REF. NO.: 2004/031

DATE: 17 MARCH 2004

GEOHYDROLOGICAL RISK/IMPACT ASSESSMENT FOR CLOSURE OF THE EXISTING LANDFILL SITE – RICHMOND COMMONAGE No 5319

36 Haraldene Road
Glenwood 4001
PostNet Suite # 187
Private Bag X04
Dalbridge 4014
Tel: (031) 2058624
Fax: (031) 2054075
www.geomeasuregroup.co.za
Reg. No 2000/014164/75

GEOMEASURE GROUP

Groundwater & Environmental Consultants

2.2(2671)

CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

GEOHYDROLOGICAL RISK/IMPACT ASSESSMENT FOR CLOSURE OF THE EXISTING LANDFILL SITE – RICHMOND COMMONAGE No 5319

A. GENERAL INFORMATION

A.1 INTRODUCTION AND TERMS OF REFERENCE

The Richmond Municipality have, for decades, been using the disused borrow-pit situated to the east of the R 56 to Ixopo opposite Andersons Garage for the disposal of all waste generated in the area.

This site, which is situated on the eastern bank of the Lovu River, still offers considerable air-space, but there is a critical shortage of cover material and landowners/residents of the surrounding agricultural holdings regularly file complaints related to bad odours and smoke emanating from fires, which break out sporadically on this site.

Land-filling operations have not been well co-ordinated and, as a result, isolated bodies of waste have been placed haphazardly within the borrow-pit and some waste extends well into the floodplain of the river. The Department of Water Affairs and Forestry (DWAF) have expressed concern about the impact of this "dump-site" on the river and groundwater resources and have instructed the Municipality to close this site as soon as an alternative suitable waste disposal site can be developed.

Efforts to identify and permit a suitable replacement landfill were initiated in 1998 by Messrs Chew Bowen Marais (CBM) and this initiative culminated in identification and ranking of 4 candidate landfill sites with Candidate Site 1 situated on Richmond Commonage about 2 km southeast of the town emerging as the favoured site. The project unfortunately was curtailed due to a lack of funding for further detailed and site specific geotechnical and geohydrological investigations.

However, in the interim Messrs Ninham Shand Inc were successful in securing the necessary funds from CMIP on behalf of the Richmond Local Council and with Messrs SKC as specialist landfill consultants and the Geomeasure Group as geohydrological consultants the site specific investigations were commissioned. These investigations confirmed that Candidate Site 1 was suitable for development as a G:C:B^+ site and Messrs SKC prepared the conceptual design report and drawings and submitted a Landfill Permit Application to the Department of Water Affairs and Forestry.

In the interim, our brief was extended to include a geohydrological risk/impact assessment for closure of the existing site and this investigation was carried out in tandem with investigations on Candidate Site 1.

Our findings, conclusions and recommendations are presented below.

B. PROJECT AREA DESCRIPTION

B.1 LOCATION, TOPOGRAPHY AND DRAINAGE

The town of Richmond is situated approximately 35 km southwest of Pietermaritzburg to the west of the R 56 to Ixopo and Kokstad (see Locality Plan - Dwg No. 2004/031 Figure 1).

Richmond and the areas to the west, north, and east of this village fall within the Lovu River catchment, whilst both the Ndaleni and KwaMagoda townships and areas to the south of the town fall within the Mkomazi River catchment.

The terrain around the town of Richmond itself is moderately to gently undulating with shallow dendritic drainage features, which drains toward and discharges into the Lovu River. The surface conformation of the areas to the west and southwest of the town is more rugged, with steeper slopes and deeply incised drainage courses. The north-eastern portion of the study area, which includes Arnold's Hill, drains north-eastward toward the Mlazi River catchment and drainage patterns are generally dendritic, which suggest moderately uniform rock types or flat-lying sediments (see Area Plan - Dwg No. 2004/031 Figure 2).

Elevations in the area range from about 900 m AMSL (above mean sea level) on the ridge tops to about 450 m AMSL in some river valleys. However, in the area immediately around Richmond, the relief is not so severe with elevation changes of less than 50 m.

The existing landfill site is situated in a disused borrow-pit east of the R 56 and opposite the Andersons's Garage. The district road to the farms Tendele and Ma Chaumiere form the northern and eastern boundary of the site, the southern boundary is defined by the edge of a Mondi Forest Eucalyptus plantation, whilst the Lovu River constitutes the western boundary (see Remote Sensing & Hydrocensus Dwg No. 2004/031 Figure 4).

B.2 CLIMATE

The rainfall and evaporation data for the Richmond area was obtained from the Agricultural College at Cedara, which obtains meteorological data from the farm Little Harmony, situated approximately 10 km to the southeast of the town of Richmond.

We consider this data to be moderately representative of the climatic conditions of the Richmond area and relevant data is shown in Table 1 below.

Table 1: Basic Climatic Data

Mean Annual Precipitation (MAP)	900 mm/annum
A-Pan Evaporation	1230 mm/annum
Ave. Rainfall Deficit	330 mm/annum
Temperature Range	10° C to 26° C
Summer Maximum	> 30° C
Winter Minimum	< 5° C

The closest weather station with wind recording instruments is situated at Pietermaritzburg, and although this station is situated approximately 35 km northeast of Richmond, the data shown in Diagram 1 is considered representative of the area.

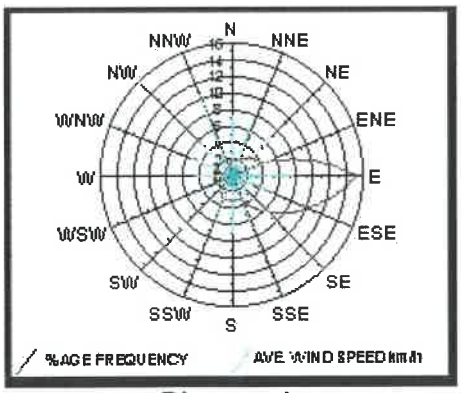


Diagram 1:
Wind Frequency and Direction

The above diagram shows the prevailing winds are easterlies, which diminish in frequency in May to July when south-westerly winds associated with cold fronts moving in from the Southern Ocean reach up into the KwaZulu-Natal interior and coastal areas.

Seasonal variation of the above data is shown in Table 2.

Table 2: Seasonal Wind Data

Season	Calm	East	East South East	South East
Summer (October - March)	32.1 %	19.2 %	12.4 %	7.0 %
Winter (April - September)	48.2 %	11.0 %	6.3 %	4.3 %

Wind occurs 60 % of the time, whilst the remaining 40 % constitutes wind still days. The average wind speed is 3.5 m/s or 12.6 km/h.

B.3 VEGETATION

In terms of bioclimatic zones, the Richmond area falls within the transition of Zones 2 and 3 of the bioclimatic classifications, which comprise Coastal Hinterland and Mist Belt vegetation types respectively.

Natural vegetation in these regions include sour Ngongoni grassveld and scattered thornveld (Acocks Veld Types -1988), most of which have been replaced by forestation and cultivation. Isolated patches of indigenous woodland can however still be found on elevated steep south-facing slopes in the region.

B.4 GEOLOGY AND SOILS

B.4.1 Stratigraphy and Tectonics

The geology of the area is shown on the Geological Plan - Dwg No. 2004/031 Figure 3.

This map shows that the project area is underlain predominantly by shale of the Pietermaritzburg Formation of the Ecca Series in the Karoo Sequence. These stratified shale horizons, particularly in the areas to the south and west of Richmond, have been intruded by Jurassic age dolerite sills.

To the east, displacement faulting has juxtaposed the diamictite/tillite bedrock of the Dwyka Formation against the Pietermaritzburg shale, whereas to the west, Vryheid Formation sediments are followed by Volksrust Formation bedrock in the elevated topography.

The sedimentary rocks of the Ecca Group (Pietermaritzburg, Vryheid and Volksrust Formations) are generally sub-horizontally bedded and no faults occur in the immediate vicinity of Richmond. However, a minor east/west trending fault is shown on the 1 : 250 000 Durban Geological Sheet approximately 7 km to the north of the town.

The contact between the Pietermaritzburg Formation and the Dwyka Formation is shown as faulted and comprise a series of north/east trending faults.

B.4.1.1 Soils

The soils in the study area are generally derived from the in-situ weathering of the underlying geology. Due to the extensive areas underlain by shale, most of the soils are clayey in nature and form yellow to yellow-brown hydromorphic soils, which are characterised by seasonal perched water tables giving rise to colour mottling in the soil profile.

B.4.1.1.1 Shale

Soil profile depths on well-drained steep areas underlain by shale usually range between 0.5 – 1 m and represent the Mispah Form.

The shale bedrock on plateau areas is often weathered to depths > 10 m and the yellow apedal residual soil profiles represent the Avalon Form.

On lower slopes and valley bottom areas profiles are usually deeper (2 – 3 m) and darker due to the prevailing anaerobic conditions (high, permanent water tables). In well-drained conditions the Bonheim and Valsrivier Forms predominate, but in poorly drained areas mottled soils of the Katspruit and Rensburg Forms occur.

B.4.1.1.2 Dolerite

This basic intrusive rock is generally deeply weathered in this region and produces the red apedal soils of the Hutton Form. These soils are generally well-drained and often extend to depths of > 2 m. These deep and often leached profiles do however often contain hard corestones remnant of spheroidal weathering.

B.4.1.2 Agricultural Potential

The areas to the east and southeast of Richmond are used extensively for cultivation of citrus, vegetable and other cash crop farming, whilst the areas to the south, west and north are mainly used for the production of timber.

In terms of the agricultural potential of the soils, the area has been classified as having a very high agricultural potential (Edwards and Scotney (1978)).

B.5 GEOHYDROLOGY AND GROUNDWATER QUALITY

"The Characterisation and Mapping of the Groundwater Resources of KwaZulu-Natal Province – Units 4 & 8", prepared for DWAF by Messrs Davies Lynn and Partners, depict the areas underlain by Pietermaritzburg Formation sediments in proximity of Richmond, Ndaleni and KwaMagoda as areas of very good groundwater development potential and median yields are reported to be > 3 l/s.

It is considered that the yield potential of these sediments increases further when the host rock has been intruded and disturbed by dolerite bodies, particularly dolerite dykes. However, the Karoo dolerite intrusions themselves are considered poor aquifers due to the relatively massive nature and "tight" joints of these "young" intrusive structures.

The prime groundwater development targets in this region are the indurated sedimentary contact zones adjacent to dolerite dykes and/or faults and, to a lesser extent, the contact zones of dolerite sills.

Groundwater recharge in this region is considered to be approximately 3 % of the Mean Annual Precipitation (MAP).

Water quality in the region is generally good to moderate and average Electrical Conductivity (EC) values range between 30 and 70 mS/m. Considerable localised variations do however occur in this region and high concentrations of Iron and Manganese, which pose no significant health risk to consumers, often impact negatively on the aesthetic appeal of groundwater sources.

The regional static water levels and depth of water strikes in the boreholes of the region vary considerably in sympathy with surface topography but mean values range between 25 and 50 m b.g.l. (below ground level). However, the rest water level in many boreholes often rises to between 3 and 10 m b.g.l. and in some cases to less than 1 m b.g.l. due to phreatic pressures within the aquifer.

