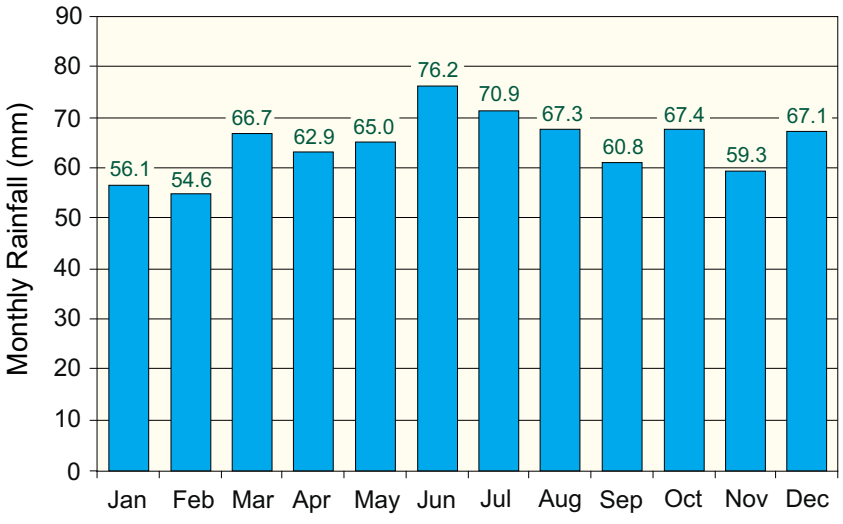


Figure 3

Average monthly rainfall for Australian Bureau of Meteorology rainfall station 092033, St Helens Post Office.

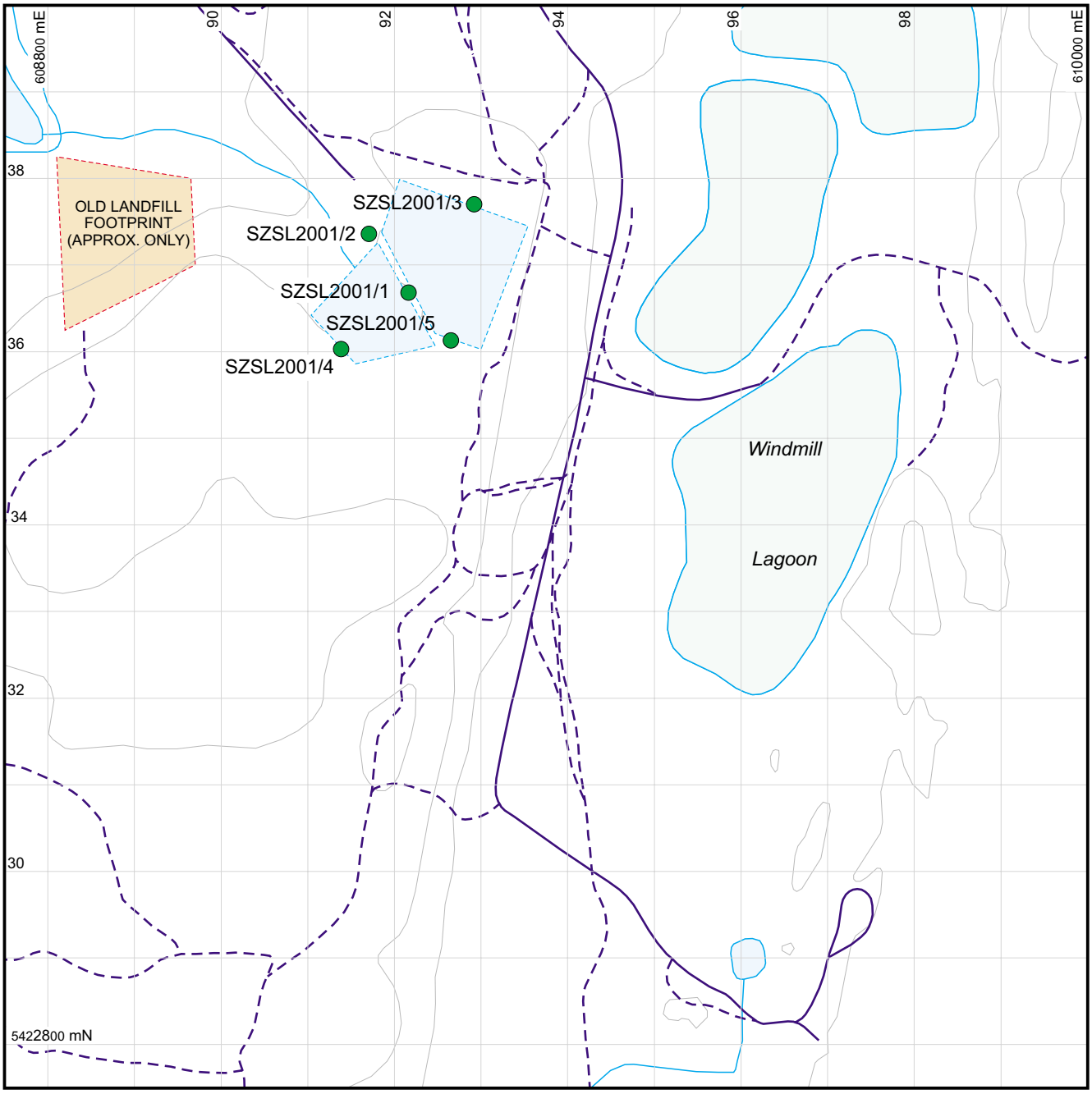


Figure 4

Locations of environmental monitoring bores installed at the Stieglitz sewage lagoons.

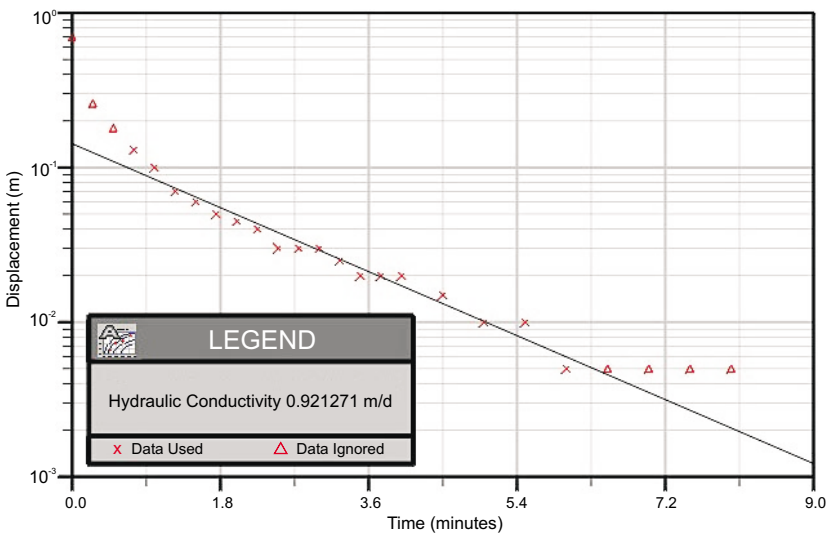


Figure 6

Hydraulic conductivity value for SZSL2001/3 (K = 0.92 m/d = 1.07×10^{-5} m/sec) calculated in AquiferWin32 (Version 2.17, Environmental Simulations Inc.), Bouwer and Rice (1976 Unconfined Aquifer) solution.

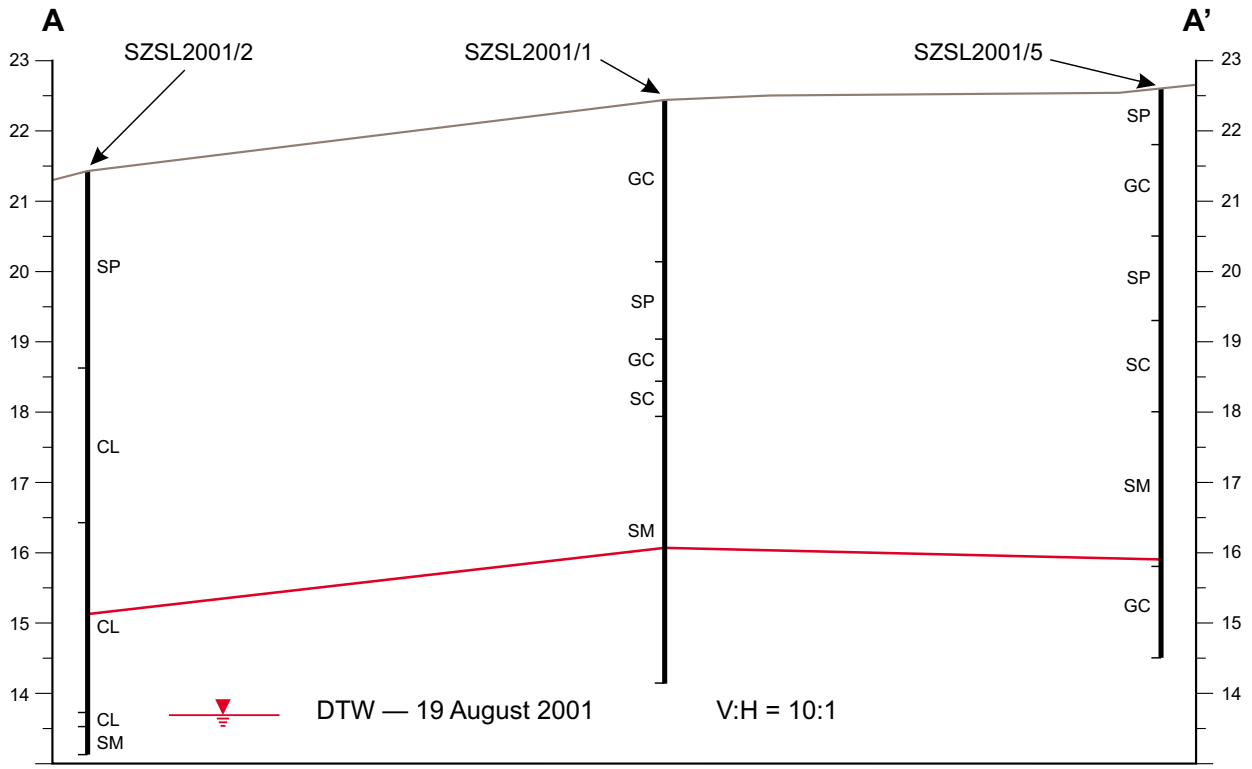


Figure 5

Cross-sections and related standing water levels on 19 August 2001 for bores SZSL 2000/2, 1 and 5 [A-A'].

HYDROLOGICAL MODEL

Constraints related to the drilling contractor's depth capacity did not allow for a complete groundwater flow-regime investigation. Iron pans within the sediments appear to be producing perched water tables. The drying up of borehole SZSL2001/4 (refusal on iron pan) after surface drainage control works supports this comment.

Some of the gravel is clay bound (also demonstrated by low yields), implying the main groundwater storage capacity occurs within the sandy zones. Perched water is also most likely occurring above the clay-enriched layers/lens. It is expected that holes drilled to greater depth would intercept additional groundwater and allow for a more complete interpretation of the groundwater flow regime in the area of the lagoons.

An interpretation of the piezometric surface (based on surveyed heights and groundwater depths of the boreholes in the limited area of the lagoons) is shown in Figure 7. The water table appears to slope towards the northwest and a groundwater mounding effect is also indicated close to and beneath the lagoons.

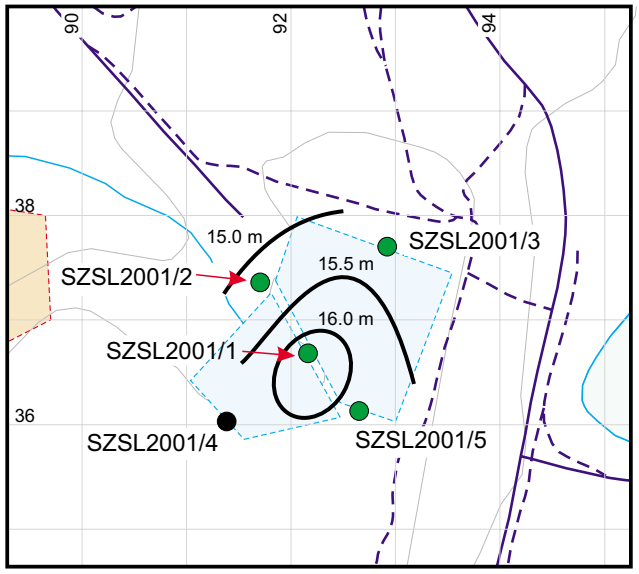


Figure 7

Interpretation of the piezometric surface based on surveyed heights and groundwater depths of the boreholes (RL water surface contours).

GROUNDWATER CHEMISTRY

All bores were sampled in accordance with Australian/New Zealand Standard AS/NZS 5667.11:1998 on 15 May 2001. Bore SZSL2001/4 contained no water and therefore was not sampled. Laboratory testing of samples of groundwater extracted form the boreholes was carried out by Analytical Services Tasmania, in accordance with relevant Australian and international standards (Appendix 3). Values for pH ranged between 5.0 and 5.5. Conductivity values ranged between 430 and 656 µS/cm. Analytical results are presented on site maps in Appendix 4. Figure 8 is a cation Ternary plot for the results of the groundwater analyses. Tables 1 and 2 compare the analytical results against international standards where a guideline/emission value is stated by the relevant standard.

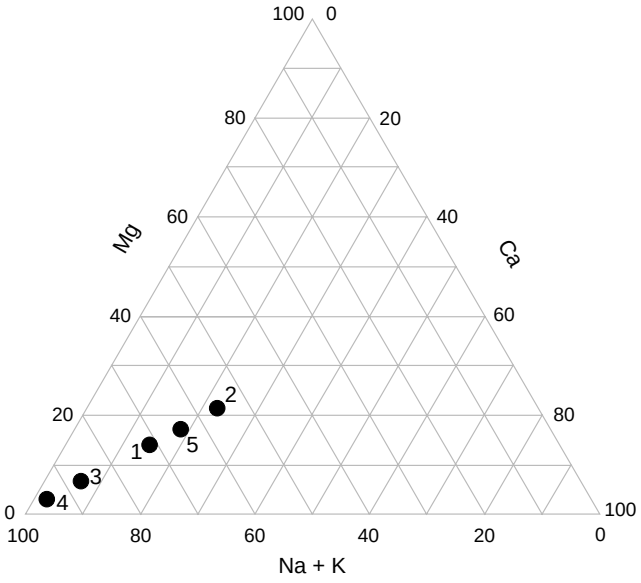


Figure 8

Cation ternary plot for groundwater bores at the Stieglitz sewage lagoons. 1 – SZSL2001/1; 2 – SZSL2001/2; 3 – SZSL2001/3; 4 – SZSL2001/5; 5 – average of all MRT groundwater records for Quaternary coastal sands.

For the water parameters analysed, the groundwater chemistry shows little variation in the area of the lagoons. Groundwater that was interpreted as down-gradient of the lagoons (SZSL2001/2 and 5) had some slightly elevated chemical results for sulphate, magnesium, and iron. The water chemistry of SZSL2001/3 and 5 is dominated by sodium and potassium cations (fig. 8), with the other two bores containing higher levels of magnesium and calcium cations. SZSL2001/3 and 5 are both screened predominantly in clayey gravel, which may account for these differences.

CONTAMINATION ASSESSMENT

The combination of *in situ* permeability testing, the cross section (fig. 5) and piezometric surface map (fig. 7) demonstrate that the Tertiary unconsolidated sedimentary aquifer may potentially transport any leakage from the sewage lagoons. There is a high potential for significant migration of effluent and consequent effects in the coastal sediments and the Tertiary plain area. Transport velocities, based on slug test data, may be as high as one metre per day. This implies that leakage from the sewage lagoons could reach Chimneys Lagoon or Windmill Lagoon in approximately one year.

There are currently no known users of groundwater in the area.

PRINCIPAL CONCLUSIONS

Layers and/or lens of clayey gravel, clay and iron pans (acting as aquitards) control perched groundwater. Migration of effluent water from the lagoons may follow preferred pathways to a deeper, unconfined unconsolidated aquifer. This aquifer most likely has hydraulic connection to Chimneys and Windmill lagoons. Investigations of groundwater quality in the area should consider potential impacts of the unlined old landfill to the west.

FURTHER WORK

Because of the clay content within the gravel, geophysical investigations may not detect a distinct groundwater plume at the site. A ground conductivity survey may identify potential sand/gravel channels and therefore preferred pathways of flow within the sediments. Any identified channels/pathways may represent future drilling targets.

The drilling of a background bore some distance from the lagoons would enable the determination of local TDS levels. A comparison of background TDS combined with the installation of strategically placed additional bores may indicate the degree of recharge to groundwater from the lagoons.

