GROUNDWATER RESOURCE INFORMATION PROJECT
EASTERN CAPE PROVINCE

GROUNDWATER INFORMATION SOURCE REFERENCE SHEET

SOURCE REF NR:	KV065	Own Archive	X	Copy attached	X
		Sourced		Copy at source	

A: SOURCE DESCRIPTION

District Municipality:	Amatole		Chris Hani		O.R Tambo	X
	Ukhahlamba		Cacadu		Alfred Nzo	
Local Municipality:	MHLONTLO					
Institution where Information is held:	KHULANI VSA GROUNDWATER CONSULTANTS					
Branch of Institution:	DEPARTMENT OF GEOHYDROLOGY					
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B: TYPE OF INFORMATION

Information format:	Hard copy	X	Data Summary	X	Electronic Report	
	Specify Other:					
Report / Info Title:	TSOLO WASTE DISPOSAL SITE: GEOHYDROLOGICAL AND GEOTECHNICAL REPORT FOR THE TSOLO SOLID WASTE DISPOSAL SITE					
Report Nr:	PEC/312 /02		Date:	1-Mar-03		
Author Details:	M.MADIKIZELA					
Author's Qualification:	Hydrogeologist		Govt Dept		Project Manager	
	Engineer		Technician		Other	X
	Specify Other: GEOLOGIST					
Captured by:	NOMSA NKOMO Date: 16-Mar-04 Signed:					

C: GEOHYDROLOGICAL CATEGORIZATION

Project Type	Source development		Feasibility Study	X	Sanitation Study:
	Specify Other:				

Reference Co-ordinate:	Latitude	Longitude
	S 31.3000000	E 28.7833333

	Yes	No	Complete	Incomplete
Lithological & Construction Logs	X		X	
Hydrocensus Data	X		X	
Pump Testing Data	X			X
Chemical Water Analysis Data	X		X	
Geohydrological Data	X		X	
Spring Data		X		
Remote Sensing Data		X		X
Map Data	X			X

Comments: According to DWAF's classification of landfill waste disposal site,its classified as a **Communal** site.

Reviewed by: EUNICE GOOSSENS Date: 25/3/04 Signed:

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TSOLO WASTE DISPOSAL SITE: GEOHYDROLOGICAL AND GEOTECHNICAL REPORT FOR THE TSOLO SOLID WASTE DISPOSAL SITE, TSOLO, O. R. TAMBO DISTRICT MUNICIPALITY EASTERN CAPE PROVINCE.

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Date: March 2003

Technical Report No.: PEC 312 / 02

GEOHYDROLOGICAL AND GEOTECHNICAL INVESTIGATION REPORT FOR THE TSOLO WASTE DISPOSAL SITE.

LIST OF APPENDIXES

INDICES

Aquifer: Water-bearing stratum of fractured or permeable rock, sand or gravel. When capable of sustaining community water needs, such structures are considered to represent strategic water resources, requiring protection from pollution.

Environmental Impact Assessment (EIA): An investigation to determine the potential detrimental or beneficial impact on the surrounding communities, fauna, flora, water, soil and air, arising from the development or presence of a landfill.

Fatal Flaw: A factor or situation, which prevents the development of an environmentally acceptable waste disposal facility, except at prohibitive cost.

Feasible: Acceptable, capable of being used or implemented successfully, without unacceptably damaging the environment.

General Waste: Waste that does not pose an immediate threat to man or the environment, i.e. household waste, builders'rubble, garden waste, dry industrial and commercial waste. It may however with decomposition, infiltration and percolation, produce leachate with an unacceptable pollution potential.

Groundwater: Water occupying pores in the soil and cavities and spaces in rocks. This water may rise from a deep, magmatic source or be due to infiltration of rainfall.

Leachate: An aqueous solution with a high pollution potential, arising when water is permitted to percolate through decomposing waste. It contains final and intermediate products of decomposition, various solutes and waste residues.