B.6 WATER RESOURCES

B.6.1 Surface Water

The Lovu River and its tributaries represent the main natural surface water sources in the area.

The Beaulieu Dam, which is situated approximately 3 km northwest of Richmond in the Lovu River, has a storage capacity of approximately 24 million m^3 and is owned jointly by the Municipality and riparian owners. This dam supplies the bulk of the water demand of the village and the balance is used extensively for irrigation of cash crops and pastures on farms east of the town.

There are also a number of smaller dams on privately owned farms in the district, which are mainly used for irrigation and stock watering. The distribution of some of the more significant structures is shown on the Area Plan – Dwg No. 2004/031 Figure 2.

The Lovu River flows from south to north along the western boundary of this site and a spring emerges in the eastern face of the borrow-pit. This water is captured and piped under the landfill body to discharge into the river.

B.6.2 Groundwater

Surface water supplies to Richmond are augmented from production boreholes located in the northern and south-western portions of the town-lands. The townships of Ndaleni and KwaMagoda, as well as private landowners in the region, are almost totally reliant on production boreholes for their domestic water and irrigation requirements.

The existing borehole data for the region was obtained from the DWAF National Groundwater Database, Messrs Steffen, Robertson and Kirsten (SRK) and our own in-house database. The distribution of these boreholes is shown on Dwg No. 2004/031 Figure 2, whilst the available incomplete and unverified borehole data is contained in Appendix A.

This resource is clearly used extensively and we accept that there are probably at least 50% more boreholes than shown on the abovementioned figure.

B.6.3 Current Domestic Water Demand

The current domestic water demand from residents and commerce in Richmond is in excess of 1 000 kl/day and the bulk of this supply is obtained from the Beaulieu Dam. Production boreholes north of the village are used to augment this supply during periods of below average rainfall.

Residents of Ndaleni and KwaMagoda and most of the private landowners in the region are totally reliant on groundwater from boreholes and springs in the study area, but the bulk water demand for these areas is not known.

C. FIELD INVESTIGATION

C.1 DESK STUDY & REMOTE SENSING

A detailed desk study and remote sensing exercise of the entire Richmond Municipal area was carried out as part of the investigation for a new landfill site and the relevant geological lineaments identified on or in close proximity to the existing site are shown on Dwg No. 2004/031 Figure 4.

C.2 HYDROCENSUS

The bulk of the borehole data for the region was sourced from the DWAF National Groundwater Database (see Dwg No. 2004/031 Figure 3) but privately owned boreholes located on the farms immediately surrounding the existing site are shown on Dwg No. 2004/031 Figure 4.

The landowners of the smallholdings east of the site have no records of the two boreholes which supply their domestic and agricultural water demand. The limited data obtained for RM 4 on Tendele is shown in Table 3.

Table 3: Borehole Data

BH No	Location	Depth	Water Level	Yield	Use
RM 4	Tendele Farm	90m	45m	2 000 l/hr	Domestic & Agricultural

C.3 GEOPHYSICAL INVESTIGATION & DRILLING

Two magnetic and VLF electro-magnetic geophysical traverses were run within the disused borrow pit and the graphically plotted data is contained in Appendix B.

A single monitoring borehole RM 3 was sited on the basis of these results and Messrs KwaNatal Drilling drilled this borehole under supervision and direction of our Field Geohydrologist in the period 29 – 30 June 2003. The geological and construction log is included in Appendix C, whilst basic details of the borehole are summarized in Table 4.

Table 4: Summarised Exploration Borehole Drilling Data

BH No	Depth m b.g.l.	Casing m b.g.l.	Water Strike m b.g.l.	Water Level m b.g.l.	Airlift Yield	
					l/s	l/hr
RM 3	60	22	18	6.73	1.39	5 000

C.4 DOWN THE HOLE TESTS

C.4.1 Falling Head Permeability Tests

Falling head permeability tests were carried out during drilling of this borehole prior to the installation of casing in order to derive a representative k-value for the weathered shale in the vadose zone below this site.

The results of this test are shown in Table 5.

Table 5: Falling Head Permeability Tests

BH No	Depth Range m b.g.l.	k-value	
		cm/s	m/day
RM 3	12 - 20	3.8×10^{-5}	3.2×10^{-2}

C.4.2 Pump Tests

A variable discharge test was carried out on BH RM 3 to determine the hydraulic characteristics of the aquifer and sustainable yield of the borehole. The graphically plotted results of this test are included in Appendix C with the borehole log. The transmissivity and theoretical sustainable yield of this borehole is shown in Table 6.

Table 6: Summarised Pumptest Data – Borehole RM3

Pump Inlet (m b.g.l.)	Test Duration (hrs)	Volume Pumped (kl)	Total Drawdown (m b.g.l.)	% Recovery @ 8 hrs
56	8	29.66	11.13	95

C.4.3 Water Quality

Water samples were collected from BH RM 3 to determine the groundwater quality below this site. BH RM 4 on Tendele Farm was sampled to provide "background" groundwater quality data.

Surface water samples were collected from the Lovu River both up and down-stream of this site.

These samples were submitted to Umgeni Water Analytical Services for Abr SABS 241:1999 analysis and Certificates of Analysis as well as tabulated results of these analyses are shown in Appendix D.

The Kempster - "Fitness for Use" - Classification based on the results of these analyses is shown in Table 7.

Table 7: Water Quality Classification

BH No	Kempster Classification	Comments
BH RM 3	Class III	Generally Class 0 – except for high concentrations of Fe, moderate Mn & high Faecal Coliforms
BH RM 4	Class II	Generally Class 0 – except for moderate Fe No Faecal Coliforms
Lovu U/S	Class III	Generally Class 0 – except for elevated Fe very high Faecal Coliforms
Lovu D/S	Class III	Generally Class 0 – except for elevated Fe and very high Faecal Coliforms

The above results would suggest that bacteriological contamination in BH RM 3 and Lovu River D/S sample can be attributed to negative impact from the landfill operation

D. GEOTECHNICAL INVESTIGATION

Messrs Moore Spence Jones (Pty) Ltd carried out a geotechnical investigation on the proposed new landfill site and a number of materials, which could be used as capping material for closure of the existing site, were sampled.

The results of these materials analysis are summarised in Table 8.

Table 8: Summarised Physical Materials Parameters

Material	**Colluvial Soils** Grey brown silty CLAY (2 No. samples)	**Residual Clay** Reddish orange silty CLAY (3 No. samples)	**W5 Shale** Dk yellow clayey SHALE (1 No. sample)	**W3 Shale** Lt grey SHALE (1 No. sample)
Range of Results				
Rev. US Classification	A-7-5	A-7-5	A-7-5	A-2-7
Liquid Limit	43 - 52	44 - 62	62	50
Plasticity Index	13 - 15	12 - 23	23	13
Linear Shrinkage	6.0 - 7.5	6 - 12	11.5	6.5
% Clay	71 - 80	78 - 87	87	24
% Sand	17 - 22	10 - 18	11	8
% Gravel	3 - 7	2 - 4	2	68
Grading Modulus	0.36 - 0.55	0.25 - 0.39	0.26	2.2
*D10	0.0004	0.0003	0.0003	0.008
Derived k-value ($D10^2$) cm/s	1.6×10^{-7}	9×10^{-8}	9×10^{-8}	6.4×10^{-5}
Derived k-value ($D10^2$) m/day	1.4×10^{-4}	7.8×10^{-5}	7.8×10^{-5}	6×10^{-2}
Recomp. Permeability cm/s	4×10^{-6}	$*3 \times 10^{-8}$	-	-
Recomp. Permeability m/day	3×10^{-4}	$*3 \times 10^{-5}$	-	-

* - Empirical Values

Perusal of the above results clearly shows that the colluvium, residual and completely weathered shale exhibit very similar characteristics and that clay contents are consistently > 70%.

E. GEOHYDROLOGICAL RISK ASSESSMENT

Section 12 of the DWAF "Minimum Requirements for Waste Disposal by Landfill" contains generic guidelines for waste disposal site closure and the primary objectives stated include:

- To ensure public acceptability of the proposed End-use Plan
- To rehabilitate the landfill so as to ensure that the site is environmentally and publicly acceptable and suitable to the proposed End-use.

In order to determine if the site is suitable for the proposed End-use it is necessary to assess the potential or actual risk/impact associated with this landfill site and to define Risk Based Corrective Action (RBCA) site rehabilitation measures to reduce negative impact on surface and groundwater resources to acceptable levels.

The RBCA principle requires that all three of the elements outlined below exist simultaneously to constitute risk and/or impact and we have used this method for this assessment:

- Contaminant
- Pathways
- Receptors

E.1 CONTAMINANTS

The Richmond area falls within a surplus water balance region as illustrated in Table 9.

Table 9: Climatic Water Balance – 10 Wettest years from 1937 - 1998

Year	Rainfall	Evaporation	Converted Evaporation	Balance
1943	1292.2	1229.8	860.86	431.34
1987	1270.2	1229.8	860.86	409.34
1996	1233.8	697.6	488.32	745.48
1978	1179.7	1229.8	860.86	318.84
1976	1162.6	1229.8	860.86	301.74
1967	1139.7	1229.8	860.86	278.84
1995	1139.7	887.3	621.11	518.59
1974	1111	1229.8	860.86	250.14
1942	1105.1	1229.8	860.86	244.24
1997	1090.5	775.5	542.85	547.65

All waste disposal sites generate leachate and it is therefore reasonable to assume that this site generates significant quantities of leachate which is not controlled or managed. This leachate could contain a range of chemical and other organic elements which could have a significant negative impact on humans unless it can be effectively captured, contained and managed.

The main activities in the Richmond area are agriculture and forestry and although there are no major industries which produce hazardous waste in the region, it is reasonable to assume that the leachate generated within this waste body may contain expired pesticides, herbicides, hydrocarbon waste products etc.

The waste body also contains a high percentage of garden waste, sawdust and other organic materials and due to the general lack of cover material spontaneous combustion often result in fires within the waste body. These fires are very difficult to extinguish and the smoke and odour from these fires are a constant source of complaints from the residents living in close proximity to the site.

The possibility also exists that materials which would classify as hazardous materials could have been "dumped" on these sites without the knowledge of the Site Operator due to inadequate access control.

Leachate generated on General landfill sites which only accept domestic and commercial waste usually contain ammonia and elevated levels of dissolved salts, but in the case of this site we have assumed that the leachate could also contain organo-phosphates.

E.2 PATHWAYS

This site occupies a borrow-pit and all soil-cover and soft weathered shale was removed during the lifespan of the borrow-pit to expose the hard closely fractured shale bedrock within the floor of the borrow-pit.

The narrow joints, fractures and closely spaced bedding planes in this sedimentary formation thus offer the only pathways along which any contaminants generated on this site can migrate both vertically and laterally through the vadose zone to contaminate the groundwater and/or the river.

E.3 RECEPTORS

Groundwater is used extensively for both domestic and agricultural use in this region and as a result residents of the area, their livestock and the aquatic environment as well as down-stream users of the Lovu River represent the receptors in this instance.

E.4 TIER 2 - RBCA ASSESSMENT

A conceptual geohydrological model was developed for this site (see Dwg No. 2004/029 Figure 5) and by inputting site specific physical and hydraulic characterises of the shale bedrock and other relevant data the Tier 2 RBCA assessment returned a ***minor*** risk through the groundwater resource to human receptors on and hydraulically down-gradient of this site.