Future monitoring of microbiological water quality parameters may help to confirm the extent of the degradation of groundwater quality in the local area and the processes associated with potential natural attenuation at the site. Effluent water chemistry from the lagoons should be considered as part of this assessment.

REFERENCE

MCCLENAGHAN, M. P.; TURNER, N. J.; WILLIAMS, P. R. 1987. *Geological Atlas 1:50 000 Series. Sheet 41 (8515S). St Helens.* Department of Mines Tasmania.

[30 May 2002]

Table 1

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

Parameter	*SZSL 2000/1*	*SZSL 2000/2*	*SZSL 2000/3*	*SZSL 2000/5*	*Emission limit*
pH	5.2	5.5	5.3	5.0	N/A
Conductivity (µS/cm)	430	594	656	587	N/A: note average sea water value 36 000.
TDS (mg/L)	226	324	368	331	N/A
Bromide (mg/L)	0.71	2.7	0.96	0.20	N/A
Chloride (mg/L)	83	110	86	81	250* (mg/L)
Fluoride (mg/L)	<0.02	0.09	<0.02	0.04	1.5* (mg/L)
Sulphate (mg/L)	11	36	150	140	250* (mg/L)
Ammonia (mg-N/L)	<0.05	0.34	0.08	<0.05	0.5* (mg/L) nitrogen (as ammonia)
Nitrate (mg-N/L)	<0.03	<0.03	0.46	0.04	10.0* (mg/L) nitrogen (as nitrate or nitrite)
Nitrite (mg-N/L)	<0.10	<0.10	<0.10	<0.10	10.0* (mg/L) nitrogen (as nitrate or nitrite)
Phosphate (mg-P/L)	<0.10	<0.10	<0.10	<0.10	2.0* as phosphorus
Calcium (mg/L)	10.2	22.4	4.30	2.18	N/A
Potassium (mg/L)	1.13	1.63	0.78	0.98	N/A
Magnesium (mg/L)	5.98	12.9	2.94	2.10	N/A
Sodium (mg/L)	56.3	62.1	68.2	113	N/A
Aluminium (mg/L)	<0.020	<0.020	0.033	0.032	N/A
Arsenic (mg/L)	<0.005	<0.005	<0.005	<0.005	0.05* (mg/L)
Cadmium (mg/L)	<0.001	<0.001	<0.001	<0.001	0.01* (mg/L)
Cobalt (mg/L)	<0.001	0.006	<0.001	<0.001	N/A
Chromium (mg/L)	<0.001	<0.001	<0.001	<0.001	0.5* (mg/L)
Copper (mg/L)	<0.001	<0.001	<0.001	<0.001	1.0* (mg/L)
Iron (mg/L)	<0.020	**4.540**	<0.020	<0.020	(Combined iron and manganese total) 1.0* (mg/L)
Manganese (mg/L)	0.183	0.850	0.118	0.016	(Combined iron and manganese total) 1.0* (mg/L)
Nickel (mg/L)	0.003	0.009	0.006	0.003	0.1** (mg/L)
Lead (mg/L)	<0.005	<0.005	<0.005	<0.005	0.05* (mg/L)
Zinc (mg/L)	<0.001	0.005	0.003	0.003	5.0* (mg/L)

* *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 2

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

Bore hole number	STIEGLITZ SEWAGE LAGOONS				ANZECC 2000		
	SZSL 2000/1	SZSL 2000/2	SZSL 2000/3	SZSL 2000/5	IRRIGATION		LIVESTOCK DRINKING
Analyte					STV (Short-term)	LTV (Long-term)	
Standing Water Level (m)	6.51	6.36	7.55	6.89			
pH (laboratory)	5.2	5.5	5.3	5.0	**6.0–8.5		
Conductivity (µS/cm)	430	594	656	587	(1)(Refer Tables 4.2.3 & 4.2.4)		
TDS (mg/L)	226	324	368	331			(2)2,000–10,000 (Refer Table 4.3.1)
Bromide (mg/L)	0.71	2.7	0.96	0.20			
Chloride (mg/L)	83	110	86	81	(3)MT (Refer Table 4.2.6) MR (Refer Table 4.2.7)		
Fluoride (mg/L)	<0.02	0.09	<0.02	0.04	4	1	
Sulphate (mg/L)	11	36	150	140			
NH_3-N (mg/L)	<0.05	0.34	0.08	<0.05			
NO_3-N (mg/L)	<0.03	<0.03	0.46	0.04			
NO_2-N (mg/L)	<0.10	<0.10	<0.10	<0.10			
PO_4-P (mg/L)	<0.10	<0.10	<0.10	<0.10			
Aluminium (µg/L)	<20	<20	33	32	20,000	5,000	5,000
Arsenic (µg/L)	<5	<5	<5	<5	2000	100	500
Cadmium (µg/L)	<1	<1	<1	<1	50	10	10
Cobalt (µg/L)	<1	6	<1	<1	100	50	1,000
Chromium (µg/L)	<1	<1	<1	<1	1,000***	100***	1,000
Copper (µg/L)	<1	<1	<1	<1	5,000	200	400-5,000
Iron (µg/L)	<20	4540	<20	<20	10,000	200	NST
Manganese (µg/L)	183	850	118	16	10,000	200	NST
Nickel (µg/L)	3	9	6	3	2000	200	1,000
Lead (µg/L)	<5	<5	<5	<5	5,000	2,000	100
Zinc (µg/L)	<1	5	3	3	5,000	2,000	20,000
Calcium (mg/l)	10.2	22.4	4.3	2.18			1,000
Potassium (mg/l)	1.13	1.63	0.78	0.98			
Magnesium (mg/l)	5.98	12.9	2.94	2.10			250–2,000
Sodium (mg/l)	56.3	62.1	68.2	113	(2)MT (Refer Table 4.2.8)		

Shaded areas indicate values above relevant guideline levels

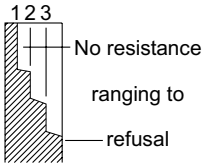
Notes:
** set to limit potential for corrosion and fouling of pumping, irrigation and stock watering systems.
*** Chromium (VI)
(1) Suitability depends on salt tolerance of crop & calculation of ECse, the average root zone salinity. ECse depends on soil type & average root zone leaching fraction.
(2) Depending on animal type, within this salinity range may be reluctance to drink or may be some scouring but stock should adapt without loss of production.
(3) ES = Suits extremely sensitive crops
MT = Suits moderately tolerant crops
MR = Medium risk of increasing crop cadmium concentrations
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

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

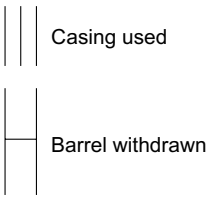
		%
VL	Very loose	0 – 15
L	Loose	15 – 35
MD	Medium dense	35 – 65
D	Dense	65 – 85
VD	Very dense	85 – 100

Fracture description

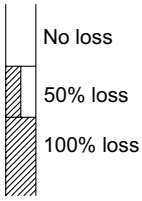
RP	Rough planar
RL	Rough irregular
SP	Smooth planar
SL	Smooth irregular

Cored borehole log

Case - lift



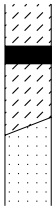
Fluid loss



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 x 10^{-4} mm / sec.

Graphic log



No core

Rock substances represented by clear, contrasting symbols consistent for each project.

Weathering

Fr	Fresh
SW	Slightly weathered
HW	Highly weathered
EW	Extremely weathered

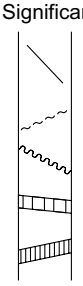
Strength

		point load strength index $I_{s\,(50)}$ (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



MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **SZSL2001/1**
Sheet 1 of 2

Project Stieglitz sewage lagoons — Location St Helens Point Road, Stieglitz

Co-ordinates 55 609216 mE, 5423668 mN
R.L.
Inclination Vertical
Bearing

Drill type Auger
Drill method Rotary
Drill fluid Nil

Hole commenced 8 March 2001
Hole completed 8 March 2001
Drilled by T.O. Bresnehan Pty Ltd
Logged by Mr Andrew Ezzy
Checked by Mr Adrian Waite

penetration 1 2 3	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
		Cement	D Sample ID 1			GC	GRAVEL - orange and light brown	D	L	Fill - Reworked Tertiary sediments
				0.5						
			D Sample ID 2	1.0		GC	GRAVEL - brown	M	L	Fill - Reworked Tertiary sediments
				1.5						
				2.0						
			D Sample ID 3			SP	SAND - coarse, black, gravelly, strong organic odour	M	S	Fill - Reworked Tertiary sediments
	No Screen	Back fill	D Sample ID 4	2.5		SP	SAND - coarse, dark grey, gravelly	M	S	Fill - Reworked Tertiary sediments
			D Sample ID 5	3.0						
			D Sample ID 6	3.5		GC	GRAVEL - light brown, sandy	M	L	Fill - Reworked Tertiary sediments
			D Sample ID 7			GC	GRAVEL - fine, dark grey-brown, sandy	M	L	Fill - Reworked Tertiary sediments
			D Sample ID 8, 9	4.0		SC	SAND - fine, orange, clayey	M	VL	Tertiary sediments
		Bentonite	D Sample ID 10	4.5		SM	SAND - fine, light brown	M	VL	Tertiary sediments

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **SZSL2001/1**
Sheet 2 of 2

Project Stieglitz sewage lagoons — Location St Helens Point Road, Stieglitz

Co-ordinates 55 609216 mE 5423668 mN
R.L.
Inclination Vertical
Bearing

Drill type Auger
Drill method Rotary
Drill fluid Nil

Hole commenced 8 March 2001
Hole completed 8 March 2001
Drilled by T.O. Bresnehan Pty Ltd
Logged by Mr Andrew Ezzy
Checked by Mr Adrian Waite

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	structure, geology
	No Screen	7 mm Gravel	D Sample ID 11		5.5		SP	SAND - coarse, light brown-grey	W	L	Tertiary sediments
	No Screen	7 mm Gravel	D Sample ID 12		6.0		SP	SAND - coarse, light brown-grey	W	VL	Tertiary sediments
	1.4 metre Pro Screen	Back in fill			6.5						
					7.0						
					7.5						
					8.0						
			Sample ID numbers refer to samples stored in MRT core shed					End of hole at 8.3 m Pumped at 0.4 L/m for 5 minutes.			

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. SZSL2001/2
Sheet 1 of 2

Project	Stieglitz sewage lagoons			Location	St Helens Point Road, Stieglitz
Co-ordinates	55 609170 mE 5423736 mN	Drill type	Auger	Hole commenced	8 March 2001
		Drill method	Rotary	Hole completed	8 March 2001
R.L.		Drill fluid	Nil	Drilled by	T.O. Bresnehan Pty Ltd
Inclination	Vertical			Logged by	Mr Andrew Ezzy
Bearing				Checked by	Mr Adrian Waite

penetration 1 2 3	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
	No Screen	Cement / Back fill	D Sample ID 1	0.5		SP	SAND - medium, humic, dark-grey, gravelly	M	L	Fill - Reworked Tertiary sediments
			D Sample ID 2	1.0		SP	SAND - coarse, black, gravelly, strong organic odour	M	L	Fill - Reworked Tertiary sediments
			D Sample ID 3	1.5 2.0 2.5						
			D Sample ID 4	3.0		CI	CLAY - medium plasticity, mottled dark brown and grey, gravelly	M	F	Fill - Reworked Tertiary sediments
			D Sample ID 5	3.5 4.0 4.5						

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **SZSL2001/2**
Sheet 2 of 2

Project	Stieglitz sewage lagoons	Location	St Helens Point Road, Stieglitz
Co-ordinates	55 609170 E 5423736 N	Drill type	Auger
		Drill method	Rotary
		Drill fluid	Nil
R.L.		Hole commenced	8 March 2001
Inclination	Vertical	Hole completed	8 March 2001
Bearing		Drilled by	T.O. Bresnehan Pty Ltd
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration 1 2 3	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
		Bentonite					(As sheet 1)			
	No Screen		D Sample ID 6	5.5		CL	CLAY - low plasticity, light grey-brown	M	F	Tertiary sediments
		7 mm Gravel		6.0						
				6.5						
	1.4 metre Pro Screen			7.0						
			D Sample ID 7	7.5		CL	CLAY - low plasticity, light yellow, silty	M	F	Tertiary sediments
			D Sample ID 8			CI	CLAY - medium plasticity, light brown	M	F	Tertiary sediments
			D Sample ID 9	8.0		SM	SAND - fine, light grey	W	S	Tertiary sediments
			Sample ID numbers refer to samples stored in MRT core shed				End of hole at 8.3 m			

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **SZSL2001/3**
Sheet 1 of 2

Project	Stieglitz sewage lagoons	Location	St Helens Point Road, Stieglitz
Co-ordinates	55 609292 mE 5423770 mN	Drill type	Auger
		Drill method	Rotary
		Drill fluid	Nil
R.L.		Hole commenced	8 March 2001
Inclination	Vertical	Hole completed	8 March 2001
Bearing		Drilled by	T.O. Bresnehan Pty Ltd
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration 1 2 3	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
		Cement	D Sample ID 1	0.5		SP	SAND - medium, humic, dark grey, gravelly	M	L	Fill - Reworked Tertiary sediments
			D Sample ID 2	1.0		GC	GRAVEL - fine, orange-brown, sandy	M	L	Fill - Reworked Tertiary sediments
				1.5						
			D Sample ID 3	2.0		CL	CLAY - low plasticity, brown, gravelly	M	F	Fill - Reworked Tertiary sediments
	No Screen	Back fill		2.5						
			D Sample ID 4	3.0		GC	GRAVEL - fine, orange-brown, sandy	M	L	Fill - Reworked Tertiary sediments
			D Sample ID 5			GC	GRAVEL - fine, light brown, clayey	M	L	Fill - Reworked Tertiary sediments
			D Sample ID 6	3.5						
			D Sample ID 7	4.0		GC	GRAVEL - fine, black, sandy	M	L	Fill - Reworked Tertiary sediments
			D Sample ID 8	4.5		SM	SAND - fine, brown	M	L	Fill - Reworked Tertiary sediments
			D Sample ID 9			SM	SAND - fine, light brown	M	VL	Tertiary sediments

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **SZSL2001/3**
Sheet 2 of 2

Project Stieglitz sewage lagoons — Location St Helens Point Road, Stieglitz

Co-ordinates 55 609292 mE, 5423770 mN
R.L.
Inclination Vertical
Bearing

Drill type Auger
Drill method Rotary
Drill fluid Nil

Hole commenced 8 March 2001
Hole completed 8 March 2001
Drilled by T.O. Bresnehan Pty Ltd
Logged by Mr Andrew Ezzy
Checked by Mr Adrian Waite

penetration 1 2 3	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
	No Screen	Back fill		5.5			(As sheet 1)			
		Bentonite		6.0						
	1.4 metre Pro Screen			6.5						
			S.W.L. 08/03/01	7.0						
		7 mm Gravel	D Sample ID 10			GC	GRAVEL - fine, light brown	W	VL	Tertiary sediments
				7.5						
			D Sample ID 11	8.0		SM	SAND - fine, light yellow	W	VL	Tertiary sediments
			Sample ID numbers refer to samples stored in MRT core shed				End of hole at 8.1 m			

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **SZSL2001/4**
Sheet 1 of 2

Project Stieglitz sewage lagoons — Location St Helens Point Road, Stieglitz

Co-ordinates 55 609138 E
5423603 N

R.L.
Inclination Vertical
Bearing

Drill type Auger
Drill method Rotary
Drill fluid Nil

Hole commenced 8 March 2001
Hole completed 8 March 2001
Drilled by T.O. Bresnehan Pty Ltd
Logged by Mr Andrew Ezzy
Checked by Mr Adrian Waite

penetration 1 2 3	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
		Cement	D Sample ID 1	0.5		SP	SAND - medium, grey, 5 % rounded coarse gravel	D	VL	Fill - Reworked Tertiary sediments
			D Sample ID 2	1.0 / 1.5		SP	SAND - coarse, grey, 10 % quartzite rounded fine gravel	M	L	Fill - Reworked Tertiary sediments
		Back fill	D Sample ID 3	2.0		SP	SAND - coarse, light grey, 5% quartzite rounded medium gravel	M	VL	Fill - Reworked Tertiary sediments
	No Screen		D Sample ID 4	2.5						
			S.W.L. 08/03/01	3.0						
		7 mm Gravel		3.5						
			D Sample ID 5	4.0		GC	GRAVEL - fine, grey, sandy	M	VL	Fill - Reworked Tertiary sediments
	1.4 metre Pro Screen		D Sample ID 6	4.5		SP	SAND - coarse, dark brown	W	S	Tertiary sediments
		Back fill	D Sample ID 7			SP	SAND - coarse, dark brown	W	VL	Tertiary sediments

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **SZSL2001/4**
Sheet 2 of 2

Project Stieglitz sewage lagoons — Location St Helens Point Road, Stieglitz

Co-ordinates 55 609138 E
5423603 N

R.L.
Inclination Vertical
Bearing

Drill type Auger
Drill method Rotary
Drill fluid Nil

Hole commenced 8 March 2001
Hole completed 8 March 2001
Drilled by T.O. Bresnehan Pty Ltd
Logged by Mr Andrew Ezzy
Checked by Mr Adrian Waite

penetration 1 2 3	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
	Back fill	Back fill		5.5			(As sheet 1)			
				6.0		SP	SAND - coarse, black, humic	M	H	Tertiary sediments
			Sample ID numbers refer to samples stored in MRT core shed				End of hole due to auger refusal at 6.2 m Pumped for 10 minutes at 1.1 L/m.			Auger refusal may be due to iron pan?