Permeability (Primary): The rate at which fluid will pass through a porous material under a unit flow gradient. The constant of proportionality K in Darcy's Law is measured in m/y.

Permeability (Secondary): The rate at which fluid will pass through macro features of a soil, such as paleo-root canals, termite tunnels and rodent burrows, under unit flow gradient.

Pollute: To add contaminants to a natural system, to the extent that its attenuation capacity is exceeded and it becomes significantly degraded.

Waste: An undesirable or superfluous by –product, emission, or residue of any process or activity which has been discarded, accumulated or stored for the purpose of discarding or processing. The definition excludes industrial wastewater, sewage, radioactive substances, mining, metallurgical and power generating waste.

Waste Disposal Site (Land Fill): In the context of this report, a waste disposal site is referred to as a landfill, because the vast majority of waste is ultimately disposed of on land, whether it is on trenches, or other excavations, or above grade.

LIST OF TABLES

ACKNOWLEGEMENTS

- Special acknowledgements are referred to our senior Mr. Evan Chipps and the rest of Khulani VSA colleagues for their support during development of this report.
- I would also like to acknowledge Dr. Price from TERRECO cc. for his input on geotechnical data synthesis.
- The rest of the project team, which includes Mr. Dilima from Civils and Structures Consulting, is acknowledged for patience and support.

1. INTRODUCTION

1.1 Foreword

Tsolo is situated approximately 30km from Umtata on the N2 national road, in the O. R. Tambo District Municipality of the Eastern Cape Province (Appendix A: locality and geological map).

Tsolo Municipality is currently not in possession of a permitted solid waste disposal site. Solid waste must be transported to a permitted site located in Qumbu. The Municipality appointed Civils and Structures Consultants to conduct a feasibility study and design for the proposed structure. Khulani VSA was appointed to conduct hydrogeological and geotechnical investigations.
The aim of the investigation is to provide a sound basis for design of the landfill by obtaining adequate geological, geohydrological and geotechnical information for the site. The objectives of site selection are to ensure that there are no fatal flaws or critical factors, such as:

- Groundwater potential for future water supply scheme development.
- Value of groundwater usage by the communities.
- Geological structures that may influence infiltration of leachate to groundwater.

Initially two (2) sites were identified, however one site to the west was eliminated from further analysis due to fatal flaws such as sandstone outcrops and its location close to a community development (households). Detailed investigation was conducted on the site to the east.

This report therefore describes the results of the geological, hydrogeological and geotechnical investigations conducted for the proposed development. It forms part of a set of documents to be submitted to DWAF in fulfillment of the permitting requirements. The documents referred to are as follows:

- Permit Application and Feasibility Study
- Final Scoping Document
- Geological and hydrogeological Report
- Environmental Impact Report
- Landfill Design Report
- Operation and Maintenance Report
- Environmental Impact Control Report
- Rehabilitation Closure and Ea-Use Plan
- Monitoring Plan

1.2 Location and Topography

The proposed site is located in a flat lying area, referred to as the Tsolo flats. Soccer fields have been developed within the area. The topography dips gently towards the Xokonxa stream to the East. The Western portion dips 2^0 towards the west. Detailed investigation was conducted on the site located on the eastern portion of the Tsolo Flat.
Rugged hills formed of dolerite sills/sheets surround the study area. The Xokonxa stream forms a horse-shoe bent around the area, and is the only stream within the area. Vegetation is dominantly grass.

Communities on the flat are located along the western flank of the Xokonxa stream, which borders the eastern boundary of the town. Most of the area is occupied by the earlier mentioned facilities, and the rest is undeveloped land. The area however possesses high potential for future infrastructural development.
A sewerage site is currently being developed 500m from the proposed site.