F. CONCLUSIONS

- This geohydrological risk/impact assessment has revealed that this site poses a minor risk to groundwater users in close proximity to the site and down-stream users and the aquatic life in the Lovu River.

- It is therefore necessary to incorporate measures aimed at reducing leachate generation and off-site migration into the Lovu River and groundwater in the site-closure design.

G. RECOMMENDATIONS

G.1 REHABILITATION OF THE RIVER FLOODPLAIN

- All waste within the 1:50 year flood-line of the river must be uplifted and disposed of within the main waste body of this landfill site and these areas should be re-vegetated to prevent erosion of the alluvial materials.

G.2 STORMWATER CONTROL AND CAPPING

- It is vital to ensure that all runoff generated up-gradient of the site is diverted around the waste bodies within the borrow-pit. Specific attention must be given to management of runoff from the steep faces of the borrow-pit and areas up-gradient and "behind" the waste body to ensure that this water is not introduced into the waste body along the floor of the borrow-pit (see Dwg No. 2004/029 Figure 6).

- The source of the spring on the eastern portion of the site must be located and all waste must be removed from the immediate area of this source. The existing capture system must be inspected and this system, as well as the pipeline discharging into the Lovu River, must be upgraded to ensure that all water from this source is captured and discharged without risk of contamination.

- This system should be designed with adequate capacity to drain any runoff trapped behind the various waste bodies along the eastern and southern flanks of the borrow-pit.

- All exposed waste bodies must be shaped to ensure good drainage and these areas must be capped with suitable clayey material in accordance with the Capping Design specifications for a G:S:B^+ landfill as detailed in Fig A.8.11 of Appendix 8.2 of the Minimum Requirements, to prevent ingress of precipitation and reduce the incidence of spontaneous combustion.

G.3 LEACHATE COLLECTION

- All leachate or contaminated storm water runoff generated within the borrow-pit must be collected and discharged into a lined leachate sump.

- The leachate storage facility must provide adequate storage to cope with increased flow of leachate and contaminated storm water during periods of intense or extended rainfall and leachate levels in this facility must be closely monitored to prevent any spillage into the river. Once this facility reaches the 50% capacity level leachate must be transported and disposed of at a suitable waste water treatment facility.

G.4 METHANE MANAGEMENT

- Adequate and appropriate gas venting systems must be installed in the capping material to allow methane generated in the capped waste bodies to vent to atmosphere.

- However, end-use must be considered in the selection of design criteria for these systems.

G.5 MONITORING NETWORK

The proposed surface and groundwater monitoring points are shown on Dwg No. 2004/031 Figure 5.

G.5.1 Surface Water

- Surface and groundwater quality monitoring, both up and down-gradient of this site, is necessary to verify that leachate management systems are adequate and functional, especially in the 1st year after closure. However once sufficient water chemistry data has been gathered to characterise a baseline for up-stream water quality this monitoring point can be omitted from the routine monitoring programme.

- The quality of the water from the spring should also be monitored and water samples should be collected from the outlet of the discharge pipe.

G.5.2 Groundwater

- BH RM3 must be upgraded to monitoring well status in accordance with the well specification shown on Dwg No. 2004/031 Figure 6.

- This borehole will provide representative groundwater chemistry data below and hydraulically down-gradient of the site and BH RM 4 should be included in this monitoring network to provide background chemistry data against which to compare the results from BH RM 3.

G.6 MONITORING PROGRAMME

- All surface and groundwater monitoring points must be sampled on a quarterly basis. Field measurements of pH, EC, flow rates of springs and streams and static water levels in boreholes should also be recorded on each such occasion.

- Samples collected from the surface monitoring points must be submitted to an accredited analytical laboratory for the following analyses:

  pH Value
  Conductivity (EC)
  Cations (Na, K, Ca, Mg)
  Anions (Cl, SO_4, HCO_3, PO_4)
  COD (Chemical Oxygen Demand)

- Samples collected from the groundwater monitoring points must be submitted to an accredited analytical laboratory for the following analyses:

  pH Value
  Conductivity (EC)
  Cations (Na, K, Ca, Mg)
  Anions (Cl, SO_4, HCO_3, PO_3)
  COD (Chemical Oxygen Demand)

- The monitoring programme must be reviewed bi-annually and any negative impacts on surface and groundwater resources within the immediate vicinity or hydraulically down-gradient of the closed landfill site must be reported to DWAF and the Geohydrologist.

Prepared by: Theo van Niekerk

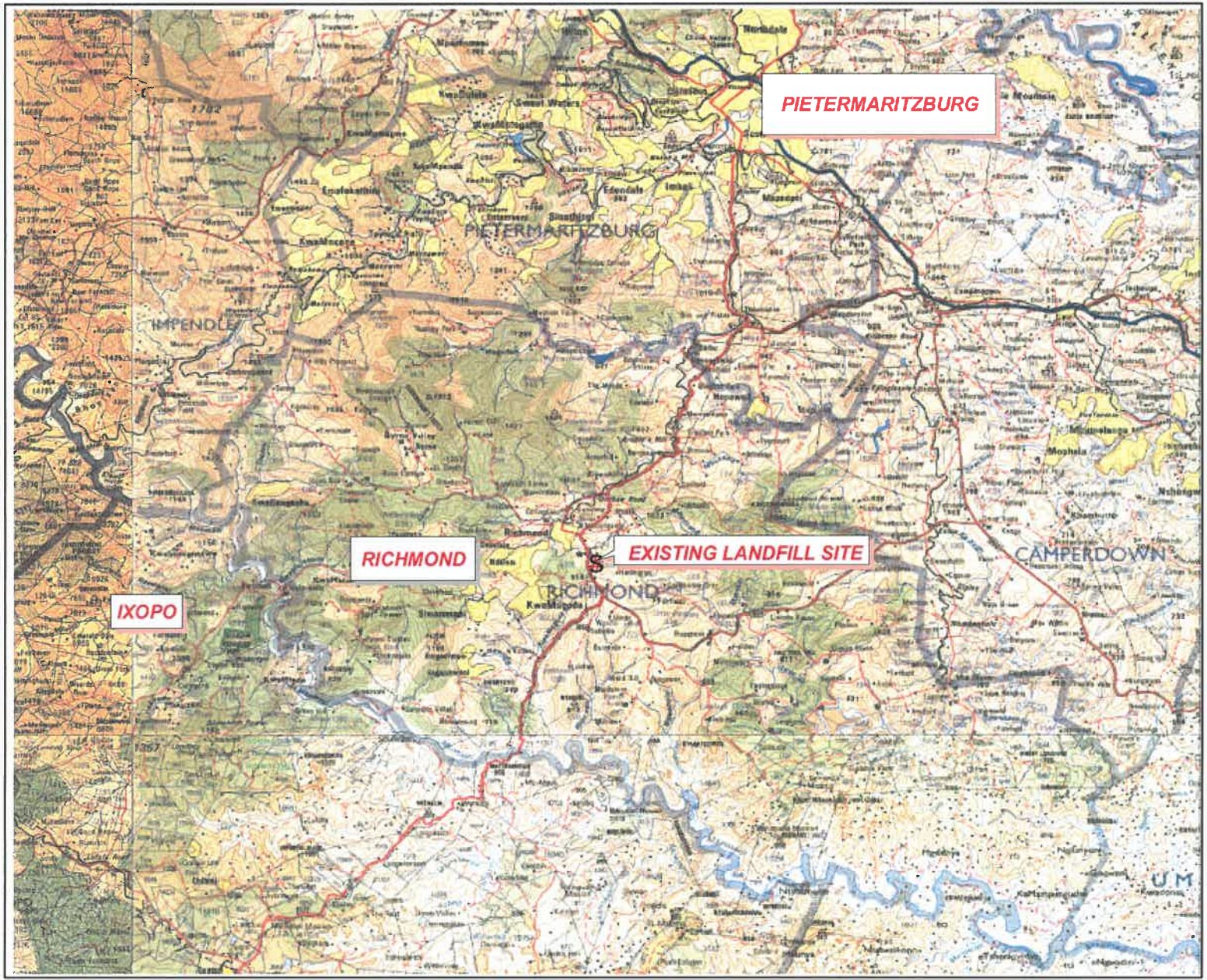
Geomeasure Group (Pty) Ltd
36 Haraldene Road
GLENWOOD
4001

SIGNATURE:

DATE : 17 MARCH 2004

FIGURES

GEOMEASURE GROUP
Groundwater & Environmental Consultants



LEGEND

N

GEOMEASURE GROUP

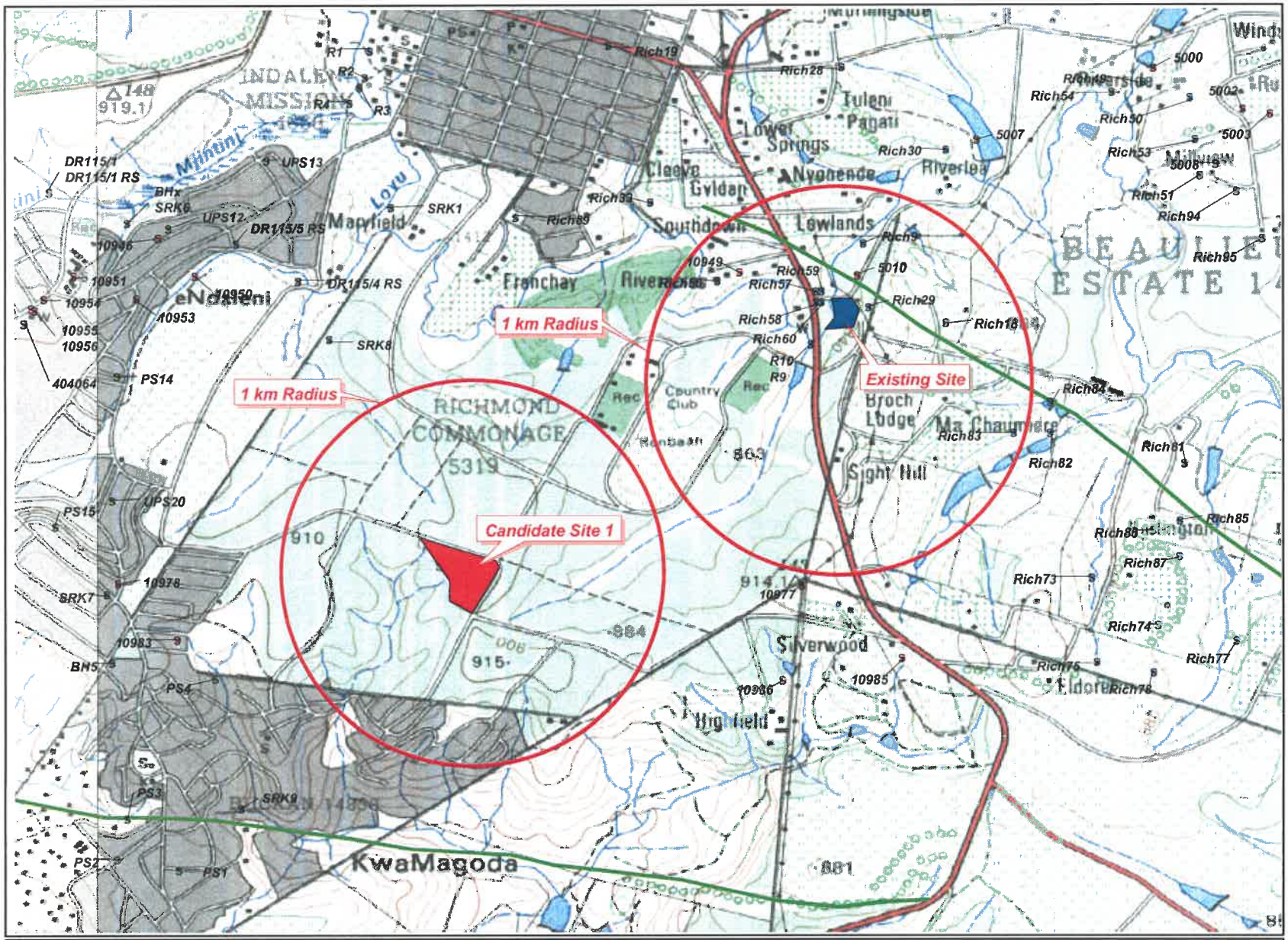
RICHMOND LANDFILL EXISTING SITE CLOSURE

LOCALITY PLAN

10 0 10 20 30 40 50 60 Kilometers

1 : 250 000 Digital Coverage from Chief Director: Surveys and Mapping

DWG NO. 2004/031
FIGURE 1



1 : 50 000 Digital Coverage from Chief Director: Surveys and Mapping

LEGEND

N

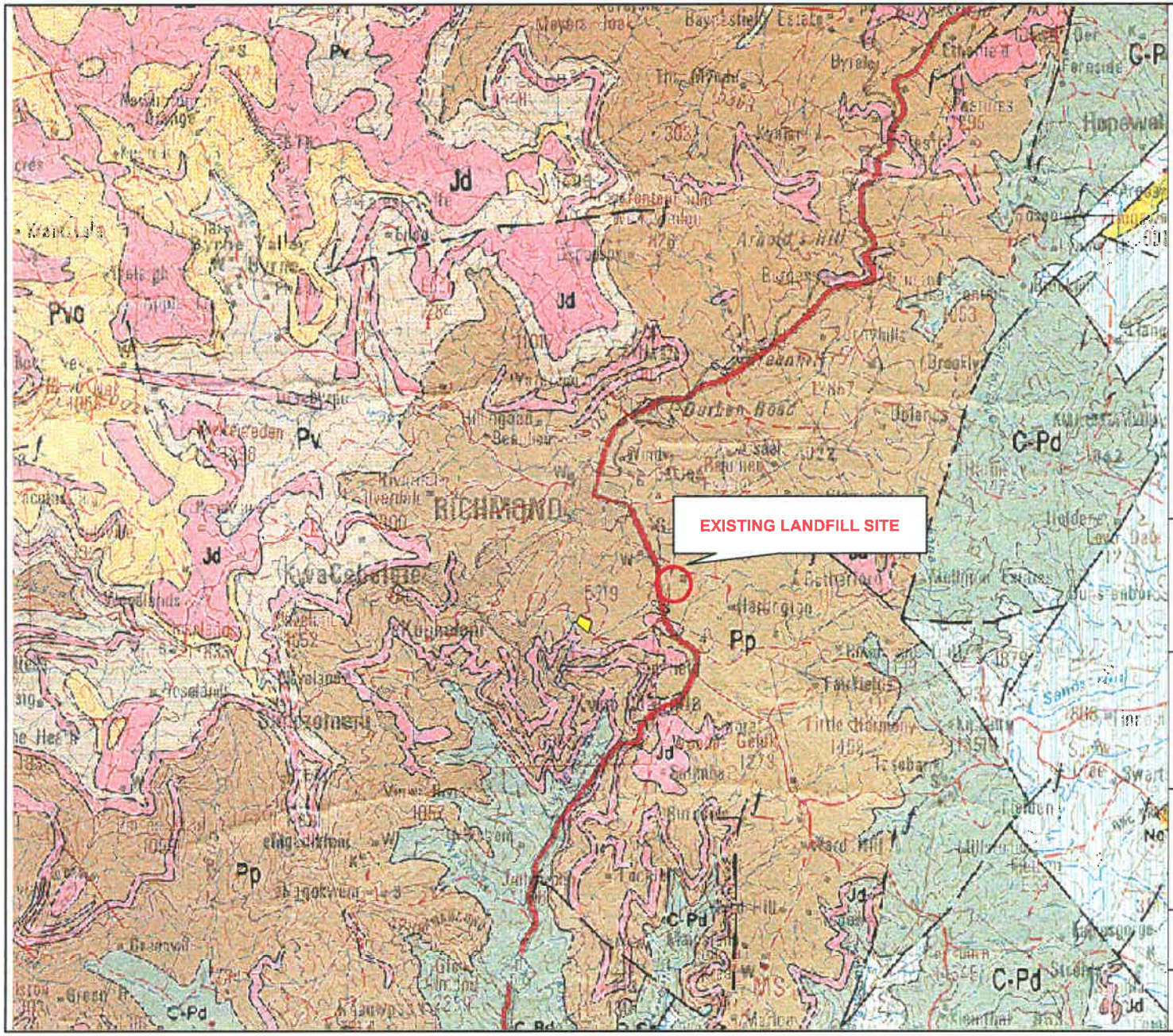
- Geomeasure data.dbf
- NGDB Data
- Springs.shp
- Lineaments.shp
- Geological faults.shp
- Dolerite dykes.shp

GEOMEASURE GROUP

RICHMOND LANDFILL EXISTING SITE CLOSURE

SITE PLAN SHOWING STRUCTURES AND HYDROCENSUS

DWG NO. 2004/031
FIGURE 2



LEGEND :

- Approximate position of Candidate Site
- Jurassic Dolerite
- Volksrust Formation
- Vryheid Formation
- Pietermaritzburg Formation
- Dwyka Formation
- Natal Group

GEOMEASURE GROUP
Groundwater & Environmental Consultants
36 Haraldene Road, GLENWOOD 4001
Tel: 031 205 8624 Fax: 031 205 4075

PROJECT:

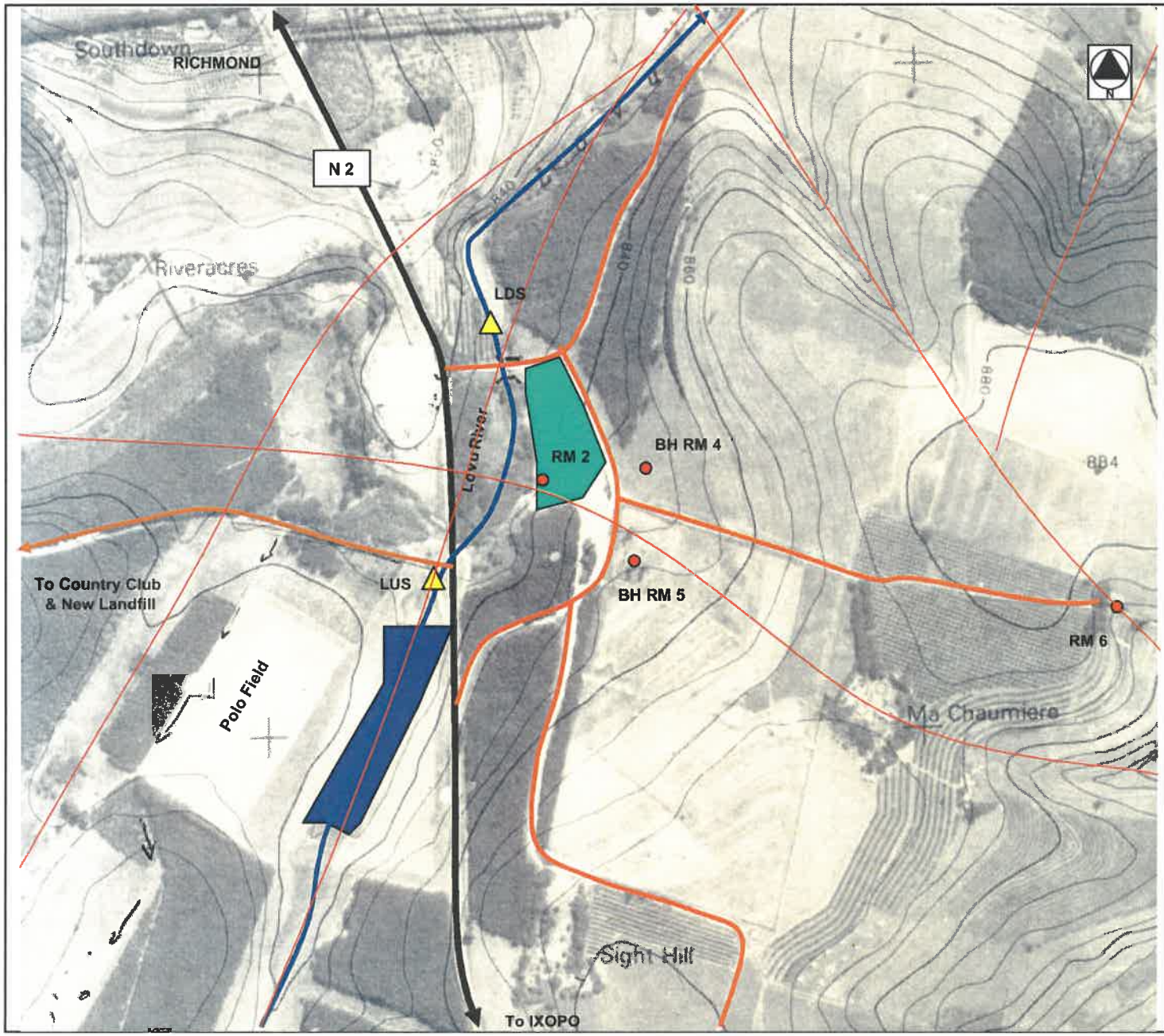
RICHMOND LANDFILL EXISTING SITE CLOSURE

TITLE:

GEOLOGICAL PLAN

SCALE: Approx. 1 : 460 000

DWG No: 2004/031
FIGURE 3



Existing Waste Disposal Site

Existing Boreholes

Surface Water Monitoring Points

Dam

N2

Secondary Roads

Photo-Lineaments

GEOMEASURE GROUP
Groundwater & Environmental Consultants
36 Haraldene Road, GLENWOOD 4001
Tel: 031 205 8624 Fax: 031 205 4075