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **SZSL2001/5**
Sheet 1 of 2

Project	Stieglitz sewage lagoons	Location	St Helens Point Road, Stieglitz
Co-ordinates	55 609265 E 5423613 N	Drill type	Auger
		Drill method	Rotary
		Drill fluid	Nil
R.L.		Hole commenced	8 March 2001
Inclination	Vertical	Hole completed	8 March 2001
Bearing		Drilled by	T.O. Bresnehan Pty Ltd
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration 1 2 3	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
		Cement	D Sample ID 1	0.5		SP	SAND - medium, red-orange	M	L	Fill - Reworked Tertiary sediments
			D Sample ID 2	1.0 / 1.5 / 2.0		GC	GRAVEL - fine, orange, sandy	M	VL	Fill - Reworked Tertiary sediments
			D Sample ID 3			SP	SAND - coarse, brown, gravelly	M	L	Fill - Reworked Tertiary sediments
	No Screen	Back fill	D Sample ID 4	2.5 / 3.0		SP	SAND - coarse, red-orange	M	L	Fill - Reworked Tertiary sediments
			D Sample ID 5	3.5 / 4.0 / 4.5		SC	SAND - medium, light brown, mottled orange	M	VL	Fill - Reworked Tertiary sediments
			D Sample ID 6			SM	SAND - fine, light brown	M	VL	Tertiary sediments

MINERAL RESOURCES TASMANIA

ENGINEERING LOG - BOREHOLE

Borehole no. **SZSL2001/5**
Sheet 2 of 2

Project	Stieglitz sewage lagoons	Location	St Helens Point Road, Stieglitz
Co-ordinates	55 609265 mE 5423613 mN	Drill type	Auger
		Drill method	Rotary
		Drill fluid	Nil
R.L.		Hole commenced	8 March 2001
Inclination	Vertical	Hole completed	8 March 2001
Bearing		Drilled by	T.O. Bresnehan Pty Ltd
		Logged by	Mr Andrew Ezzy
		Checked by	Mr Adrian Waite

penetration 1 2 3	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
	No Screen	Back fill		5.5			(As sheet 1)			
		Bentonite		6.0						
		7 mm Gravel		6.5						
	1.4 metre Pro Screen	▼	S.W.L. 08/03/01 D Sample ID 7	7.0		GC	GRAVEL - fine, light brown	W	VL	Tertiary sediments
		Back fill		7.5						
				8.0						
			Sample ID numbers refer to samples stored in MRT core shed				End of hole at 8.1m			

Appendix 2

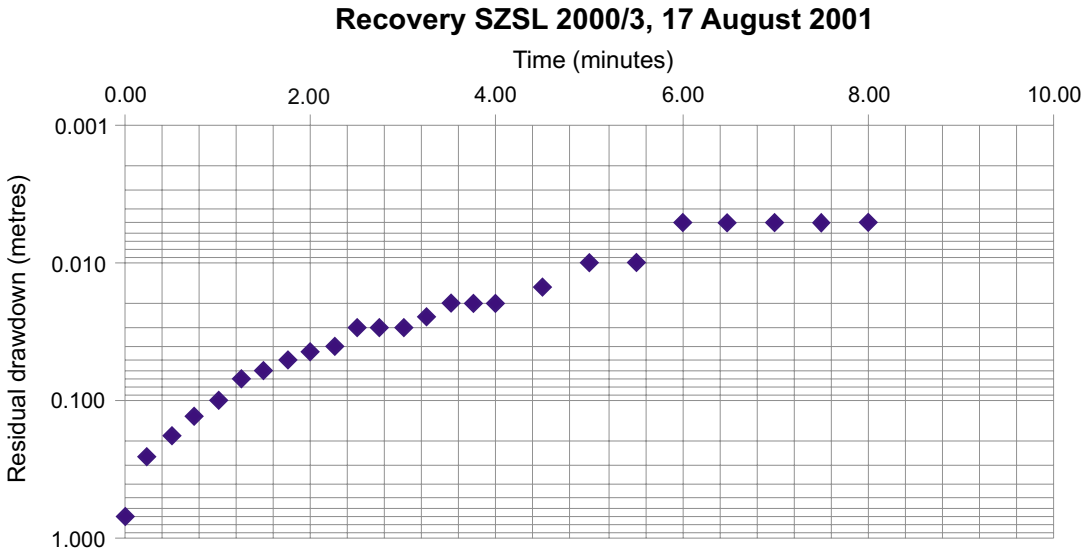
Raw data collected for slug extraction tests

Stieglitz lagoons recovery pump test — Slug extraction recovery data

Date: 17/08/2001
Bore: SZSL 2001/3
TD: 8.10 m
Flow: 2.1 l/m
SWL: 7.63 m
Stick up: 0.18 m

Recovery data

Time	*Residual drawdown*	*Measurement*
0.00	0.700	8.33
0.25	0.260	7.89
0.50	0.180	7.81
0.75	0.130	7.76
1.00	0.100	7.73
1.25	0.070	7.70
1.50	0.060	7.69
1.75	0.050	7.68
2.00	0.045	7.675
2.25	0.040	7.67
2.50	0.030	7.66
2.75	0.030	7.66
3.00	0.030	7.66
3.25	0.025	7.655
3.50	0.020	7.65
3.75	0.020	7.65
4.00	0.020	7.65
4.50	0.015	7.645
5.00	0.010	7.64
5.50	0.010	7.64
6.00	0.005	7.635
6.50	0.005	7.635
7.00	0.005	7.635
7.50	0.005	7.635
8.00	0.005	7.635



Appendix 3

Analytical Services Tasmania — Laboratory reports

Tasmania

ANALYTICAL SERVICES TASMANIA
Sandy Bay Laboratory
c/- Chemistry Department University of Tasmania
Sandy Bay Tasmania 7005
Telephone: (03) 6226 7175 Fax: (03) 6226 7825
Email: ast.sandybay@dpiwe.tas.gov.au

NATA Accreditation Number: 5589

Laboratory Report

Report No:	14943	***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:	15-May-01	**Client Order No:**
Report Date:	01-Jun-2001 10:18	
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
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

NATA Accreditation Number: 5589

The tests, calibrations or measurements covered by this document have been performed in accordance with NATA requirements which include the requirements of ISO/IEC 17025 and are traceable to national standards of measurement.

This document shall not be reproduced, except in full.
Samples analysed as received.

*** NATA accreditation does not cover the performance of this service.**

Mike Johnson
Manager

Tasmania

ANALYTICAL SERVICES TASMANIA
Sandy Bay Laboratory
c/- Chemistry Department University of Tasmania
Sandy Bay Tasmania 7005

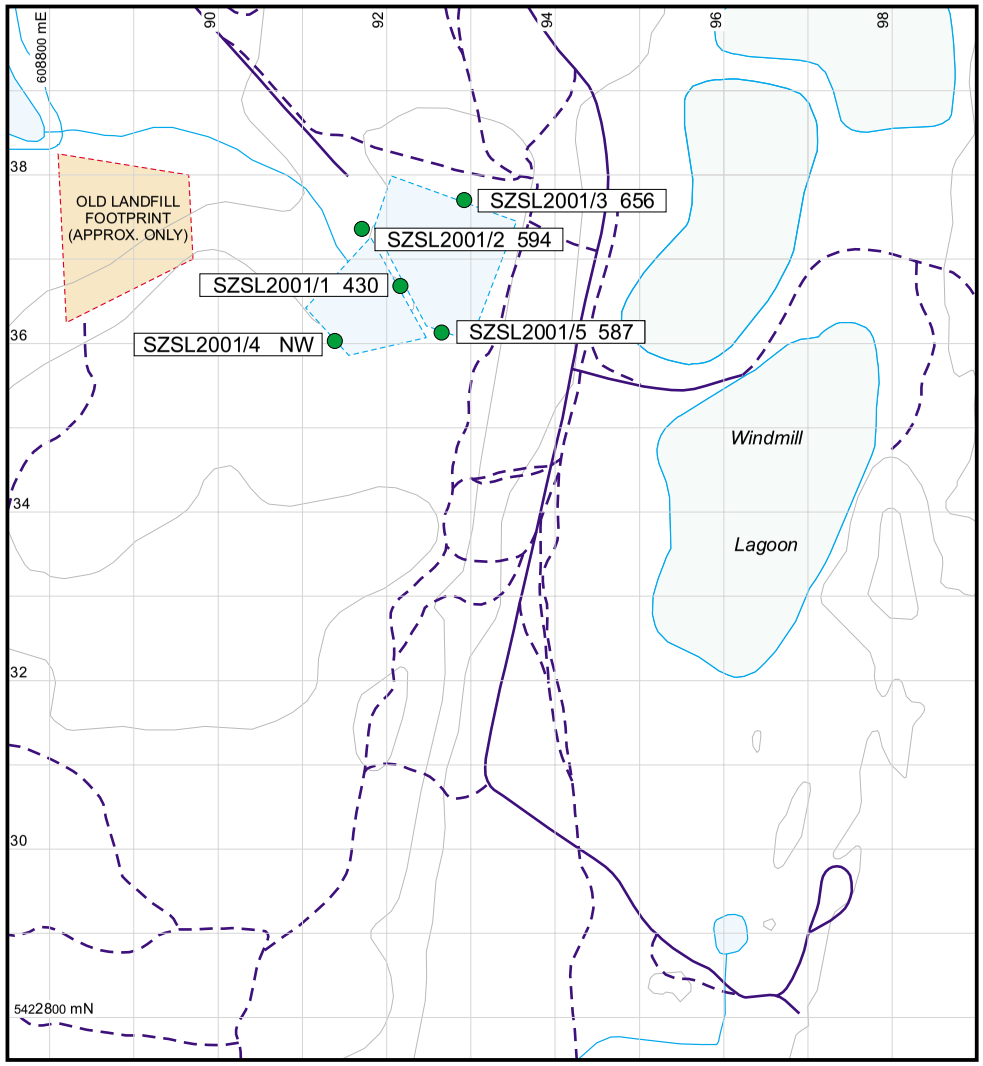
NATA Accreditation Number: 5589

Report No: 14943 **Report Date:** 01-Jun-2001 10:14

Method	Analyte	Units / Sampled On :	Lab.No.: 20852 / Sample Id.: SZSL2001/1 / 15-05-01 11:20	20853 / SZSL2001/2 / 15-05-01 11:40	20854 / SZSL2001/3 / 15-05-01 10:30	20855 / SZSL2001/5 / 15-05-01 12:15
1001-Water	pH		5.2	5.5	5.3	5.0
1002-Water	Conductivity	µS/cm	430	594	656	587
1004-Water	TDS	mg/L	226	324	368	331
1103-Water	Bromide	mg/L	0.71	2.7	0.96	0.20
	Chloride	mg/L	83	110	86	81
	Fluoride	mg/L	<0.02	0.09	<0.02	0.04
	Nitrate	mg-N/L	<0.03	<0.03	0.46	0.04
	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	11	36	150	140
1204-Water	Ammonia	mg-N/L	<0.05	0.34	0.08	<0.05
1301-Water	Al (Dissolved)	µg/L	<20	<20	33	32
	As (Dissolved)	µg/L	<5	<5	<5	<5
	Cd (Dissolved)	µg/L	<1	<1	<1	<1
	Co (Dissolved)	µg/L	<1	6	<1	<1
	Cr (Dissolved)	µg/L	<1	<1	<1	<1
	Cu (Dissolved)	µg/L	<1	<1	<1	<1
	Fe (Dissolved)	µg/L	<20	4540	<20	<20
	Mn (Dissolved)	µg/L	183	850	118	16
	Ni (Dissolved)	µg/L	3	9	6	3
	Pb (Dissolved)	µg/L	<5	<5	<5	<5
	Zn (Dissolved)	µg/L	<1	5	3	3
1302-Water	Ca (Dissolved)	mg/L	10.2	22.4	4.30	2.18
	K (Dissolved)	mg/L	1.13	1.63	0.78	0.98
	Mg (Dissolved)	mg/L	5.98	12.9	2.94	2.10
	Na (Dissolved)	mg/L	56.3	62.1	68.2	113

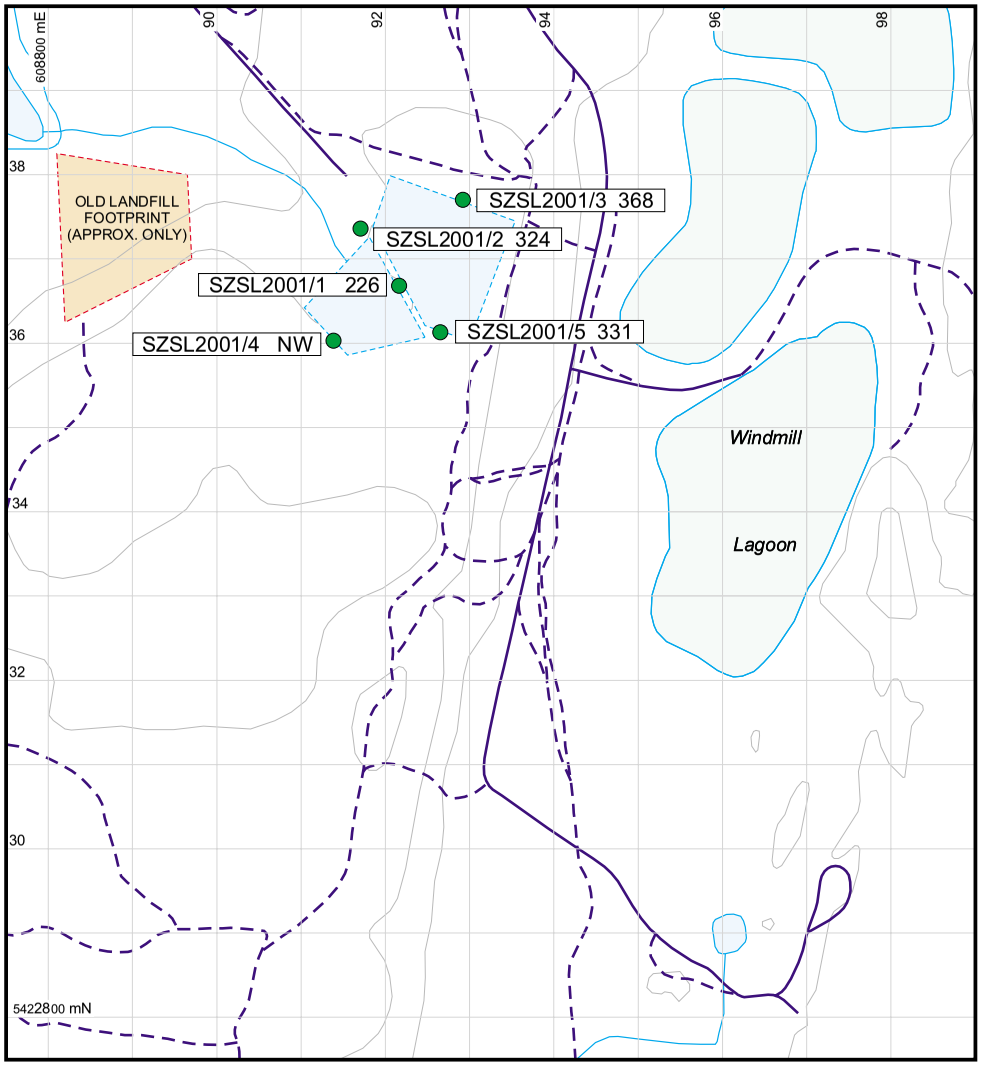
Appendix 4
Analytical results on site maps

Stieglitz Sewage Lagoons
May 2001
Conductivity (μS/cm)