1.3 Geology

The regional geology comprises Beaufort Group sediments of the Karoo Supergroup and dolerite sheets and dykes of the Jurassic age (Appendix A: locality and geological map).
The Beaufort Group rocks, dated to be some 250 Ma old, is regarded as a continuation of the infilling of the Karoo Basin with the sediments being deposited under fluviatile conditions. In the study area the sediments of the Katberg Formation of the Tankastad Subgroup dominate. A thick succession of purplish sandstones dominates with minor lenses of brownish red siltstone and mudstone.
Alluvial clay covers approximately 500m of the eastern portion of the area next to the river where the site is located.
The widespread intrusion of dolerite (sill, sheet and dykes) some 150 Ma marked the end of the Karoo Supergroup. Dykes in the area are ENE-WSW and SE-NW orientated

1.4 Hydrogeology

Two types of secondary aquifers exist in the study area:

- Those associated with porosity in sedimentary rocks. The Tarkastad sandstones are medium-coarse grained and hence they have high porosity and permeability for groundwater.
- Those associated with fractures developed during emplacement of dolerite structures.

From the geological point of view the groundwater potential of the study area is high. This assumption is based on sandstone aquifers and secondary aquifers associated with possible subsurface dolerite intrusions.

1.5 Methodology

After a desktop study, the following investigations and analyses were carried out:

- Interpretation of aerial photographs of the area.
- A hydrocensus of the area surrounding Tsolo Flat.
- A detailed geophysical survey, which included magnetic and electromagnetic traverses.
- Collection and chemical analysis of water samples from major stream and boreholes.
- Excavation of 4 shallow trail holes and recording of soil profiles
- Sampling and laboratory testing of selected soil horizons to determine soil characteristics
- Soil permeability assessment comprising in-situ percolation testing and laboratory testing of the upper soil horizons.

2 HYDROCENSUS

2.1 Method of Investigation

A hydrocensus was conducted on a 2km radius, in which streams and boreholes were analysed. However due to a limited number of boreholes, the hydrocensus was extended to more than the said radius. It should be noted that no boreholes exist close to the site, where relevant information would have been obtained.

2.2 Water Usage

The communities that surround the town use river water for domestic supply. Some is used for irrigation in the small commercial farms that exist along the river floodplain. Groundwater from private boreholes is used for domestic as well as irrigation purposes.

2.3 Water Sources

2.3.1 Streams

As mentioned earlier, only one stream (Xokonxa) has been identified. The other minor streams that originate from hills surrounding the area are outside the study area. The stream was sampled at two positions i.e. upstream and downstream of the proposed site (Table 1). Positions of the stream where samples were taken were recorded by means of a global positioning system (GPS).

2.3.2 Boreholes

Four (4) boreholes were located. These include three (3) private boreholes and one windpump (Table 1). Water levels and water samples were recorded for all these boreholes. Borehole positions were also recorded by means of GPS.

Table 1: Summary of Hydrocensus.

Borehole/stream	Co-ordinates Latitude	Longitude	Water level (m)	Water Quality	Comment
Gqwede	31-18-42	28-46-07	4.57	Class 3	Private borehole
Maqungo	31-18-45	28-45-42	5.75	Class 2	Private borehole
Crushing Plant	31-16-33	28-48-22	6.30	No sample	Private borehole
T30917	31-18-24	28-47-11	None	No sample	Closed Windmill
Upstream	31-18-26	28-46-48	N/A	Class 3	Flow East-West
Downstream	31-18-40	28-46-50	N/A	Class 4	Flow East- West
N (boreholes) = 4 N (streams) = 1 Average water level = 5.54m NB: see appendix c for description of water classes					

2.4 Water Quality

Water quality of the streams ranges between class 3 and class 4, which is considered to be of poor water quality.
Groundwater (borehole) quality ranges between class 2 and 3, which is considered to be a fair water quality (see appendix C for water quality definitions)

3 GEOPHYSICAL SURVEY

3.1 Method of Investigation

Geophysical survey comprised of both electromagnetic and magnetic traverses. Both the geophysical techniques employed are suitable for the purpose of the study.