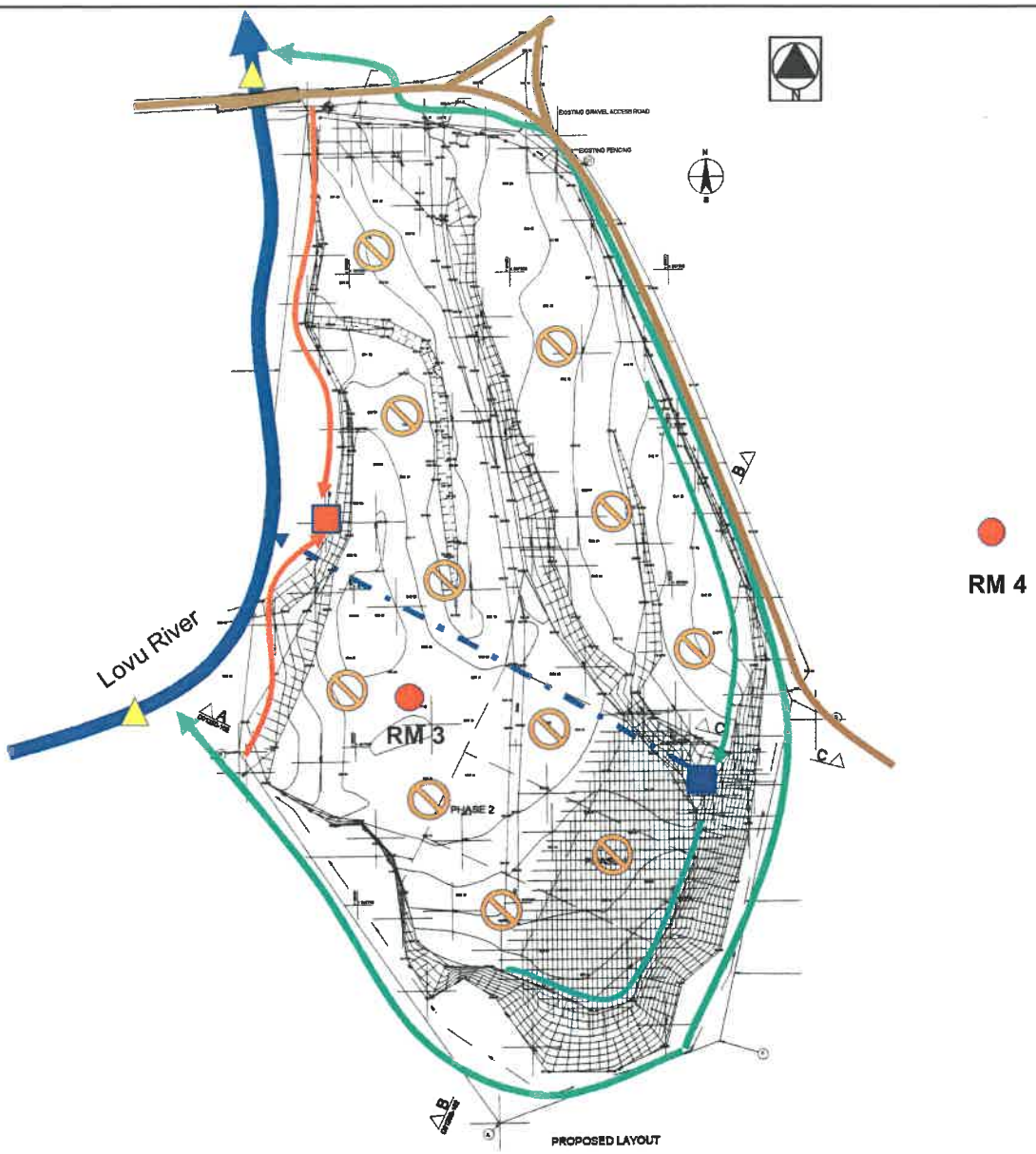
PROJECT:
RICHMOND EXISTING WASTE DISPOSAL SITE CLOSURE

TITLE:

REMOTE SENSING & HYDROCENSUS

SCALE: Approx 1 : 8 000

DWG No: 2004/031
FIGURE 4



PROJECT: RICHMOND LANDFILL CLOSURE

TITLE: DUMP SITE CLOSURE PLAN

SCALE: Approx 1 : 500

DWG No: 2004/031 FIGURE 6

GEOMEASURE GROUP
Groundwater & Environmental Consultants
36 Haraldene Road, GLENWOOD 4001
Tel: 031 205 8624 Fax: 031 205 4075

LEGEND :

- Spring Capture System
- Clean S/water piped To River
- Uncontam. S/water Diversion System
- Surface Water Monitoring Point
- Leachate Sump
- Leachate Collection Drains
- Landfill Gas Collection System
- G/water Monitoring Point

APPENDIX A

BOREHOLE DATA

GEOMEASURE GROUP
Groundwater & Environmental Consultants

TABLE A1 - NGDB BOREHOLE DATA

BH NO	SOUTH	EAST	ALTITUDE	TYPE	DEPTH	EQUIPMENT	YIELD	DISCH RATE	LITHOLOGY
5000	-29.87396	30.30667	825.00	Borehole	42.00	M	0.000	20.83	
5002	-29.87614	30.31144	860.00	Borehole	74.00	S	0.000	5.00	
5003	-29.87640	30.31291	860.00	Borehole	60.00	N	0.000	5.00	
5007	-29.87780	30.29720	960.00	Borehole	45.00	S	0.000	0.00	
5008	-29.87912	30.31000	840.00	Borehole	66.00	S	0.000	0.75	
5010	-29.88500	30.29080	860.00	Borehole	96.00	S	0.000	0.00	
10946	-29.88300	30.25333	860.00	Borehole	0.00	S	0.000	0.00	Shale
10949	-29.88483	30.28450	880.00	Borehole	0.00	S	0.000	0.00	Shale
10950	-29.88500	30.25530	860.00	Borehole	72.00		8.330	8.33	Shale
10951	-29.88500	30.24880	885.00	Borehole	0.00	S	0.000	0.00	Shale
10953	-29.88617	30.25217	840.00	Borehole	0.00	S	0.000	0.00	Shale
10954	-29.88620	30.24720	900.00	Borehole	0.00	N	0.000	0.00	Shale
10955	-29.88670	30.24650	905.00	Borehole	0.00	N	0.000	0.00	Dolerite
10956	-29.88680	30.24670	900.00	Borehole	0.00	S	0.000	0.00	Shale
10977	-29.90150	30.28783	910.00	Borehole	144.00	S	1.280	1.28	Shale
10978	-29.90133	30.25117	910.00	Borehole	0.00	S	0.000	0.00	Shale
10983	-29.90433	30.25433	900.00	Borehole	0.00	H	0.000	0.00	Shale
10985	-29.90533	30.29317	890.00	Borehole	0.00	S	0.000	0.00	Shale
10986	-29.90650	30.28683	840.00	Borehole	0.00	S	0.000	0.00	Shale

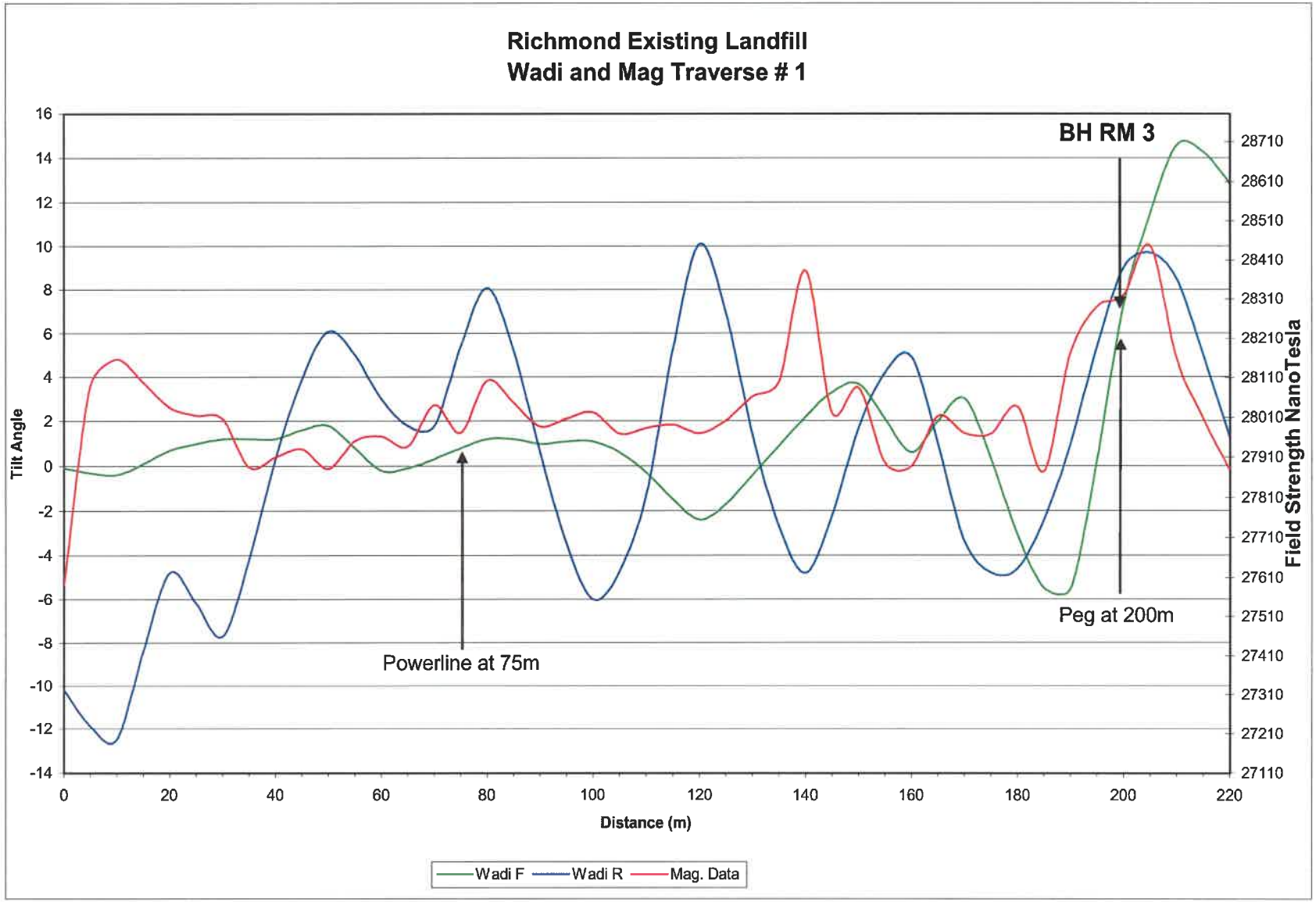
TABLE A2 - GEOMEASURE AND SRK BOREHOLE DATA