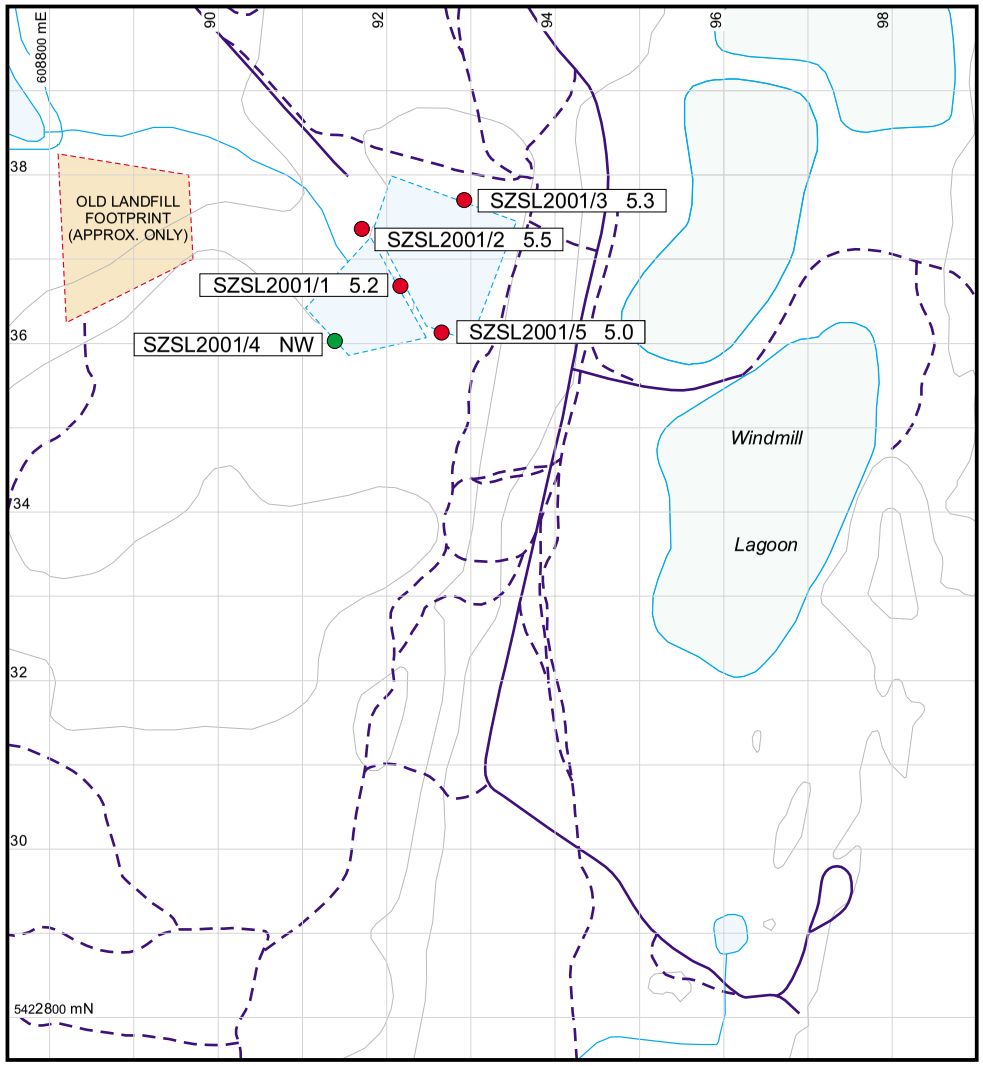
NW = no water

Stieglitz Sewage Lagoons
May 2001
TDS (mg/L)



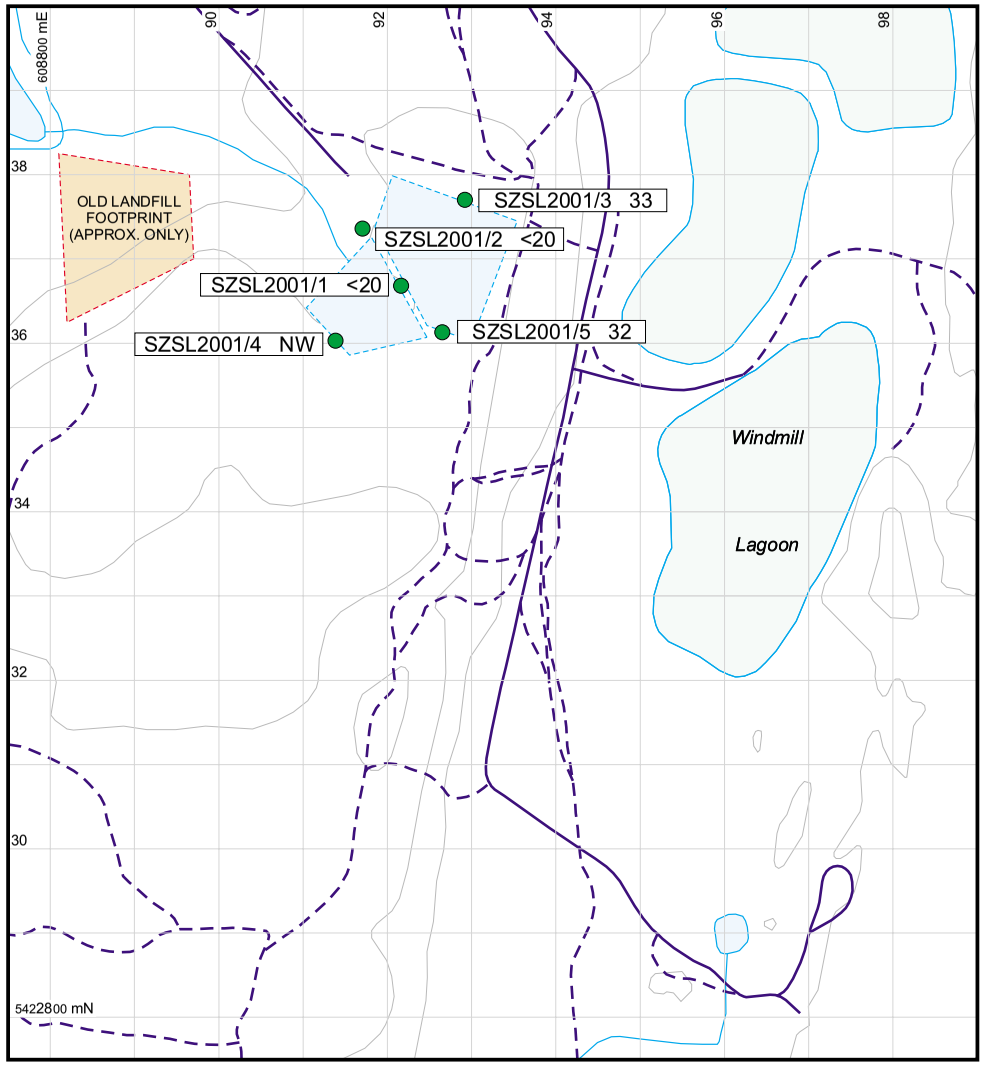
NW = no water

Stieglitz Sewage Lagoons
May 2001
pH



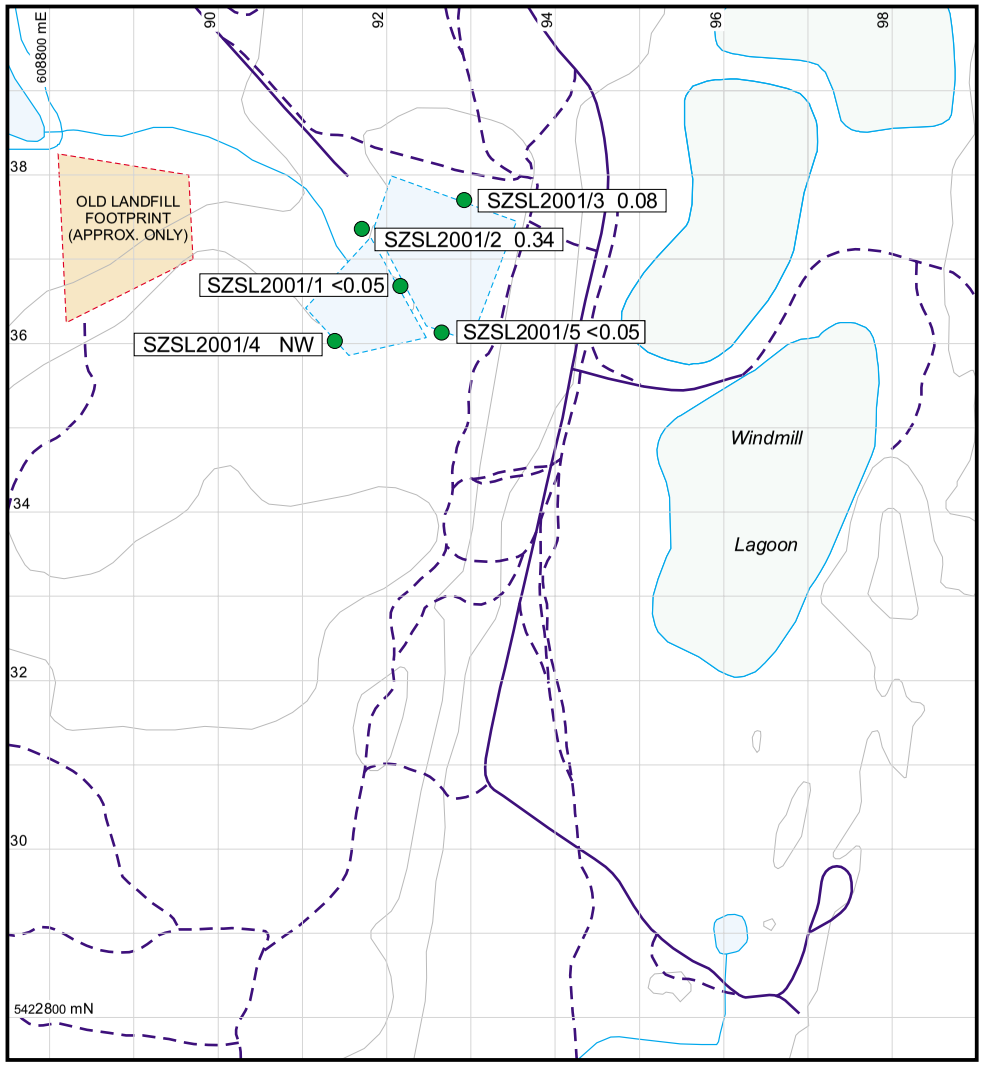
NW = no water

Stieglitz Sewage Lagoons
May 2001
Al (μg/L)



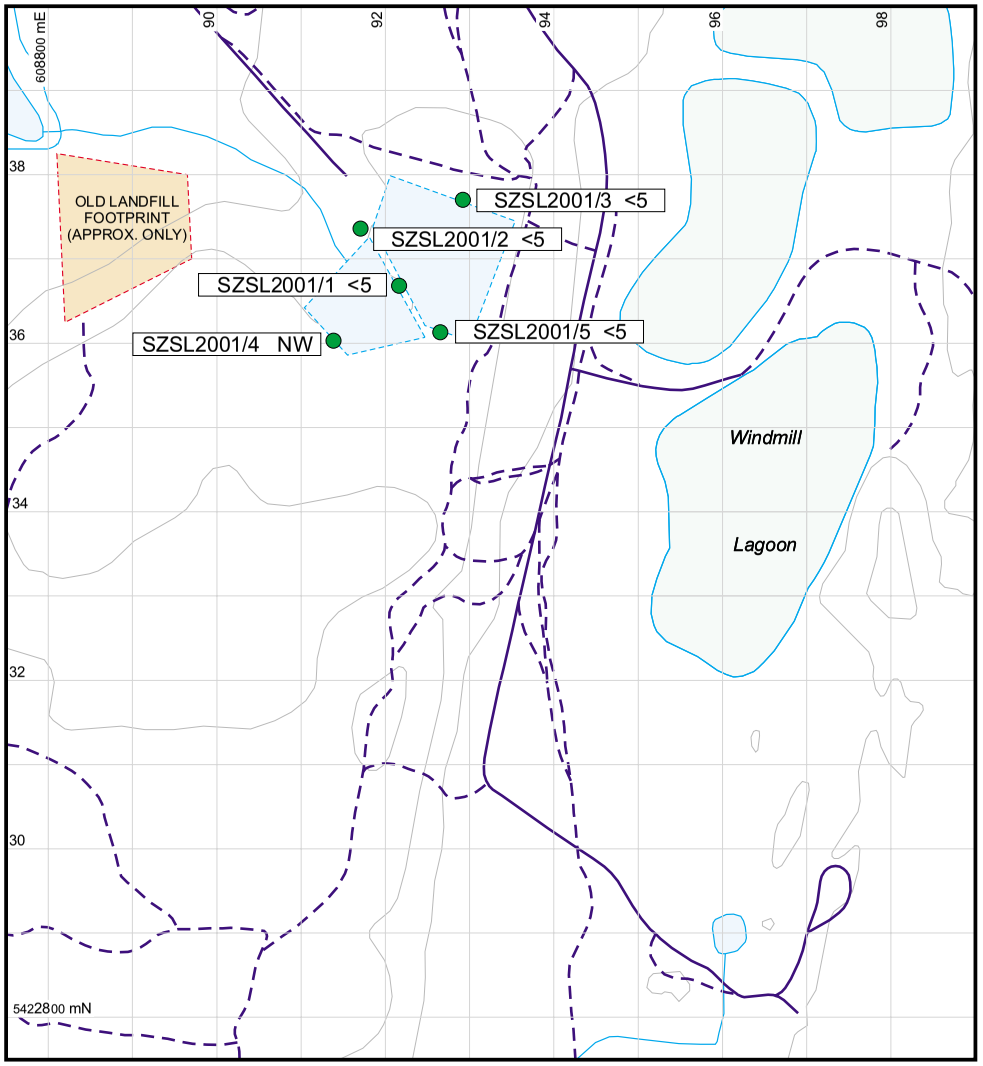
NW = no water

Stieglitz Sewage Lagoons
May 2001
Ammonia (mg-N/L)



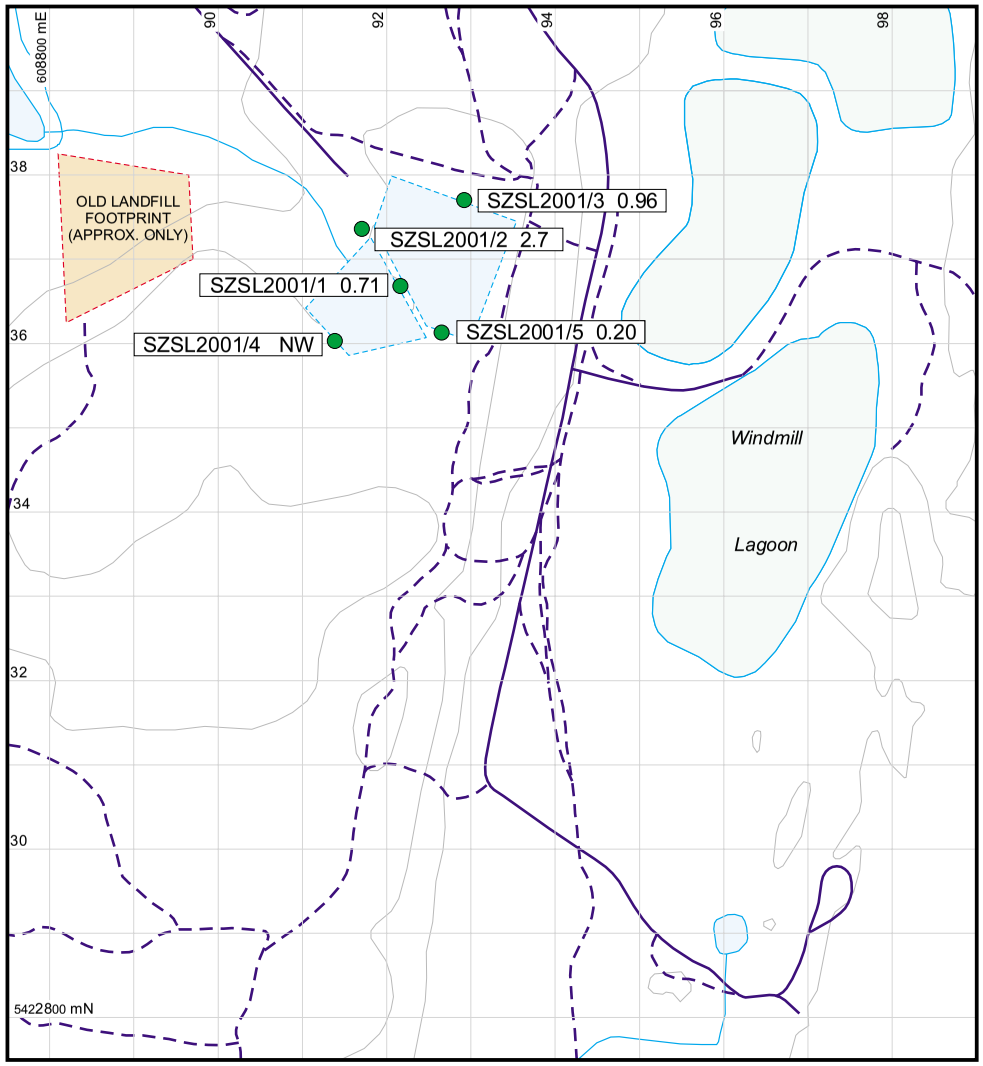
NW = no water

Stieglitz Sewage Lagoons
May 2001
As (mg/L)