- **Geotron Proton Magnetometer G5**
  This method measures the total field component of the earth's magnetic field. The different magnetic susceptibilities of different rock types result in contrasting magnetic signatures:
  - Magnetite rich dolerite dykes that are common in the entire Karoo, induce anomalies, that when interpreted, provide qualitative and quantitative information of the underlying bodies.
  - Step magnetic background or small vertical-structure anomalies caused by secondary mineralization, may distinguish geological contacts and faults.
- **EM-34-3 Electro-Magnetometer**
  The EM-34 is a horizontal loop frequency domain electromagnetic instrument and measures the apparent conductivity of the underlying geology. This is proportional to the amount of weathering and/or fracturing encountered in the underlying geology:
  - Anomalies indicate lateral changes in the conductivity and facilitate the detection of steeply dipping conductor type targets such as dolerite dykes.
  - The 10, 20, and 40m spacing can be employed to investigate various depths.

The two techniques are good at targeting, (a) contact zones between dolerite dykes and sediments, and (b) weathering/mineralization/alteration in dolerite sills due to secondary features such as shear zones, faults, and secondary younger dolerite dyke intrusions. The combination of the two proved to be successful in our investigation.

3.2 Results of the Geophysical Survey

Geophysics was conducted on the site located on the eastern portion of Tsolo flats (see locality map), as geological and environmental factors for the site on the western portion denied any possibilities for development of the proposed facility.
Four (4) magnetic, and two (2) EM-34 traverses were conducted (Appendix B: geophysical data and anomalies) around the selected site which was measured as a 100m radius. EM-34 traverses were run to verify anomalies picked up by magnetic traversing.
The following are the 4 geophysical traverses conducted:

- **Traverse 1**
  - Magnetic only
  - Length: 200m
  - Direction: 130 southeast
- **Traverse 2**
  - Magnetic only

- Length: 150m
- Direction: south-north

- **Traverse 3**
  - Magnetic and EM-34
  - Length: 300m
  - Direction: NW
- **Traverse 4**
  - Magnetic and EM-34
  - Length: 150
  - Direction north-south

A positive magnetic anomaly was identified by traverses 1 @110-150m (Appendix C). This corresponds with 20 and 40 EM-34 anomalies, which runs parallel to magnetic traverse 1. The positive anomalies are @ 100-200m (100m distance).

Positive anomalies represent high conductive zones, which define fresh bodies like dolerite sheets/dykes (depends on length). In this case, a sill-like body close to surface is suggested. This would require verification by drilling (a sill < 10m deep would cause difficult excavation).

4.0 Geotechnical Investigation

4.1 Method of Investigation

Four (4) trial pits (TP) were excavated at selected positions across the Tsolo site and the soil profile logs recorded. A number of soil samples were taken for geotechnical analysis. Trail hole excavations were taken down to the maximum reach of the excavator or where refusal or near refusal of the excavator's bucket occurred. The depth of trail holes varies from 1.0 – 1.5 m below the surface.

4.2 Description of Materials

The soil profiles are included in **Appendix D** as received from ControLab. The results for geotechnical tests are summarised in Table 2.
From the soil profiles, two prominent soil types were identified, and they are described as follows:

- **Transported Soil:** in general the upper portion of the transported soil from the four (4) trail holes comprises moist, dark and light brown sandy silt. The lower portion is comprised of moist, dark and light grey sand and clay sand. Average thickness of the transported soil horizon is 0.6 meters (m).
- **Residual Soil:** only one layer of moist, dark grey residual sandstone and clayey sand represents this horizon. Average thickness is 0.4m.

4.3 Geotechnical Evaluation

The following table is a summary of the basic soil properties synthesised from laboratory results.