BH NO	SOUTH	EAST	LOCALITY	DRILL DATE	DRILL CONTR	BH DEPTH	CASING	STRIKE 1	STRIKE 2	STRIKE 3	BLOWYIELD	SWL	AQUIFER	EXIS EQUIP	Z L/S REC	REC P RATE	PUMP CYCLE	KEMPSTER
404064	-29.88750	30.24611	Richmond Clinic	16/11/89		60.00	18.00	20.00	54.00		0.40	8.90		Handpump		1.50		
BH5	-29.90556	30.25083									0.38							
BHx	-29.88222	30.25167																III
DR115/1	-29.88056	30.24750				120.00		18.00	102.00		4.00	0.76				3.00	12.00	
DR115/1 RS	-29.88056	30.24750	Ndaleni	11/12/93	Hillson Drilling	120.00	12.00	18.00	102.00		4.00		Dolerite/Shale					
DR115/4 RS	-29.88528	30.26083	Ndaleni	14/12/93	Eastern Drilling	84.00	60.00	12.00	24.00	36.00	10.00		Dolerite/Siltstone					
DR115/5 RS	-29.88333	30.25750	Ndaleni	04/01/94	Eastern Drilling	120.00		11.00	84.00		0.33		Dolerite/Siltstone					
R1	-29.87306	30.26472				45.00		12.00	16.00		4.00	5.00						
R10	-29.88861	30.28833				90.00		9.00	24.00		0.55							
R2	-29.87444	30.26444				81.00		33.00	62.00		1.61	7.00						
R3	-29.87500	30.26417				96.00		15.00	79.00		1.25	6.50						
R4	-29.87583	30.26361				90.00		21.00	60.00		1.17	15.00						
R9	-29.88861	30.28833				102.00		7.00	18.00		1.40							
Rich18	-29.88750	30.29556				126.00					0.13							
Rich19	-29.87278	30.27750				103.00		43.00			0.23							
Rich28	-29.87389	30.29000									1.39							
Rich29	-29.88667	30.29139									1.39							
Rich30	-29.87833	30.29556									1.39							
Rich33	-29.88111	30.27972				105.00		45.00			0.72							
Rich49	-29.87472	30.30611				42.00					20.83							
Rich50	-29.87556	30.30861																
Rich51	-29.87972	30.30917																
Rich53	-29.87778	30.30889									Dry							
Rich54	-29.87528	30.30444									Dry							
Rich56	-29.88528	30.28333				55.00		22.00	45.00		1.25							
Rich57	-29.88583	30.28861				30.00					Dry							
Rich58	-29.88639	30.28861				30.00					Dry							
Rich59	-29.88583	30.28889				30.00					Dry							
Rich60	-29.88639	30.28889				30.00					Dry							
Rich73	-29.90111	30.30333				73.00					Dry							
Rich74	-29.90361	30.30694				45.00					1.11							
Rich75	-29.90556	30.30361				35.00					0.56							
Rich77	-29.90444	30.31111				60.00					3.89							
Rich78	-29.90611	30.30667				60.00					2.22							
Rich81	-29.89500	30.30833				28.00		22.00			5.00							
Rich82	-29.89333	30.30111				40.00		24.00			5.55							
Rich83	-29.89333	30.29917				38.00		24.00	27.00		11.11							
Rich84	-29.89167	30.30111				40.00					1.67							
Rich85	-29.89806	30.30806				50.00					2.78							
Rich86	-29.89861	30.30667				46.00					7.22							
Rich87	-29.90000	30.30806				40.00					1.11							
Rich89	-29.88194	30.27250				70.00		66.00			2.50							
Rich9	-29.88333	30.29111				70.00		63.00			0.74							
Rich94	-29.88056	30.31111				75.00												
Rich95	-29.88306	30.31250				75.00												
SRK1	-29.88139	30.26583				120.00		19.00	30.00	115.00	1.00							
SRK6	-29.88222	30.25167				120.00		89.00	95.00	101.00	10.00	1.73			6.00		12.00	II
SRK7	-29.90194	30.25056				150.00		15.00	90.00		4.44	1.40				3.30	12.00	
SRK8	-29.88833	30.26250				150.00		14.00			0.55							
SRK9	-29.91333	30.25778				150.00		0.00			0.36							

APPENDIX B

GEOPHYSICAL DATA PLOTS

GEOMEASURE GROUP
Groundwater & Environmental Consultants

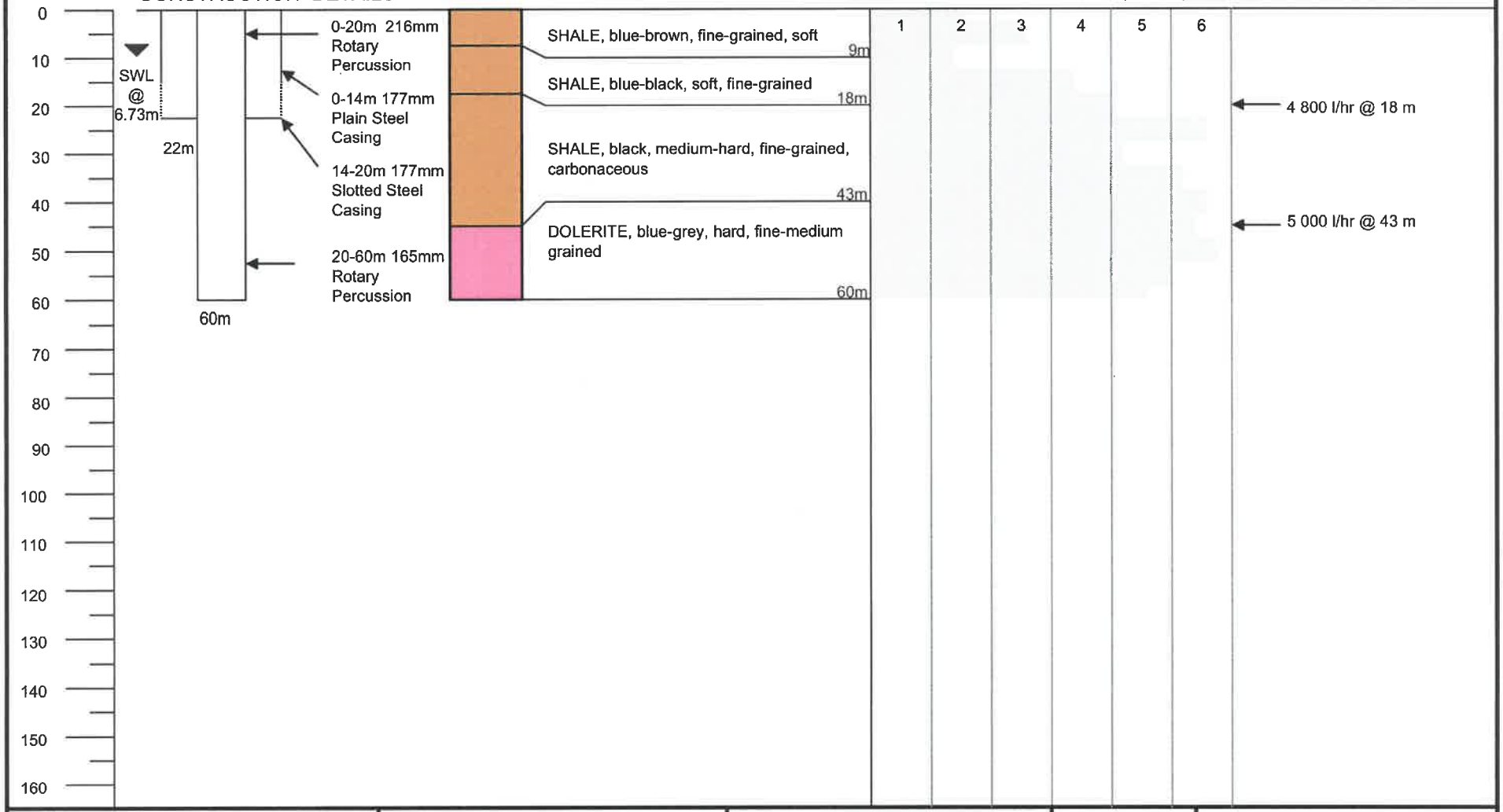

Richmond Existing Landfill
Wadi and Mag Traverse # 1
BH RM 3
Peg at 200m
Powerline at 75m
Tilt Angle
Field Strength NanoTesla
Distance (m)
Wadi F
Wadi R
Mag. Data

APPENDIX C

BOREHOLE LOG AND PUMP TEST DATA

GEOMEASURE GROUP
Groundwater & Environmental Consultants

BOREHOLE GEOLOGICAL AND CONSTRUCTION LOG



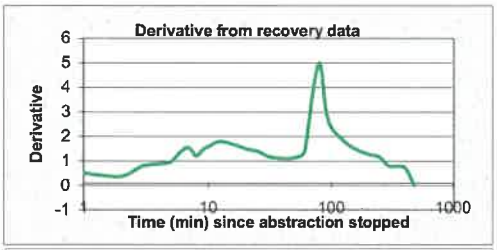
PROJECT: RICHMOND LANDFILL **DATE DRILLED: 30/06/2003** **BH NO: BH RM3 (EXISTING SITE)**	**LOGGED BY: C. MANDEW** **CONTRACTOR: KWA NATAL DRILLING** **MACHINE: SUPER ROCK** **DRILLER: H. DU PLESSIS JNR.**	**BOREHOLE COORDINATES** **29° 53' 19.7" S** **30° 17' 23.4" E**	**JOB NO.** **2004/031**	GEOMEASURE GROUP

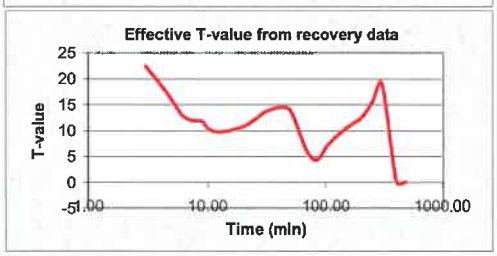
DATA sheet: Enter general info and data of constant rate pumping test and recovery (optional)

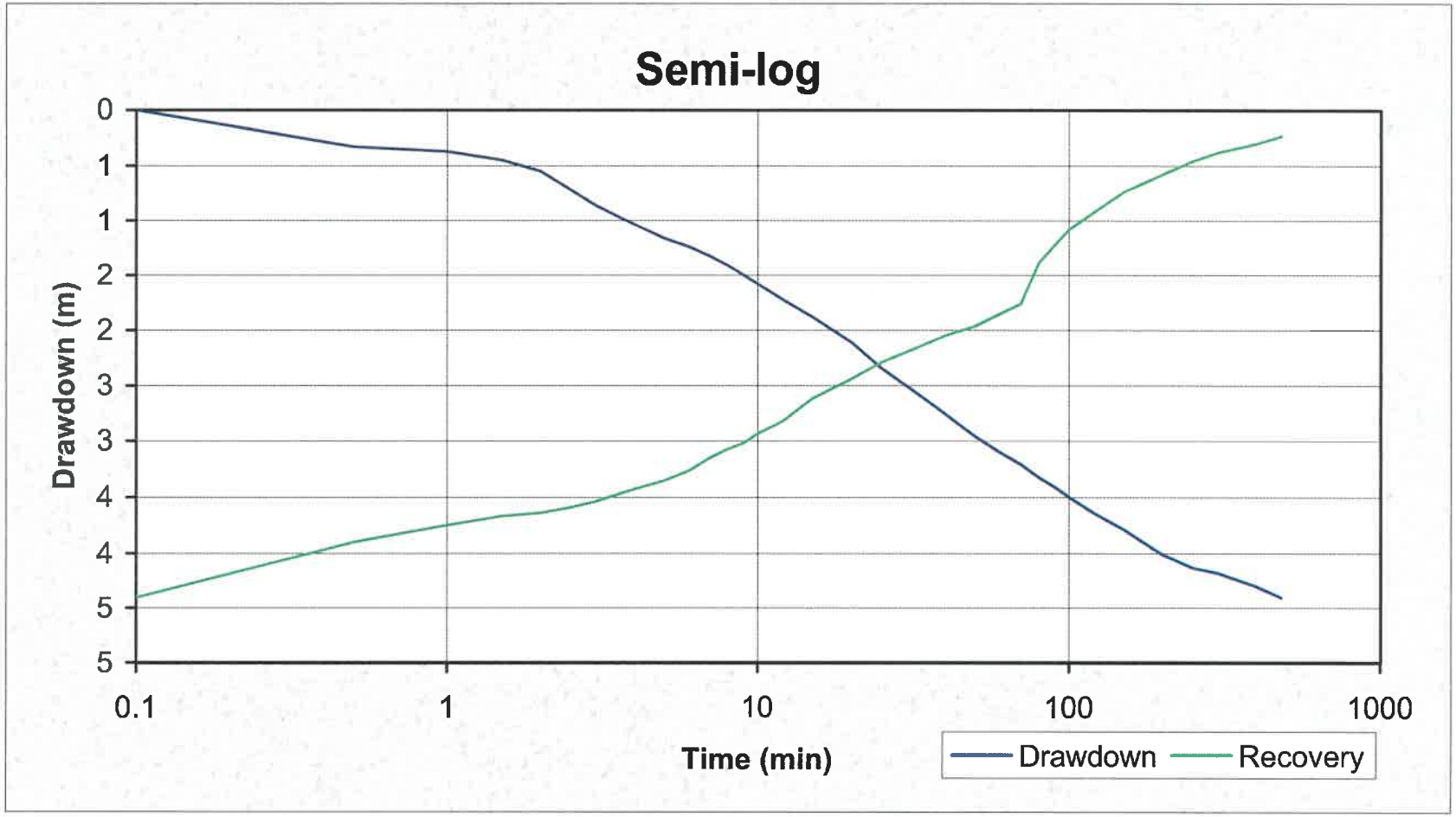
Country:		Geology:	
Region:	Richmond	Depth of BH:	59.79
Owner:	Mondi	Water strikes:	18 & 43m
X-coord:	29 53' 19.7" S	Date of Test:	11/07/2003
Y-coord:	30 17' 23.4" E	Contractor:	Eastern Drilling