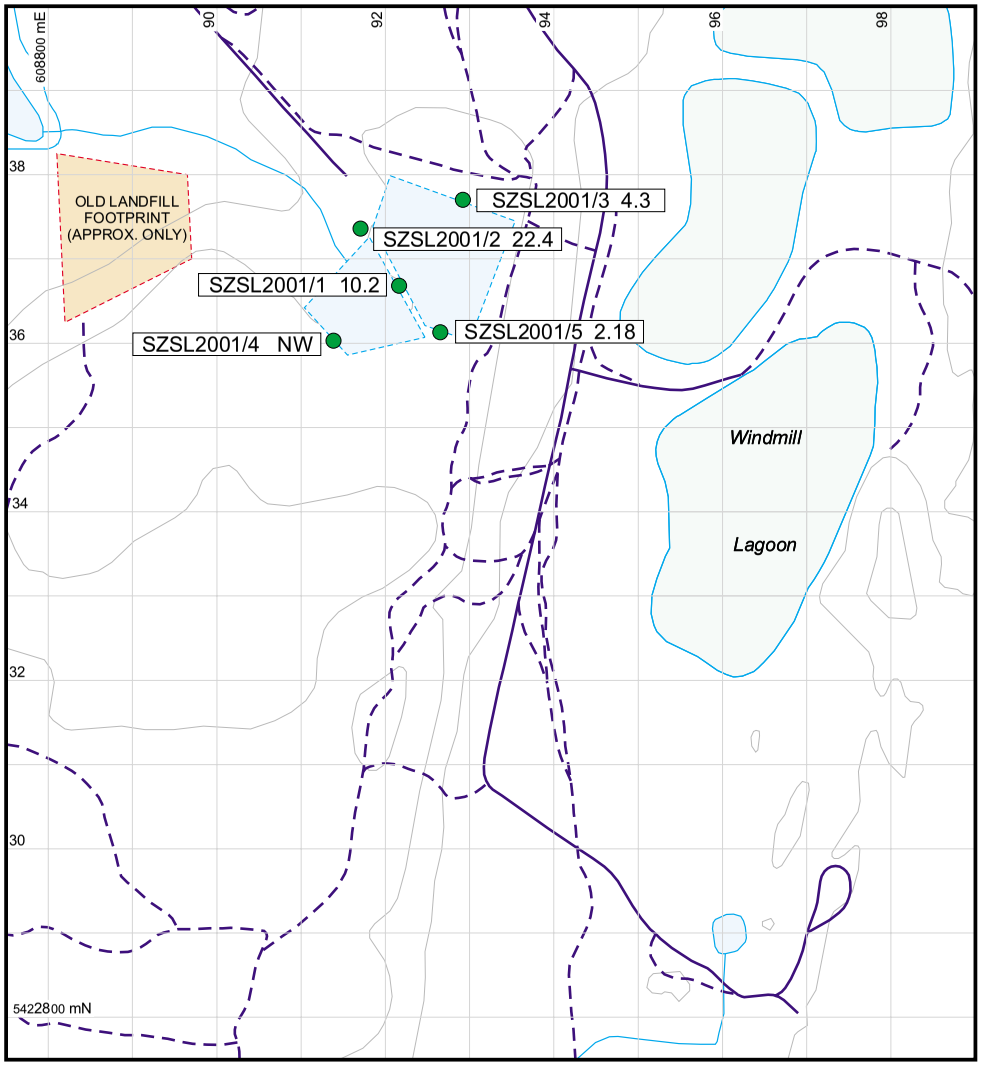
NW = no water

Stieglitz Sewage Lagoons
May 2001
Bromide (mg/L)



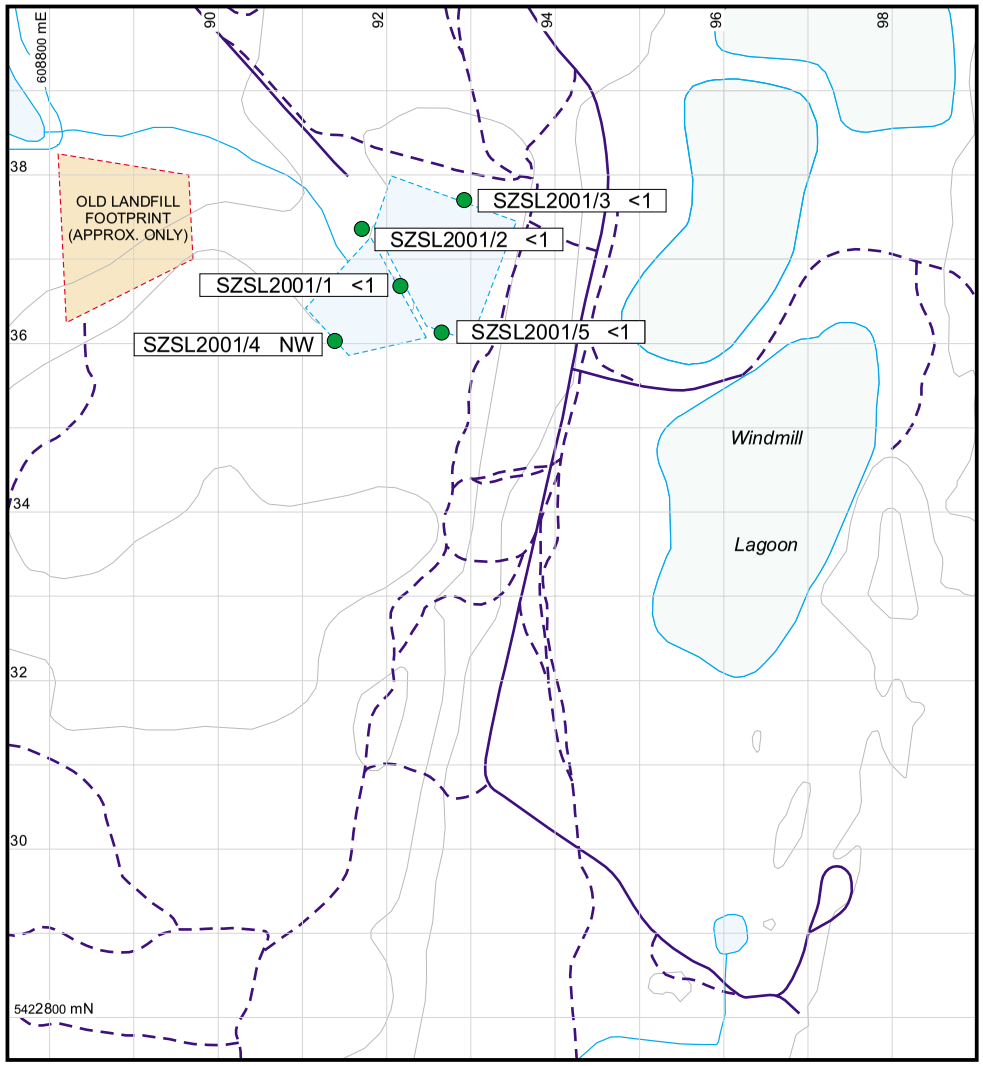
NW = no water

Stieglitz Sewage Lagoons
May 2001
Ca (mg/L)



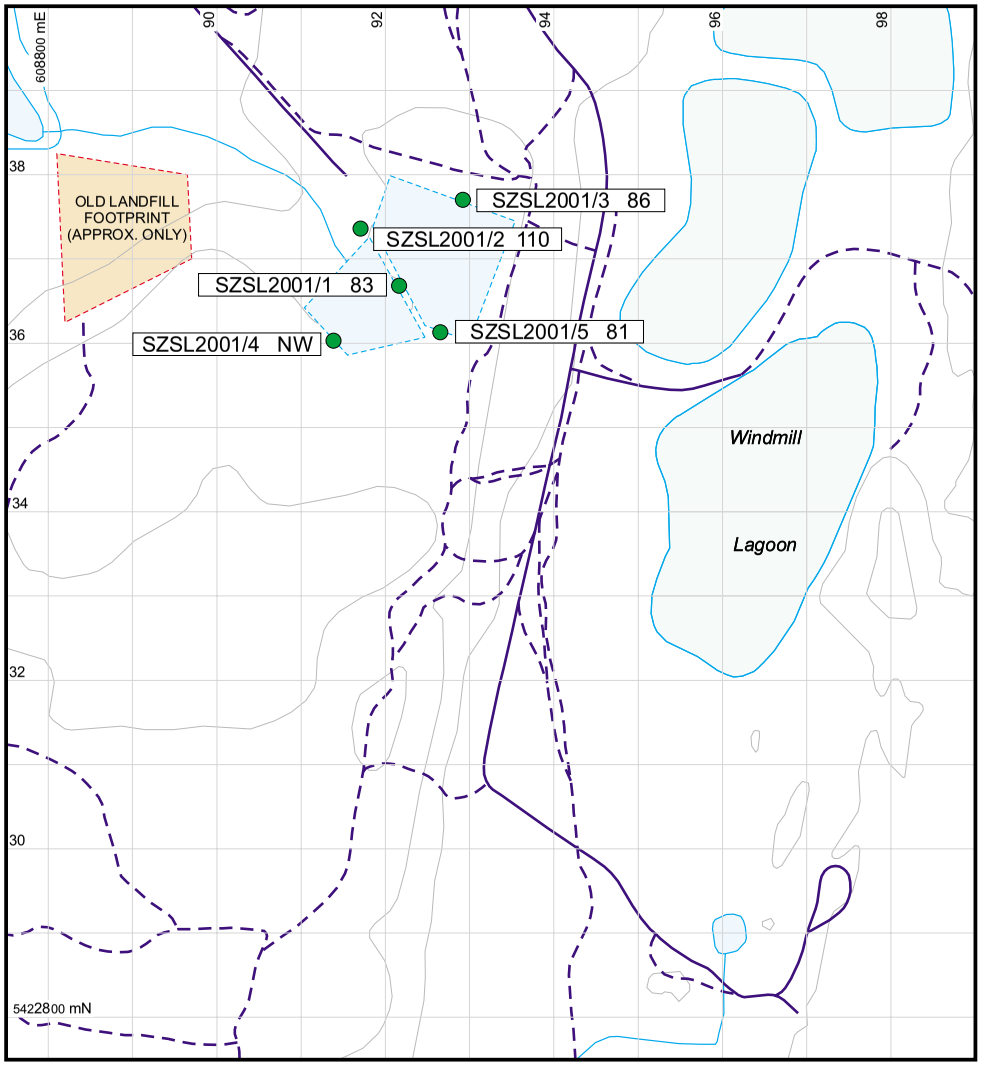
NW = no water

Stieglitz Sewage Lagoons
May 2001
Cd (μg/L)



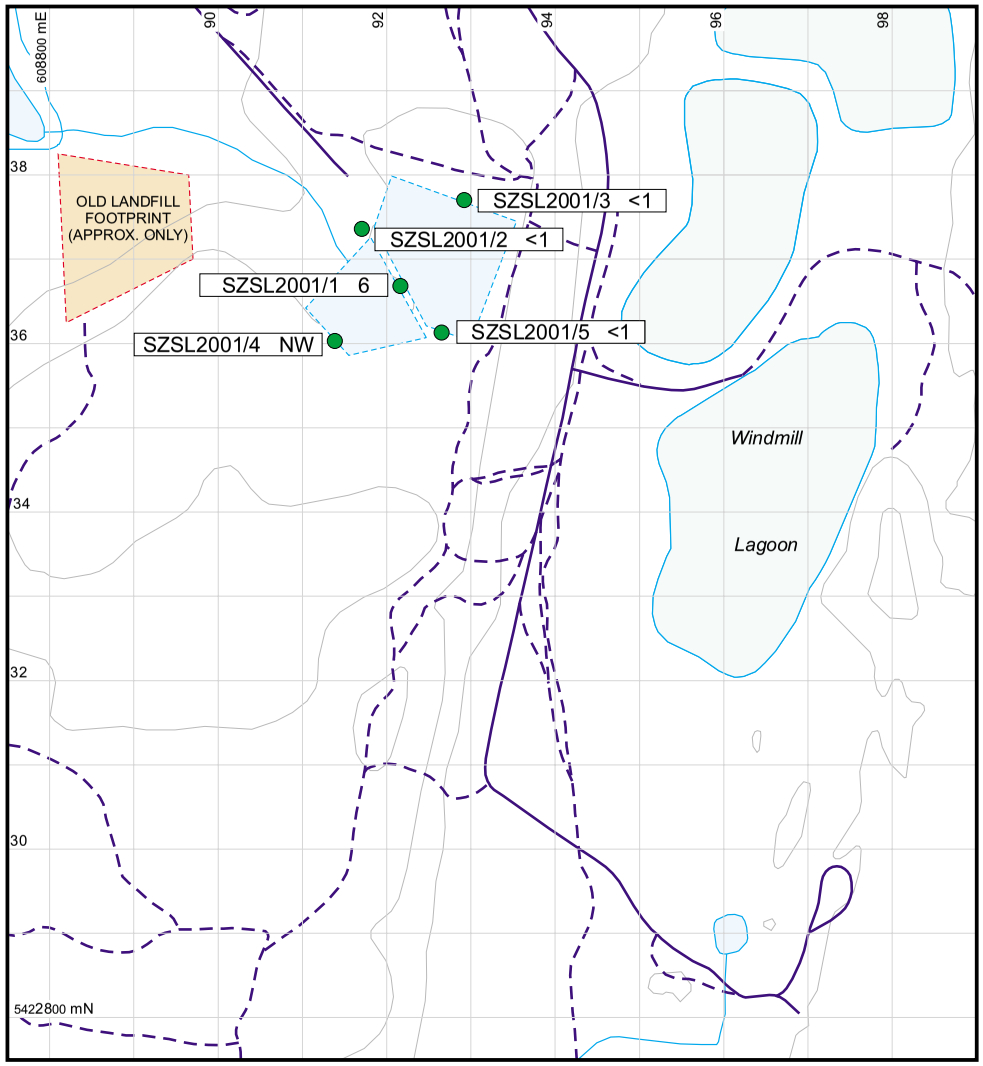
NW = no water

Stieglitz Sewage Lagoons
May 2001
Chloride (mg/L)



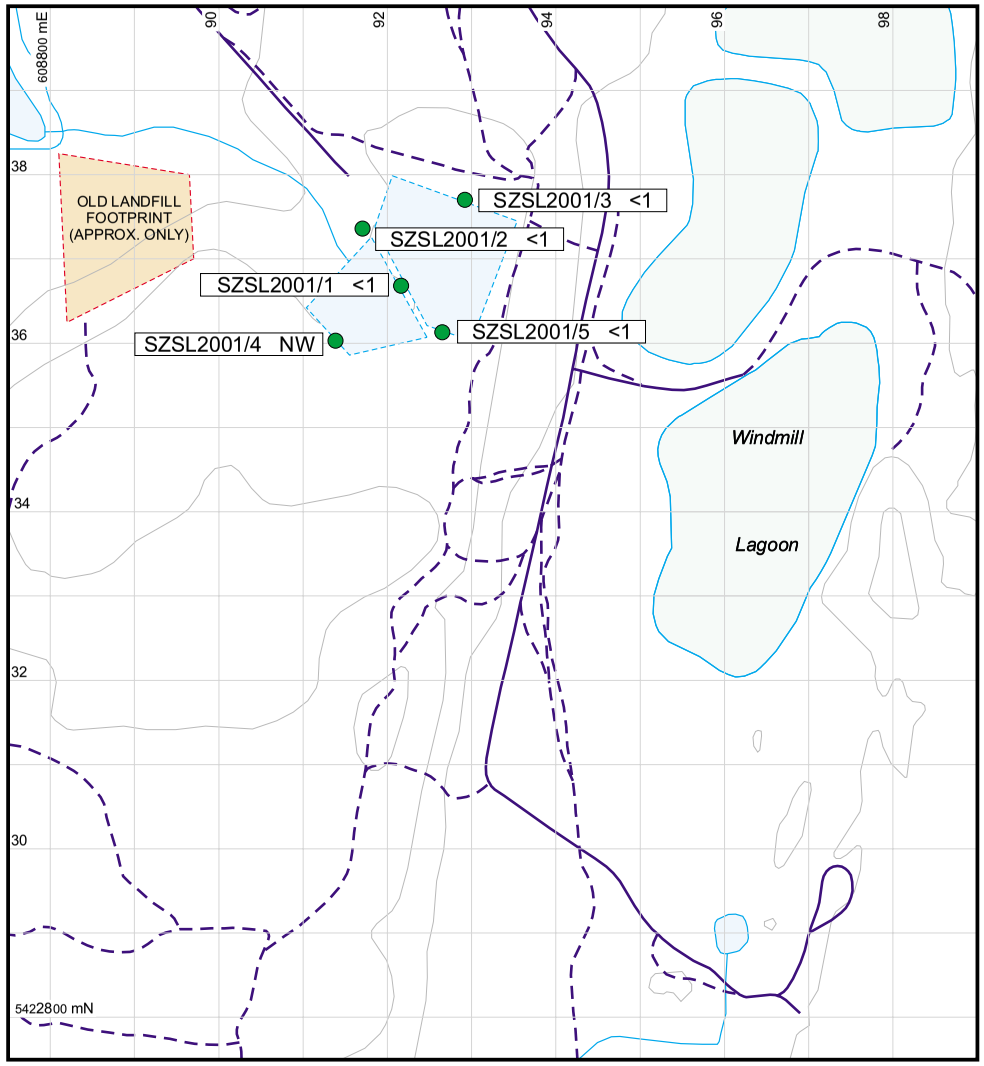
NW = no water

Stieglitz Sewage Lagoons
May 2001
Co (µg/L)