Table 2: Summary of basic soil properties

Test Pit	Depth (Meters)	Material Description	LL %	PI %	LS %	Soil Activity
TP 1	0.6-1.0	Moist, dark grey, very hard, fractured, sandstone + clayey sand	38	17	8.5	0.1-1.0
TP 2	0.3-0.6	Very moist, dark grey, soft, fissured, sandy clay + ferricrete	55	29	14.5	0.6-0.7
TP 2	0.6-1.0	Moist, light grey, very hard, fractured, sandstone + clayey sand	38	18	9.0	1.6
TP 3	0.35-0.6	Very moist, dark brown, soft, fissured, sandy clay + ferricrete	43	26	13.0	1.0-2.0
*TP 4	0.65-1.05	Moist, light grey, medium dense, fractured, sandy clay + ferricrete	54	32	16.0	0.7-1.0
TP 4	1.05-1.45	Moist, pale red, very hard, fractured, siltstone + clayey sand	51	28	14.0	1.0
N=6						
LL= liquid limit		Average LL=45%				
LS= linear shrinkage		Average LS=12%				
PI= plasticity index		Average PI=24%				
* = not included in average statistics						

Detail descriptions of the various soils encountered on the site are presented in **appendix D**. The discussion that follows concentrates on the engineering aspects of the soils.

4.3.1 Founding Conditions

There are three soil types that will dominate the behaviour of a land fill structure on the site. They are a) the upper horizon of transported soils, dominated by sandy clay with ferricrete, b) the lower horizon of transported soils, dominated by sand and clayey sand, c) residual soils consisting of sand and sandy clay, and silty clay at depth.
The transported soil is characterized by moist sand and clay sand materiel. It is considered to be of low shear strength and generally exhibits low-medium potential expansiveness. The exception was in TP 4's upper horizon, which exhibits high potential expansiveness between 0.65 and 1.05m.
The soils present a relatively high percentage of linear shrinkage in the order of 12% on average.

4.3.2 Materials Usage

- Soils are on average 1.5m deep, hence they can be used as a cover material. It can be stockpiled alongside, between trenches or around the parameter of the trench.
- The linear shrinkage for the clays from the site is relatively high (12%). This means that they will definitely shrink on drying out. Deeply fissured clay is as permeably as sand. Ordinary soils such as slightly clay silt or just silts are recommended for use as capping material.
- There are no suitably access road construction materials from the site, hence use of material from commercial sources is recommended.
- The transported soil that blankets the site has in general a plasticity index of 24 % (value excludes 32 % for TP 4's top horizon). This value makes this soil suitable for use in construction of homogenous embankments.
- Permeability of the residual material has an average k value of 10^{-5} , representing low permeability.

5.0 CONCLUSION AND RECOMMENDATIONS: Geohydrological

A detailed hydrogeological investigation of the proposed Tsolo site was undertaken to identify possible fatal flaws and assess the suitability of the site for development as a waste disposal site. The investigation included aerial photograph interpretation, geological map interpretation, hydrocensus, magnetic and EM-34 geophysical traversing, groundwater quality analysis and a **geotechnical assessment** of the soil characteristics.

Based on the information presented in this report, the following conclusions are presented.

- **Location and Topography:** the site is located on a flat area more than 500m from the nearest development and the Xokonxa stream. This makes the site suitable from both a locality and topographical perspective.

- **Geology:** the geology is comprised of sandstones and possible dolerite sill intrusions detected by geophysics. A dolerite sill < 10m below the surface would provide an impermeable layer suitable for development of the proposed structure.

- **Hydrogeological Potential:** the regional and local groundwater potential of the area is high. This is based on the hydrocensus, and the geology of the area. However if the recommended engineering measures are taken, the structure would not cause a hazard to groundwater (refer geotechnical).

- **Hydrocensus:** all boreholes located during the hydrocensus are more than 2km from the site. The potential groundwater pollution of existing boreholes is negligible.

- **Water usage:** no abstraction of surface or groundwater takes place within 2km from the proposed community disposal site.