CONSTANT RATE TEST DATA : enter values in cells which are coloured light yellow

Borehole:		RM 3									
Q (l/s)=	1.03					Recovery data					
t (min)	s (m)	avg s'	avg s"	avg T	avg S	Time t'	Res_s	t/t'	WI rise	s'	Rec_T
0.10	0					0.10	4.4	4801	0		
0.50	0.33					0.50	3.9	961	0.5	0.66	
1.00	0.37	#####	#NUM!			1.00	3.75	481	0.65	0.48	
1.50	0.45	#####	#NUM!	27.30	0.00E+00	1.50	3.67	321	0.73	0.37	40.8
2.00	0.55	1.00	#NUM!	14.70	#REF!	2.00	3.64	241	0.76	0.35	38.7
2.50	0.72	1.36	0.82	10.87	#REF!	2.50	3.59	193	0.81	0.57	30.0
3.00	0.86	1.47	0.09	10.66	#REF!	3.00	3.54	161	0.86	0.79	22.4
4.00	1.03	1.39	-0.29	11.67	#REF!	4.00	3.43	121	0.97	0.86	18.8
5.00	1.16	1.29	-0.17	12.97	#REF!	5.00	3.35	97	1.05	0.96	15.7
6.00	1.24	1.27	0.25	13.34	#REF!	6.00	3.26	81	1.14	1.36	12.9
7.00	1.32	1.38	0.68	12.06	#REF!	7.00	3.15	69.57	1.25	1.52	12.0
8.00	1.41	1.54	0.74	10.31	#REF!	8.00	3.07	61	1.33	1.20	11.8
9.00	1.5	1.67	0.44	9.50	#REF!	9.00	3.02	54.33	1.38	1.44	11.7
10.00	1.58	1.71	0.20	9.51	#REF!	10.00	2.93	49	1.47	1.58	10.2
12.00	1.72	1.76	0.18	9.48	#REF!	12.00	2.82	41	1.58	1.77	9.7
15.00	1.88	1.86	0.26	8.75	#REF!	15.00	2.62	33	1.78	1.70	9.9
20.00	2.11	2.00	0.22	8.09	#REF!	20.00	2.44	25	1.96	1.49	10.8
25.00	2.35	2.08	0.08	7.62	#REF!	25.00	2.29	20.2	2.11	1.37	12.2
30.00	2.5	2.08	-0.06	7.84	#REF!	30.00	2.2	17	2.2	1.18	13.5
40.00	2.76	2.01	-0.18	8.08	#REF!	40.00	2.05	13	2.35	1.09	14.4
50.00	2.96	1.91	-0.23	8.08	#REF!	50.00	1.96	10.6	2.44	1.13	13.7
60.00	3.1	1.83	-0.15	8.08	#REF!	60.00	1.85	9	2.55	1.37	9.1
70.00	3.2	1.81	0.02	8.08	#REF!	70.00	1.76	7.857	2.64	3.70	5.6
80.00	3.32	1.83	0.03	8.08	#REF!	80.00	1.38	7	3.02	4.98	4.2
90.00	3.41	1.82	-0.11	8.08	#REF!	90.00	1.22	6.333	3.18	3.10	4.9
100.00	3.5	1.78	-0.26	8.08	#REF!	100.00	1.08	5.8	3.32	2.36	6.7
120.00	3.64	1.69	-0.29	8.08	#REF!	120.00	0.92	5	3.48	1.93	8.5
150.00	3.79	1.58	-0.40	8.08	#REF!	150.00	0.74	4.2	3.66	1.52	10.5
200.00	4.01	1.38	-0.65	8.08	#REF!	200.00	0.58	3.4	3.82	1.26	12.5
250.00	4.13	1.17	#NUM!	8.08	#REF!	250.00	0.46	2.92	3.94	1.14	15.7
300.00	4.18	#####	#NUM!	8.08	#REF!	300.00	0.38	2.6	4.02	0.77	18.9
400.00	4.3	#####	#NUM!	8.08	#REF!	400.00	0.3	2.2	4.1	0.73	#DIV/0!
480.00	4.4	#####	#NUM!	8.08	#REF!	480.00	0.23	2	4.17	#####	#DIV/0!

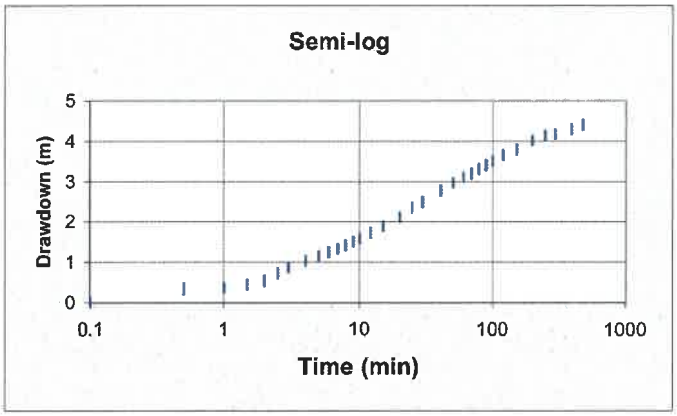


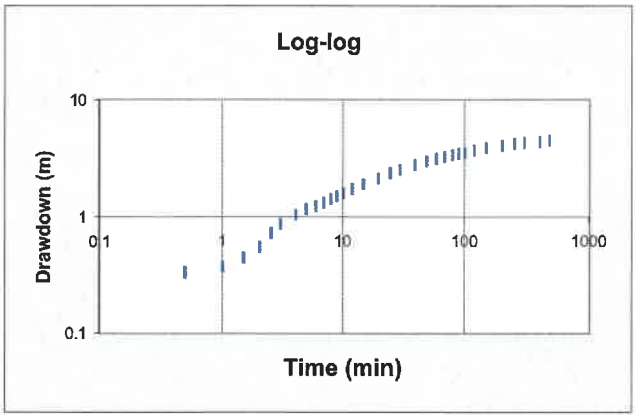


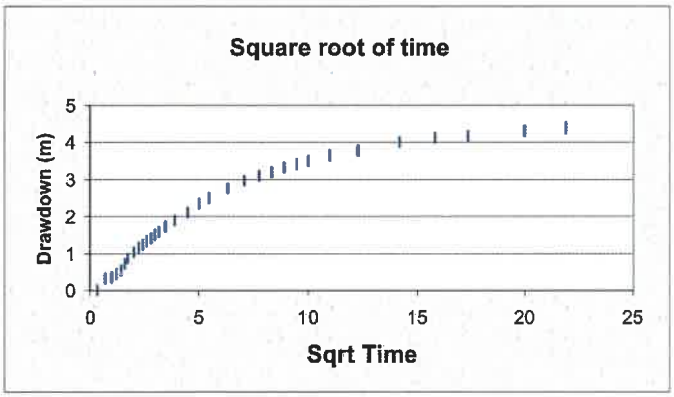

Semi-log
Drawdown (m)
0
1
1
2
2
3
3
4
4
5
5
0.1
1
10
100
1000
Time (min)
Drawdown
Recovery