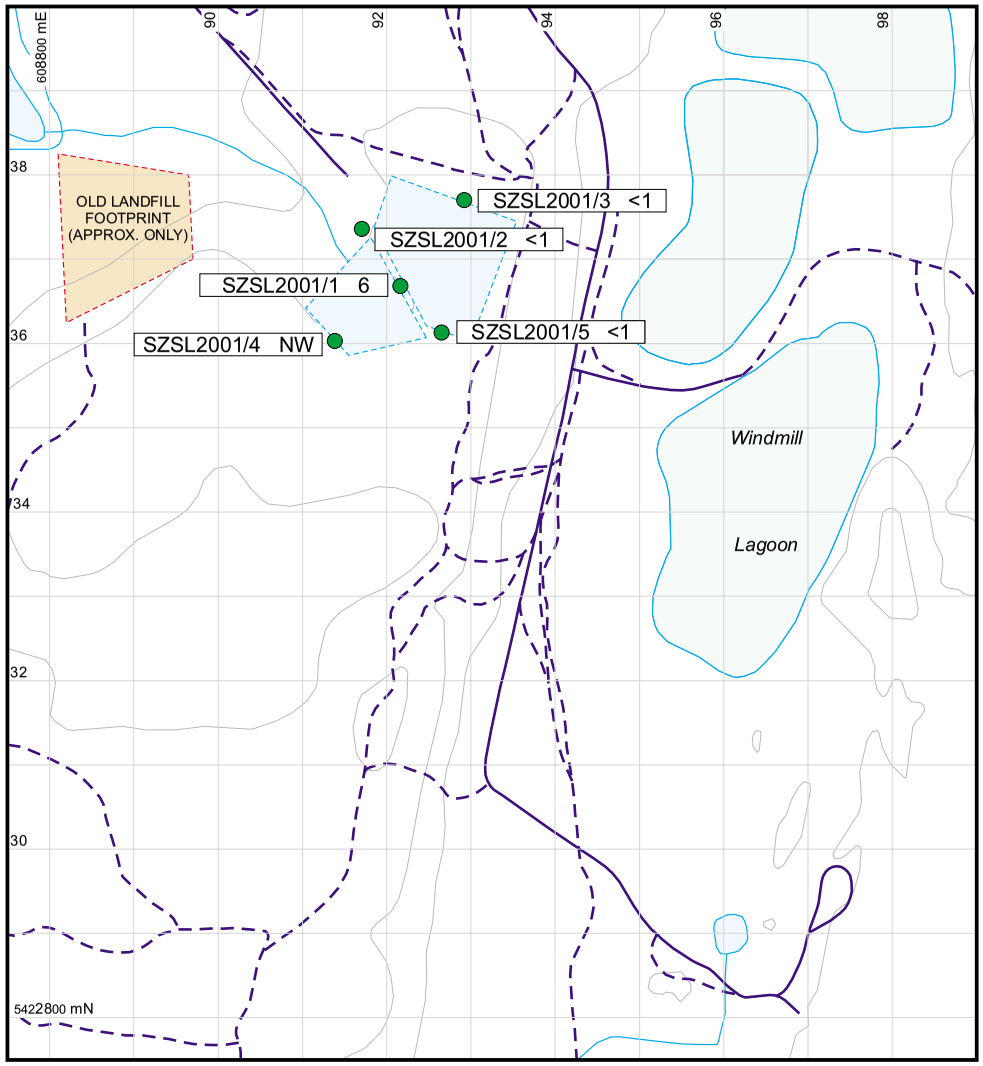
NW = no water

Stieglitz Sewage Lagoons
May 2001
Cr (µg/L)



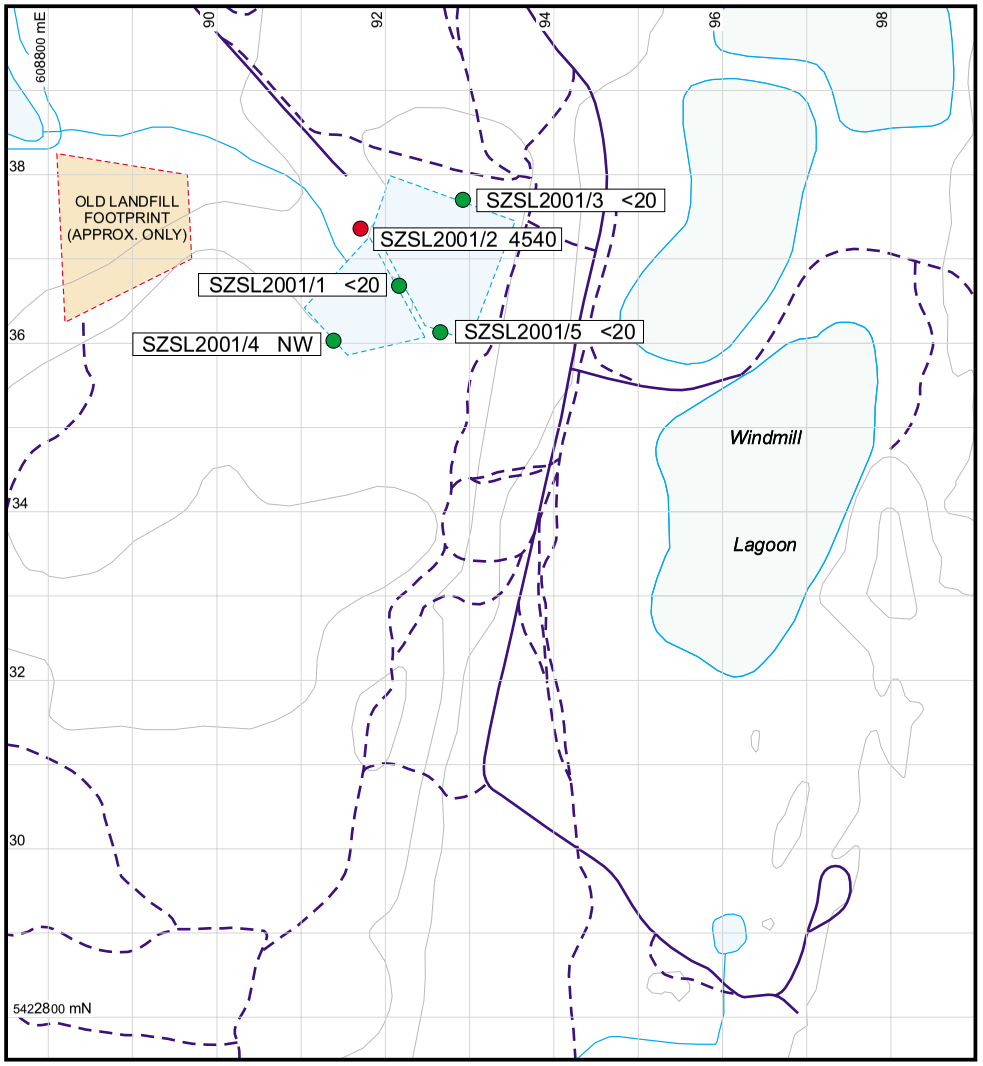
NW = no water

Stieglitz Sewage Lagoons
May 2001
Cu (µg/L)



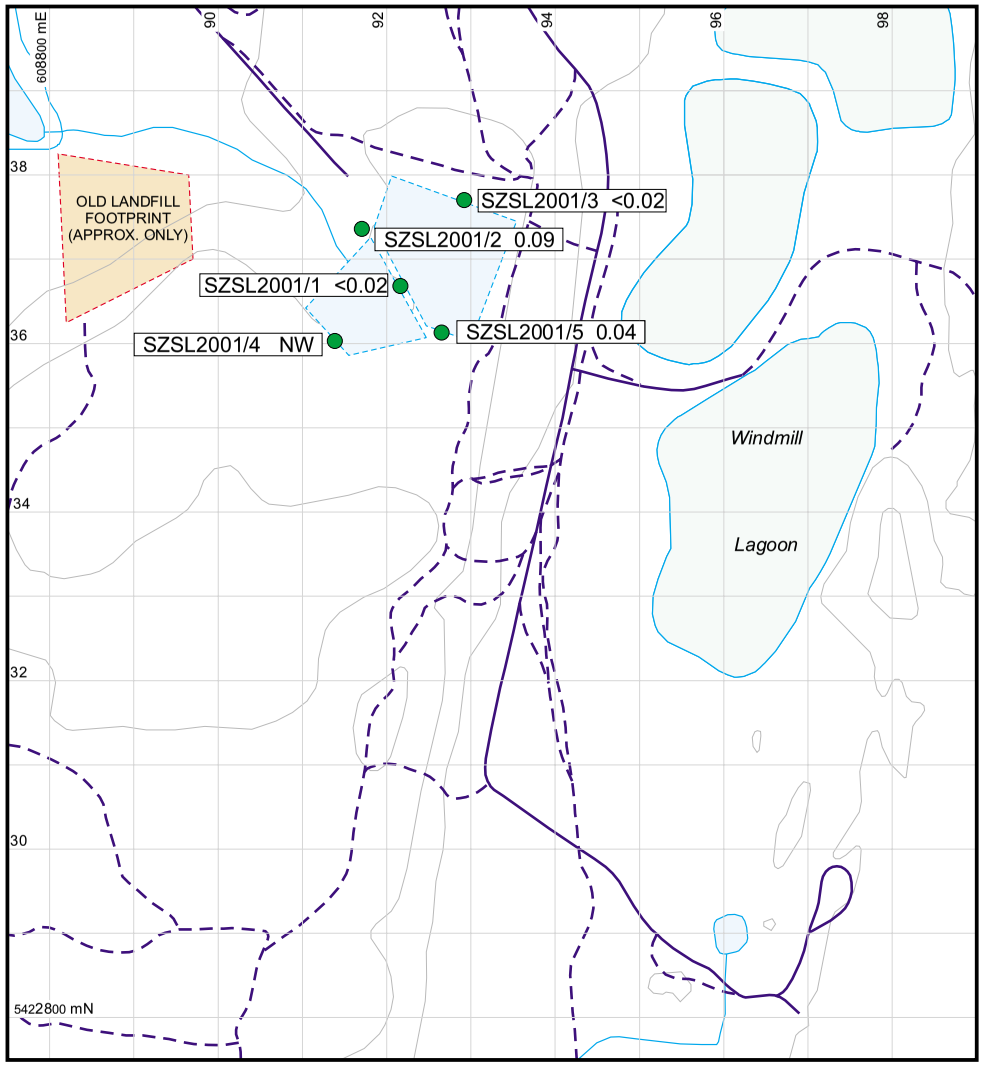
NW = no water

Stieglitz Sewage Lagoons
May 2001
Fe (µg/L)



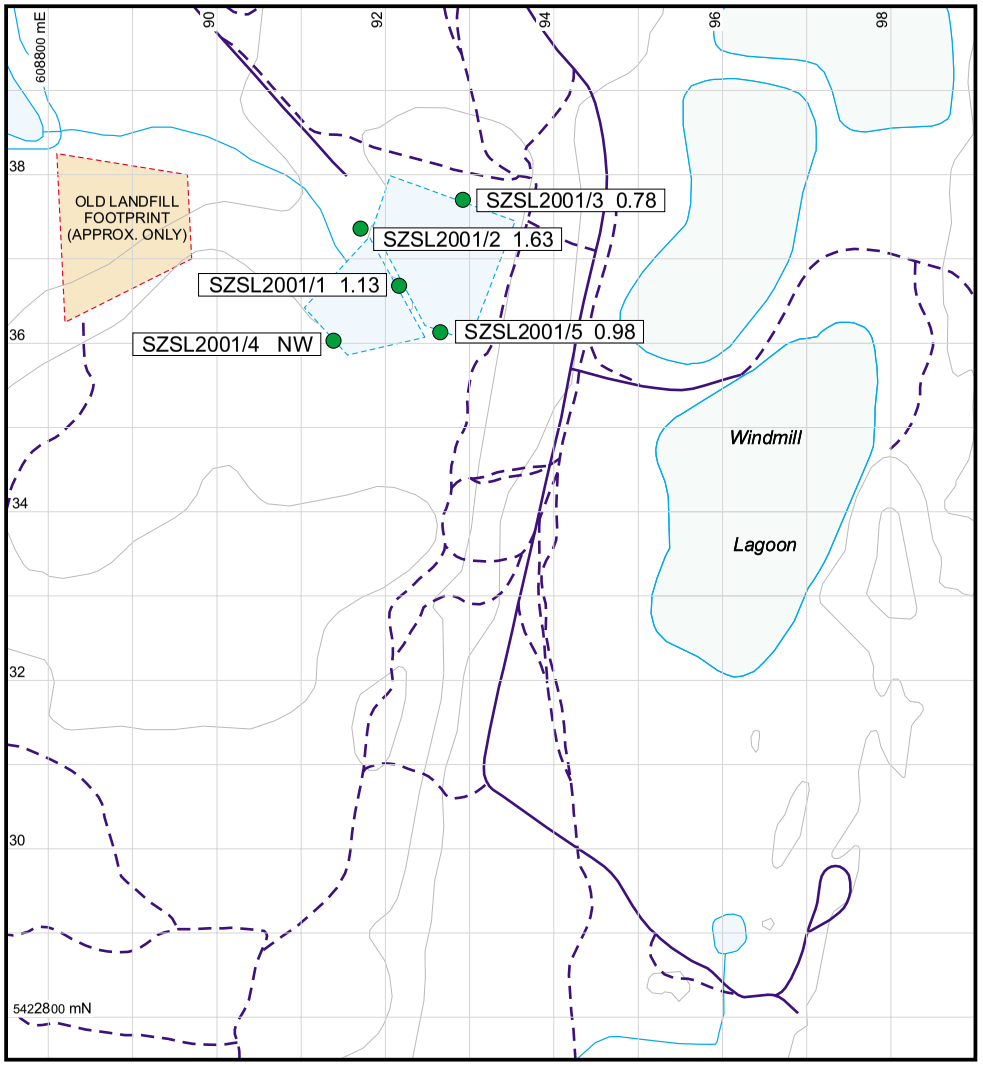
NW = no water

Stieglitz Sewage Lagoons
May 2001
Fluoride (mg/L)