From the above geohydrological investigation it is recommended that the site be licenced as a community landfill site. According to Dwarf's classification of landfill waste disposal sites, the site is classified as a **communal** site. This does not require development of exploration boreholes. However it must be noted that during the licence application to DWAF, they might require that a groundwater monitoring facility be developed even for community waste disposal sites.

6.0 CONCLUSION AND RECOMMENDATIONS: Geotechnical

- **Analytical Parameters**
  - Permeability parameters were obtained through a series of laboratory tests. Values obtained from the laboratory are more reliable since they represent the values from the soil characteristics only not the influence of external factors (as it would be the case with field tests).

- **Availability of Clay Materials**
  - It is perceived that there is enough clay material on site for construction purposes as liner material. The quality of the clays is acceptable with average permeability k value of 10^{-5}.
  - However the clay material presents high shrinkage potential, hence it is recommended that ordinary soils and a little clay should be used for lining purposes.

- **Engineering Properties**
  - Topsoil needs to be striped off and stockpiled not higher than 2m; otherwise it will loose its fertility.
  - The soil layer is less than 1.5 m deep and hence it presents no hazard to the slope stability. Excavation of pit to greater than 1.5 m would require flattening of all excavated slopes to the ratio of 1 Vertical: 2 Horizontal. The same ratio is recommended for capping. A whale back slope is recommended to ensure water run-off.
  - The base of landfill should be scarified and wetted to optimum moisture content (OMC) up to 90% MOD AASHTD
  - No clay cut-off is necessary between the site and the river because the site is greater than 500 m away.

From the geotechnical point of view, the site is suitable for development of the proposed structure.

APPENDIX B: GEOPHYSICAL DATA AND GRAPHS

Tsolo Waste Disposal Site: Geophysical Site Data

Traverse 1

Station	Magnetic
0	27562.4
5	27549.9
10	27549.9
15	27550.1
20	27551.2
25	27555.9
30	27556.9
35	27565
40	27565
45	27561.1
50	27559.6
55	27561.2
60	27560.1
65	27561.2
70	27561.2
75	27563.9
80	27559.2
85	27559.2
90	27549
95	27549
100	27546.7
105	27553
110	27555.2
115	27596.4
120	27596.4
125	27596.4
130	27588.1
135	27586.3
140	27584.6
145	27576.4
150	27576.4

Traverse 2
Magnetic

Station	Magnetic
0	27573.6
5	27561.8
10	27544.4
15	27544.4
20	27544.4
25	27539.9
30	27537.7
35	27537.7
40	27537.7
45	27537.3
50	27532.9
55	27532.9
60	27538.3
65	27538.3
70	27532.9
75	27532.5
80	27532.5
85	27532.5
90	27532.5
95	27536.5
100	27537.8
105	27537.8
110	27537.8
115	27537.2
120	27537.2
125	27537.2
130	27528.8
135	27527.7
140	27521.5
145	27518.6