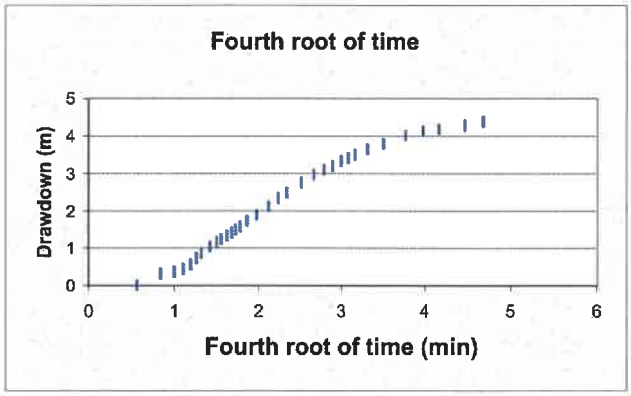
DIAGNOSTIC PLOTS

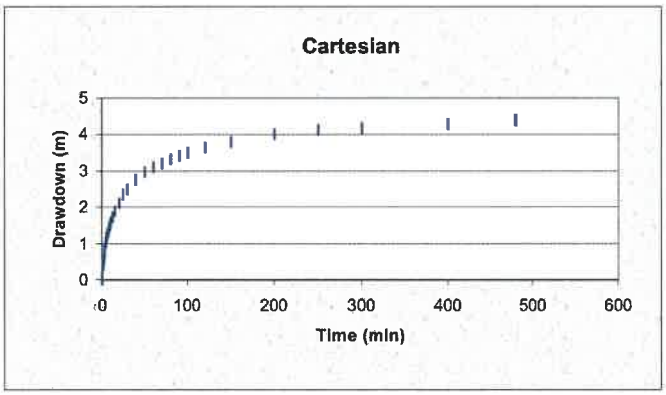
RM 3

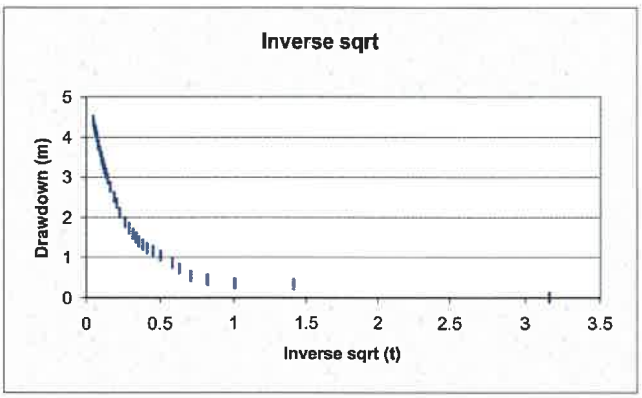


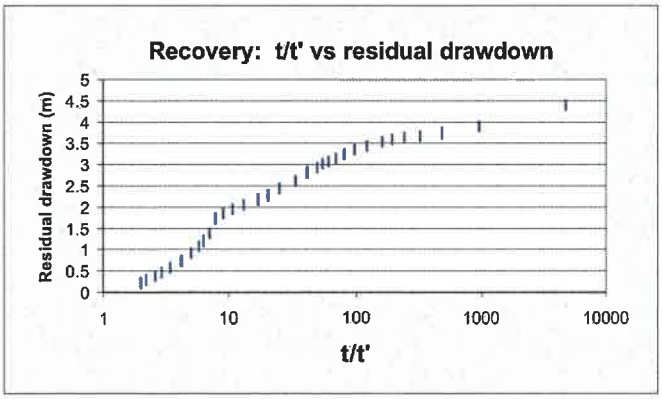


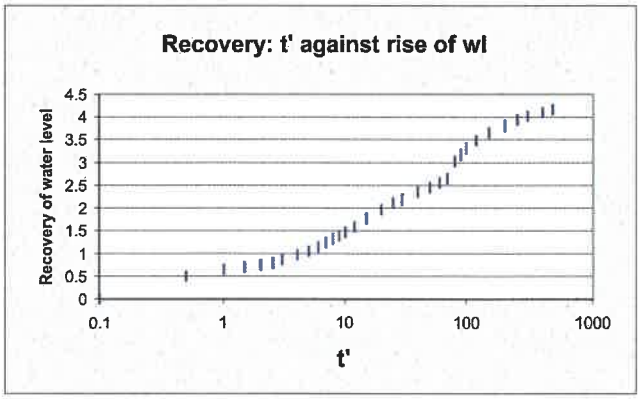












MANAGEMENT RECOMMENDATION SHEET

BOREHOLE No :	RM 3	**LOCATION :**	Richmond		
DATE :	11/07/2003	**COORDINATES :**	29° 53' 19.7" **S**	30° 17' 23.4"	**E**

BOREHOLE INFORMATION

Completed Depth (mbgl)	59.79
Diameter (mm)	165
Casing (m)	22.00
Water Strikes (mbgl)	18 & 43
Static Water Level (mbgl)	6.73
Test Pump Intake (mbgl)	56.00
Available Drawdown (m)	49.27
Airlift Yield (l/hr)	5000
Airlift Yield (l/s)	1.39

STEP TESTS

	Pump Rates l/s	Pump Rates m^3/hr	Drawdown (m)	Specific Capacity l/s/m	Specific Capacity $m^3/hr/m$	Length of step (min)
Step No 1						
Step No 2						
Step No 3						
Step No 4						
Step No 5						
Step No 6						

Recovery Test	Total DD (mbswl)	Recovery (mbswl)	Recovery Time (min)	Recovery %
				#DIV/0!

CONSTANT DISCHARGE TEST

Final Drawdown (mbswl)	Pump Rates l/s	Pump Rates m^3/hr	Duration of DD Test (min)	Specific Capacity l/s/m	Specific Capacity $m^3/hr/m$	Duration of Recovery (min)	Recovery (mbswl)	Recovery %
4.40	1.03	3.71	480	0.234	0.843	480	0.23	95

Volume Extracted (kl)	Calculation of Transmissivity Values DDΔs	RECΔs	DD m^2/day	REC m^2/day
29.66	3.2	2.6	1.70	2.09

MANAGEMENT RECOMMENDATIONS

Pump Installation (mbgl)	Dynamic Water Level (m)	Rec. Pumping Cycle (hrs/day)	Rec. Pumping Rate on Pump Cycle m^3/hr	l/s	m^3/day
Monitoring Only					

GEOMEASURE GROUP
Groundwater & Environmental Consultants

APPENDIX D

WATER QUALITY DATA

GEOMEASURE GROUP

CLASSIFICATION SYSTEM FOR ASSESSMENT OF SUITABILITY OF BOREHOLE WATER FOR POTABLE USE (INSTITUTE FOR WATER QUALITY STUDIES, KEMPSTER 1996)

PROJECT: RICHMOND LANDFILL

DETERMINANT	CLASS 0	CLASS 1	CLASS 2	CLASS 3	Date 23 Feb 04 Lovu D/stream	Date 23 Feb 04 Lovu U/Stream	Date 03-Jul BH RM 3	Date 23 Feb 04 RM 4
pH					7.5	6.55	6.58	6.24
EC mS/m	0 - 70	70 - 150	150 - 370	> 370	23.4	21.71	16.1	19.4
Units (mg/l)								
Calcium as Ca	ns	ns	ns	ns	5.9	6	10.1	3.8
Magnesium as Mg	0 - 30	30 - 70	70 - 100	> 100	3.2	3.3	5.88	3.3
Chlorides as Cl	0 - 100	100 - 200	200 - 600	> 600	15	12	13.9	6
Sulphates as SO4	0 - 200	200 - 400	400 - 600	> 600	13	9.9	11.9	11
Iron as Fe	0 - 0.1	0.1 - 0.2	0.2 - 2.0	> 2.0	1.7	1.5	2.9	0.3
Manganese as Mn	0 - 0.05	0.05 - 0.1	0.1 - 1.0	> 1.0	<0.1	<0.1	0.53	<0.1
Nitrates as N	0 - 6	6.0 - 10	10 - 20.0	> 20	<1	<1	0.06	<1
Sodium as Na	0 - 100	100 - 200	200 - 400	> 400	8.5	8.4	8.14	6.7
Fluoride as F	0 - 1.0	1.0 - 1.5	1.5 - 3.5	> 3.5	<0.1	<0.1	0.224	<0.1
Bacteriological								
Faecal Coliforms /100 ml	0	0 - 1	1.0 - 10	> 10	120	tntc	285	0
Classification					Class 3	Class 3	Class 3	Class 2

Class 0 & 1 - Suitable for long term domestic use

Class 2 - Suitable for short term domestic use.

Class 3 - Not suitable for domestic use.

CLASSIFICATION OF WATER QUALITY IN TERMS OF THE DWAF TWQR FOR DOMESTIC USE

SITE NAME:	RICHMOND LANDFILL

DETERMINANT	CLASS 0 IDEAL	CLASS 1 GOOD	CLASS 2 MARGINAL	CLASS 3 POOR	CLASS 4 UNACCEPTABLE	Date 23 Feb 04 Lovu D/stream	Date 23 Feb 04 Lovu U/Stream	Date July 03 RM 3	Date 23 Feb 04 RM 4	General Standard
pH	5 - 9.5	4.5 - 5 & 9.5 - 10	4.4 - 4.5 & 10 - 10.5	3 - 4 & 10.5 - 11	<3 or >11	7.5	6.55	6.58	6.24	5.5 - 9.5
EC mS/m	0 - 70	70 - 150	150 - 370	370 - 520	>520	23.4	21.7	16.1	19.4	70 mS/m above background
Total Dissolved Solids	0 - 450	450 - 1000	1000 - 2400	2400 - 3400	>3400	164	152	112.7	136	
Units (mg/l)										
Colour as Co/Pt units	ns	ns	ns	ns		60	50		<10	ns
Total Hardness CaCO3	0 - 200	200 - 300	300 - 600	>600		28	29		23	ns
Alkalinity as CaCO3	0 - 200	200 - 300	300 - 600	>600		29	28		20	ns
Calcium as Ca	0 - 80	80 - 150	150 - 300	>300		5.9	6	10.1	3.8	ns
Magnesium as Mg	0 - 70	70 - 100	100 - 200	200 - 400	>400	3.2	3.3	5.88	3.3	ns
Chlorides as Cl	0 - 100	100 - 200	200 - 600	600 - 1200	>1200	15	12	13.9	6	ns
Sulphates as SO4	0 - 200	200 - 400	400 - 600	600 - 1000	>1000	13	9.9	11.9	11	ns
Iron as Fe	0 - 0.5	0.5 - 1.0	1.0 - 5.0	5.0 - 10.0	>10	1.7	1.5	2.9	0.3	0.3
Manganese as Mn	0 - 0.1	0.1 - 0.4	0.4 - 4.0	4.0 - 10.0	>10	<0.1	<0.1	0.53	0.2	0.1
Nitrates as N	0 - 6	6.0 - 10	10 - 20.0	20 - 40	>40	<1	<1	0.06	<1	15
Nitrites as N	0 - 6	6.0 - 10	10 - 20.0	20 - 40	>40	<1	<1	0.05	<1	0.05
Sodium as Na	0 - 100	100 - 200	200 - 400	400 - 1000	>1000	8.5	8.4	8.14	6.7	ns
Fluoride as F	0 - 0.7	0.7 - 1.0	1.0 - 1.5	1.5 - 3.5	>3.5	<0.1	<0.1	0.224	0.3	1
Potassium as K	0 - 25	25 - 50	50 - 100	100 - 500	>500	2.7	2.5	1.41	0.9	ns
Phosphate as PO4	ns	ns	ns	ns	ns					10
Arsenic as As	0 - 0.10	0.01 - 0.05	0.05 - 0.2	0.2 - 2.0	>2.0	<0.005	<0.0005	<0.002	<0.0005	0.02
Cadmium as Cd	0 - 0.003	0.003-0.005	0.005-0.020	0.020-0.050	>0.050	<0.005	<0.005	<0.001	<0.005	0.005
Copper as Cu	0 - 1	1 - 1.3	1.3 - 2.0	2.0 - 15	>5	<0.1	<0.1		<0.1	0.01
Cyanide as CN	0 - 0.2	ns	ns	>0.3	>0.3	<0.02	<0.02	<0.01	<0.02	0.02
Lead as Pb	0 - 0.01	0.01-0.05	0.05 - 0.1	0.1 - 0.3	>0.3	<0.01	<0.01	0.004	<0.01	0.01
Mercury as Hg	0 - 0.001	0.001-0.02	0.02-0.05	0.05-1	>1	<0.005	<0.005	<0.005	<0.005	0.005
Phenols	0-0.001	0.001-0.01	0.01 - 0.1	0.1 - 3	>3	<1	<1	<0.005	<1	ns
Selenium as Se	0 - 0.02	0.02 - 0.05	0.05 - 0.1	>0.1	>0.1	<0.005	<0.005		<0.005	0.02
Aluminium as Al	0 - 0.15	0.15 - 0.5	>0.5	ns	ns	0.8	0.7		0.3	ns
Chrome as Cr	ns	ns	ns	ns	ns	<0.1	0.1		<0.1	ns
Zinc as Zn	0 - 20	>20	ns	ns	ns	<0.1	<0.1	0.03	<0.1	0.1
Bacteriological										
Faecal Coliforms /50 ml	0	0 - 1	1.0 - 10	10 - 100	>100	60	tntc	286	nil	1000

ns - not stated
na - not analysed for
nd - not detected
tntc - too numerous to count