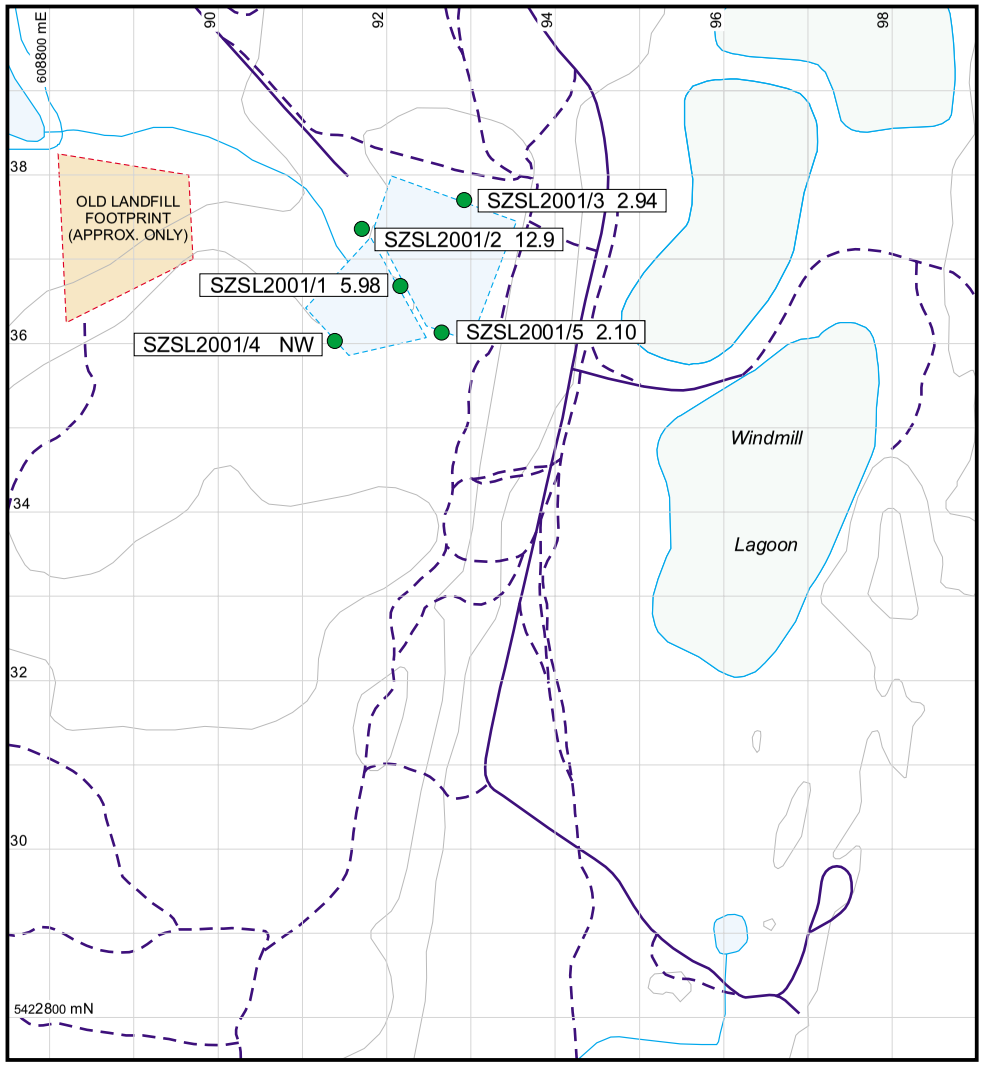
NW = no water

Stieglitz Sewage Lagoons
May 2001
K (mg/L)



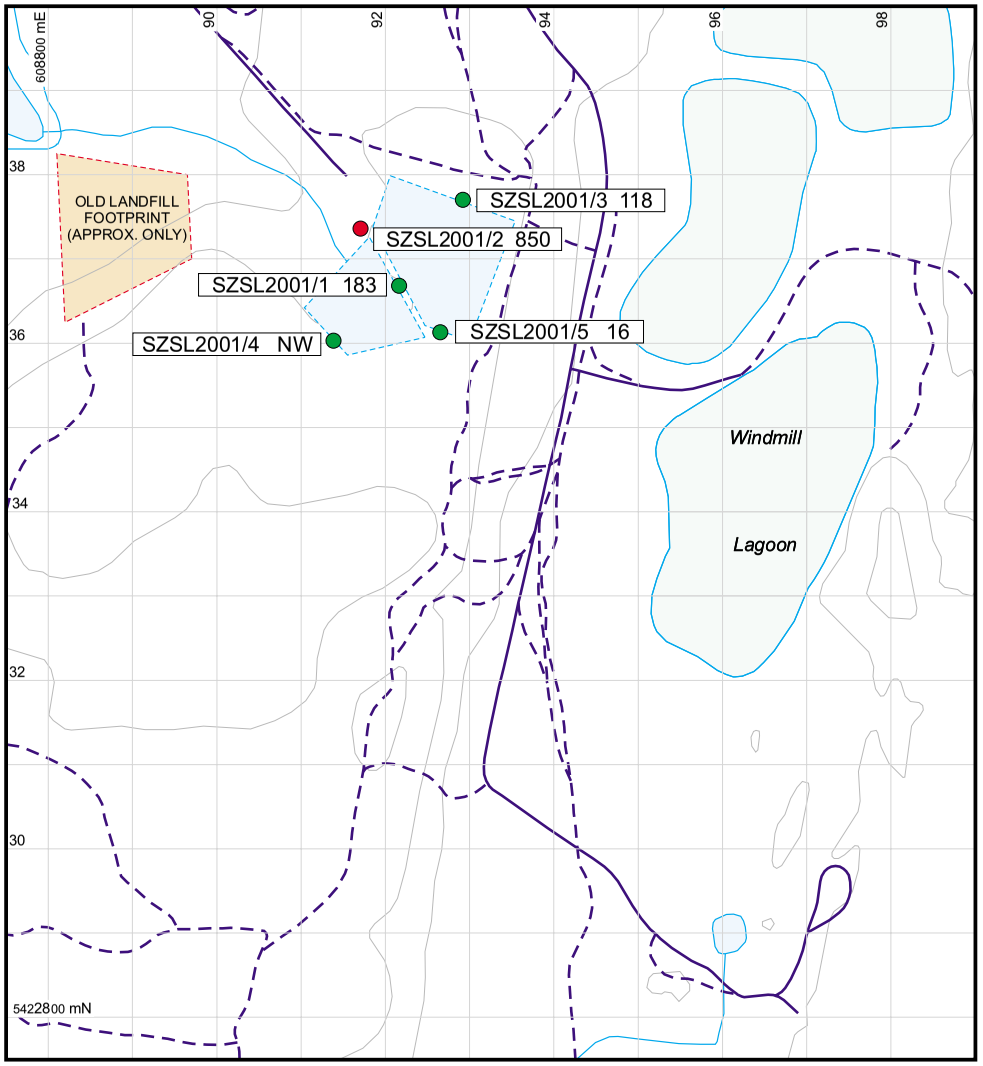
NW = no water

Stieglitz Sewage Lagoons
May 2001
Mg (mg/L)



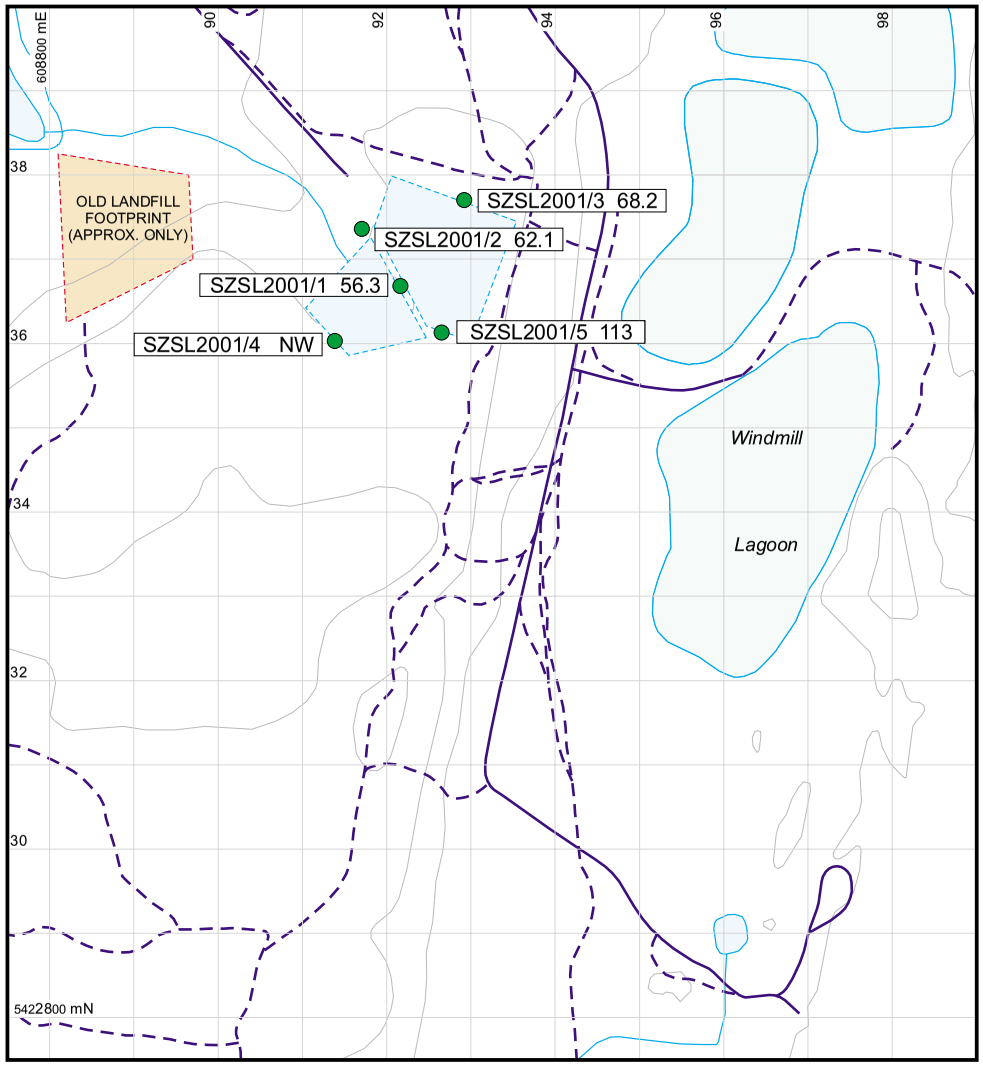
NW = no water

Stieglitz Sewage Lagoons
May 2001
Mn (μg/L)



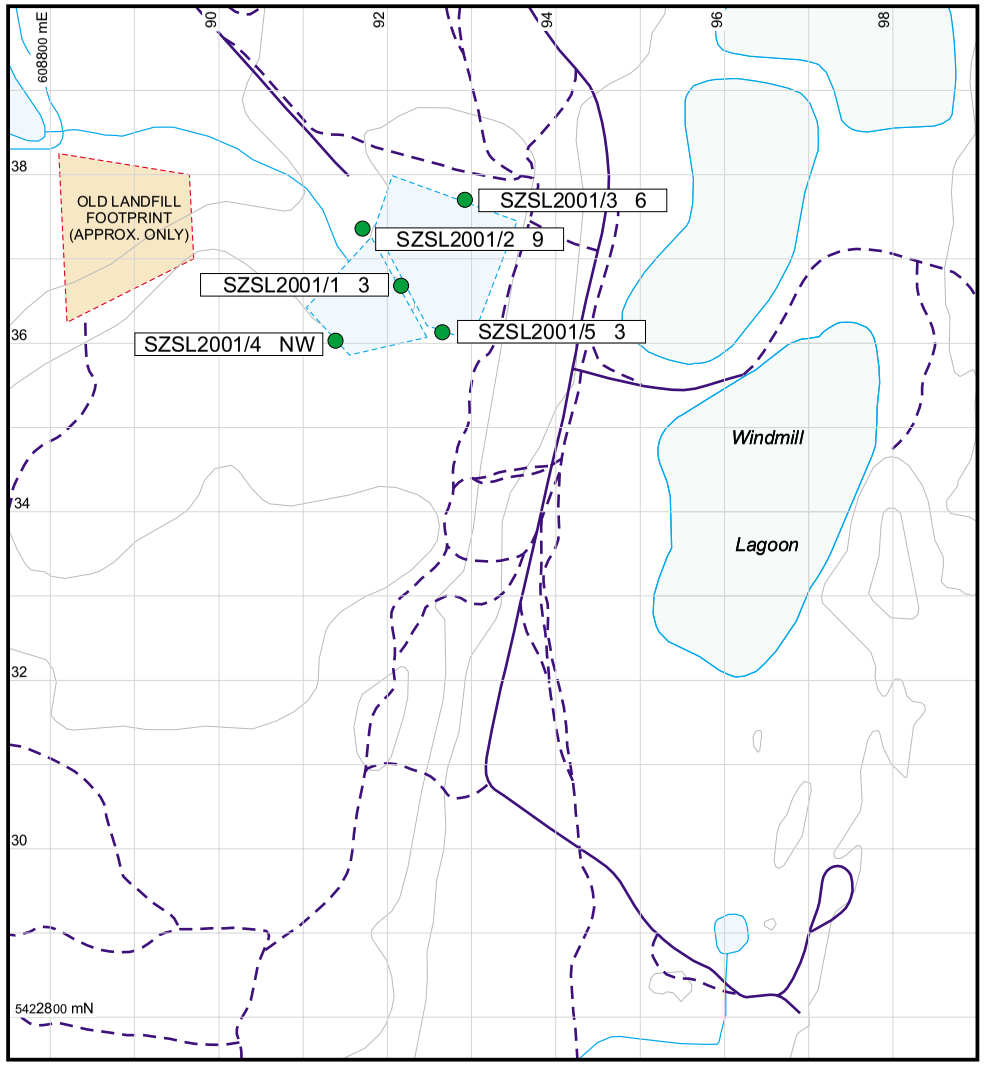
NW = no water

Stieglitz Sewage Lagoons
May 2001
Na (mg/L)



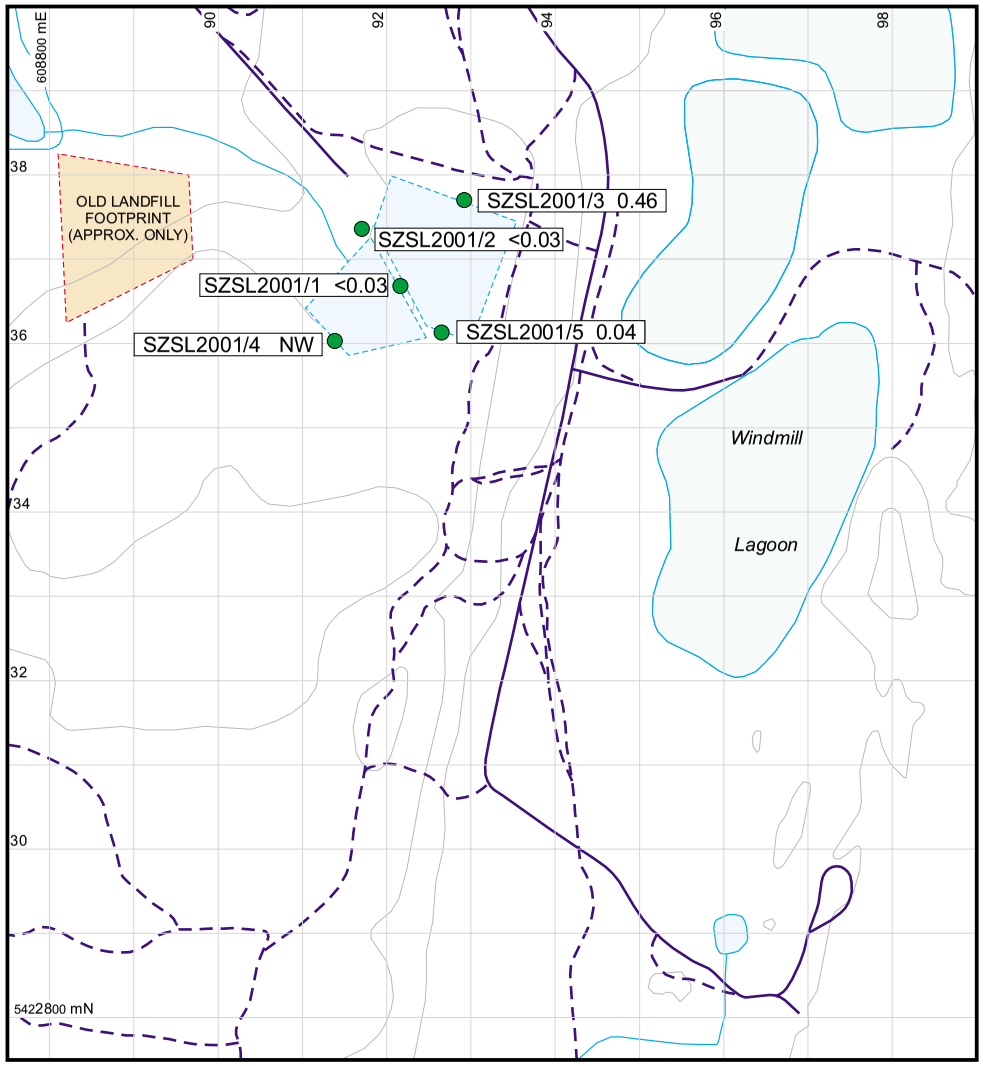
NW = no water

Stieglitz Sewage Lagoons
May 2001
Ni (μg/L)



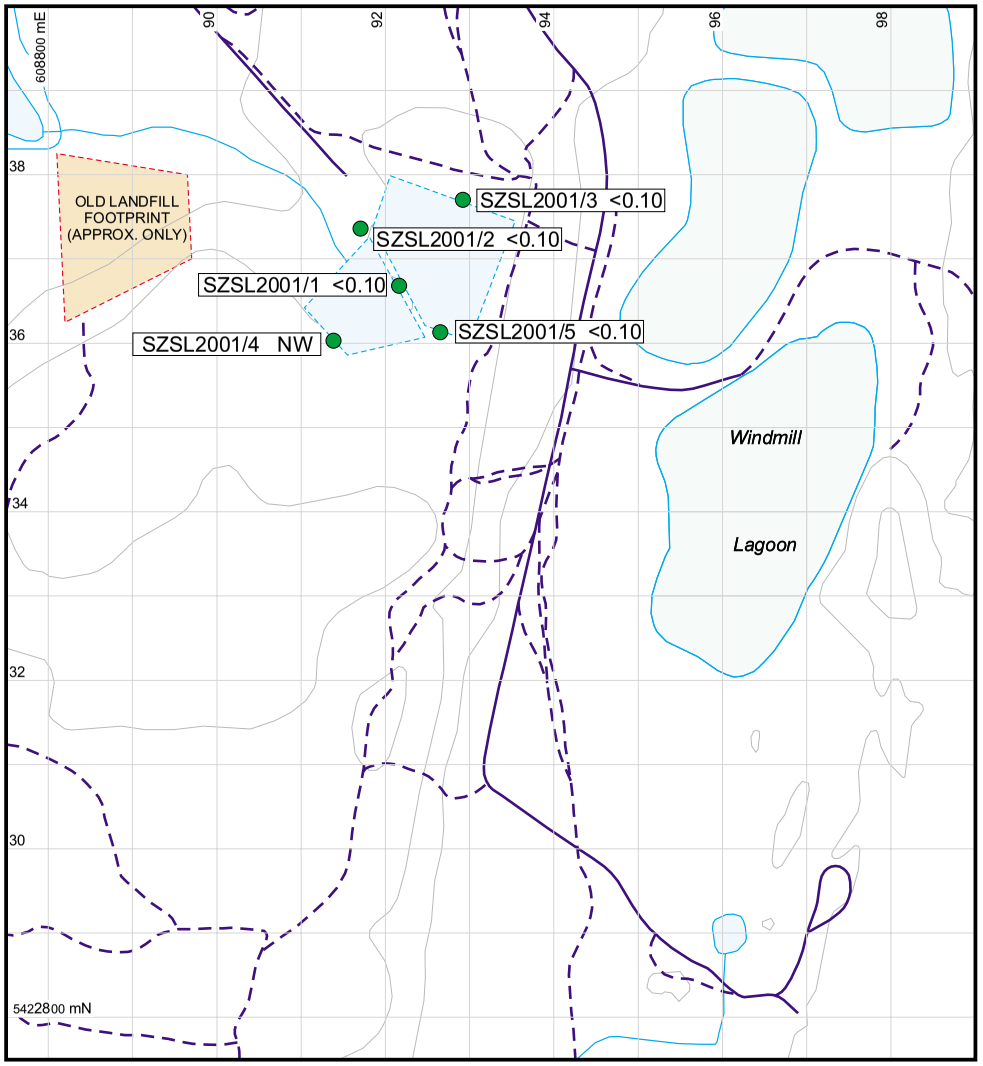
NW = no water

Stieglitz Sewage Lagoons
May 2001
Nitrate (mg-N/L)



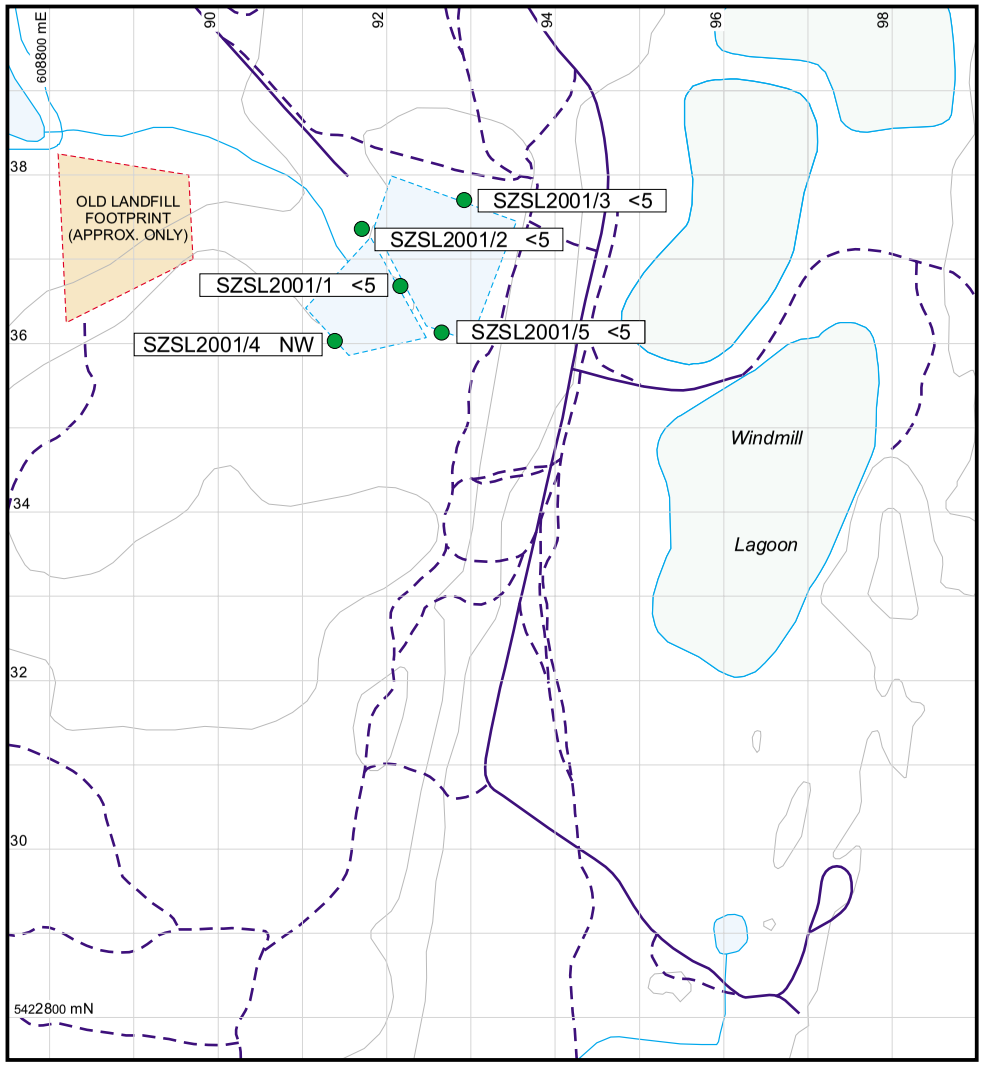
NW = no water

Stieglitz Sewage Lagoons
May 2001
Nitrite (mg-N/L)



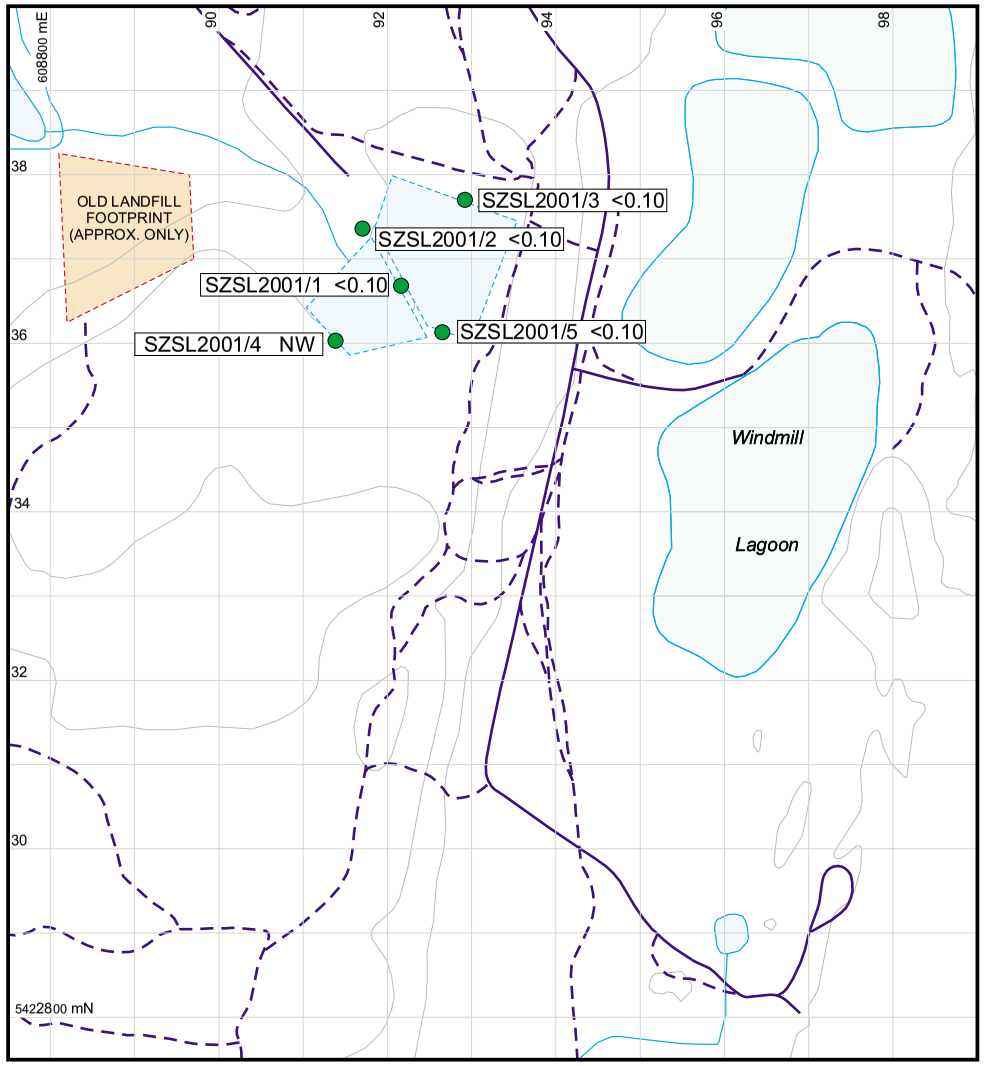
NW = no water

Stieglitz Sewage Lagoons
May 2001
Pb (µg/L)



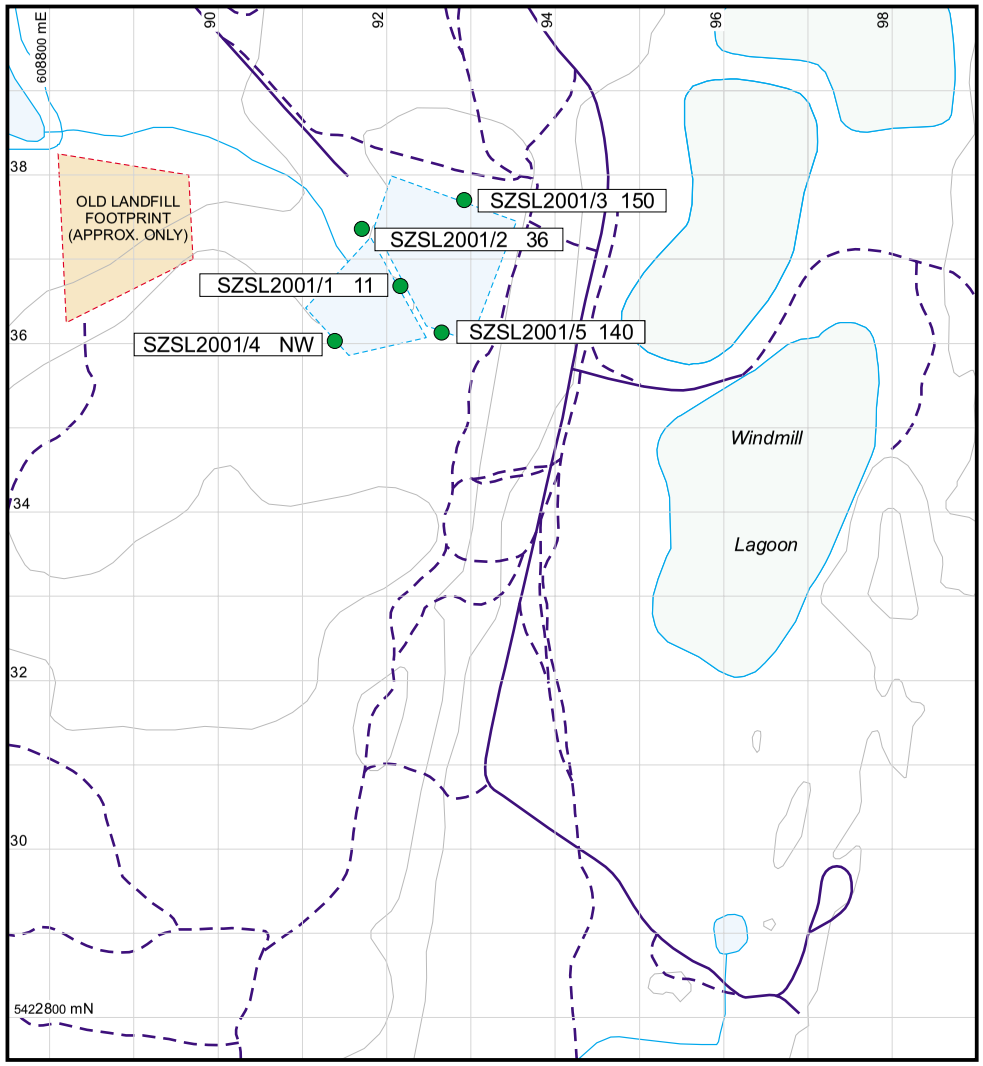
NW = no water

Stieglitz Sewage Lagoons
May 2001
Phosphate (mg-P/L)



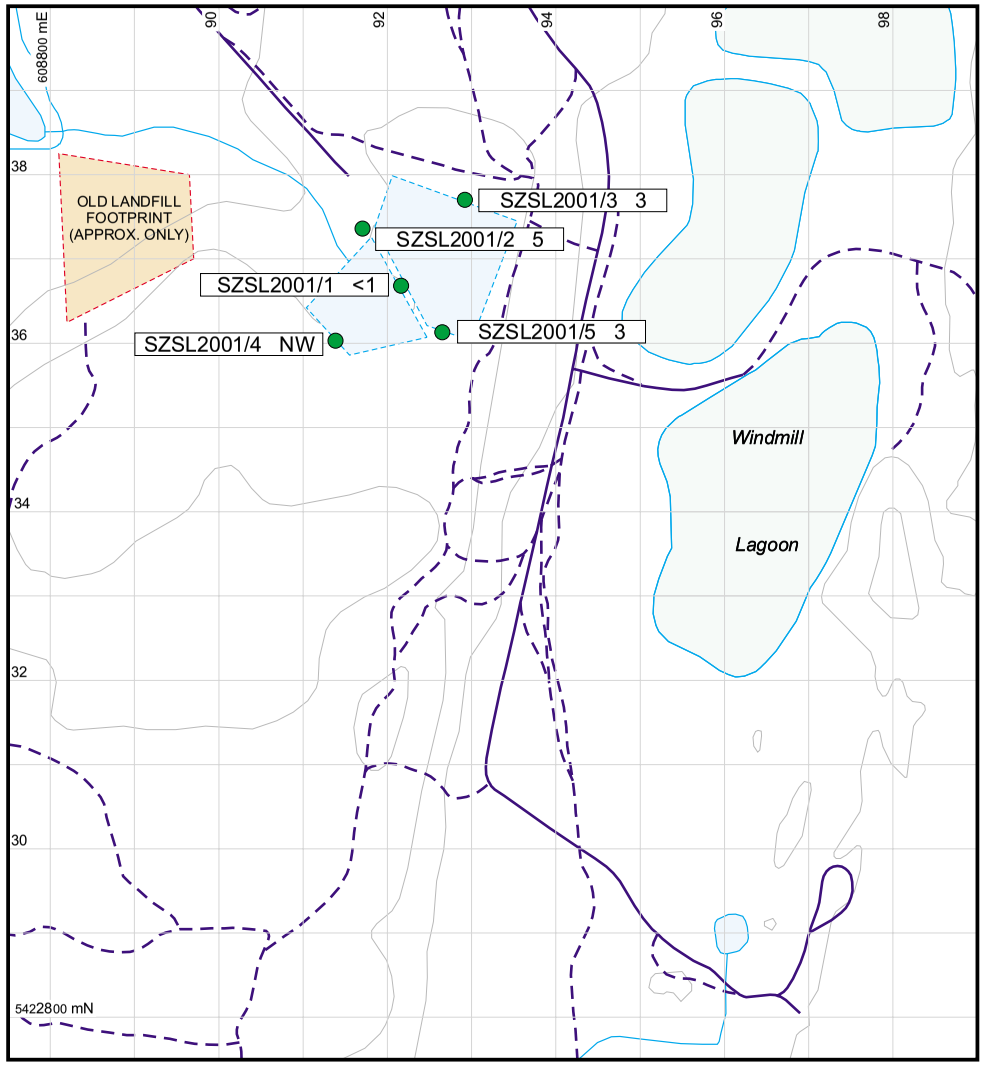
NW = no water

Stieglitz Sewage Lagoons
May 2001
Sulphate (mg/L)



NW = no water

Stieglitz Sewage Lagoons
May 2001
Zn (µg/L)



NW = no water