Traverse 3
EM-34 + Magnetic

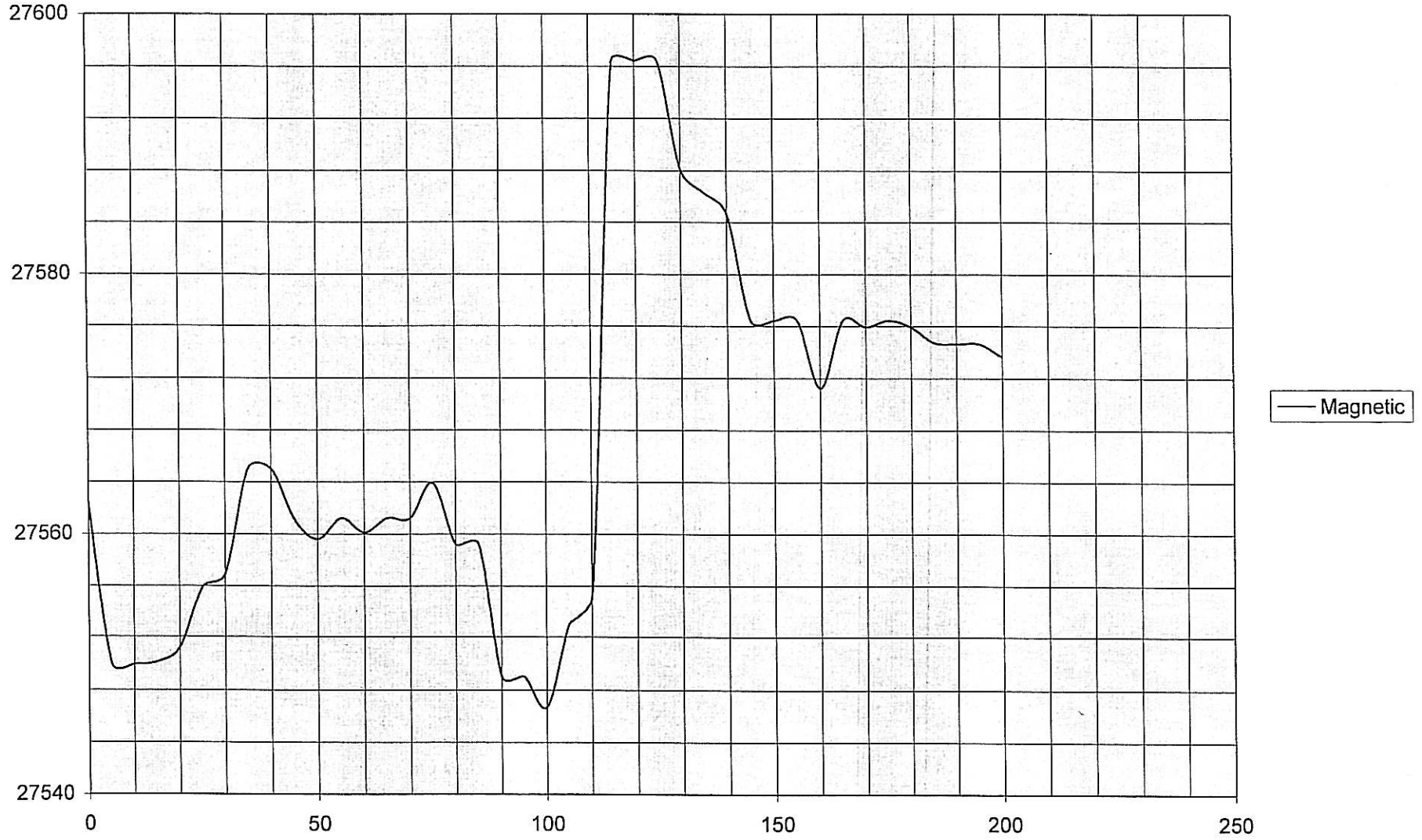
Station	Magnetic	20V	20H	40V	40H
0	27518.6				
5	27516.6				
10	27516.6	21	19		
15	27529.6				
20	27538.1	21	21	29	17
25	27538.8				
30	27543.3	21	18	23	16
35	27543.3				
40	27543.9	21	19	21	13
45	27543.9				
50	27542.6	21	18	23	16
55	27542.6				
60	27539.5	21	11	21	17
65	27539.5				
70	27542	21	15	18.5	18.5
75	27542				
80	27547.1	20	20	20	21
85	27550.2				
90	27551.5	20	24	21	18.5
95	27551.5				
100	27542	22	20	23	18.5
105	27555.5				
110	27563.1	29	9	21	15
115	27574.2				
120	27574.2	29	15	19	10
125	27574.2				
130	27523	27	18	25	10
135	27517.2				
140	27517.7	27	20	25	18.5
145	27517.7				

155	27576.4
160	27571.2
165	27576.4
170	27575.9
175	27576.4
180	27575.9
185	27574.7
190	27574.6
195	27574.6
200	27573.6

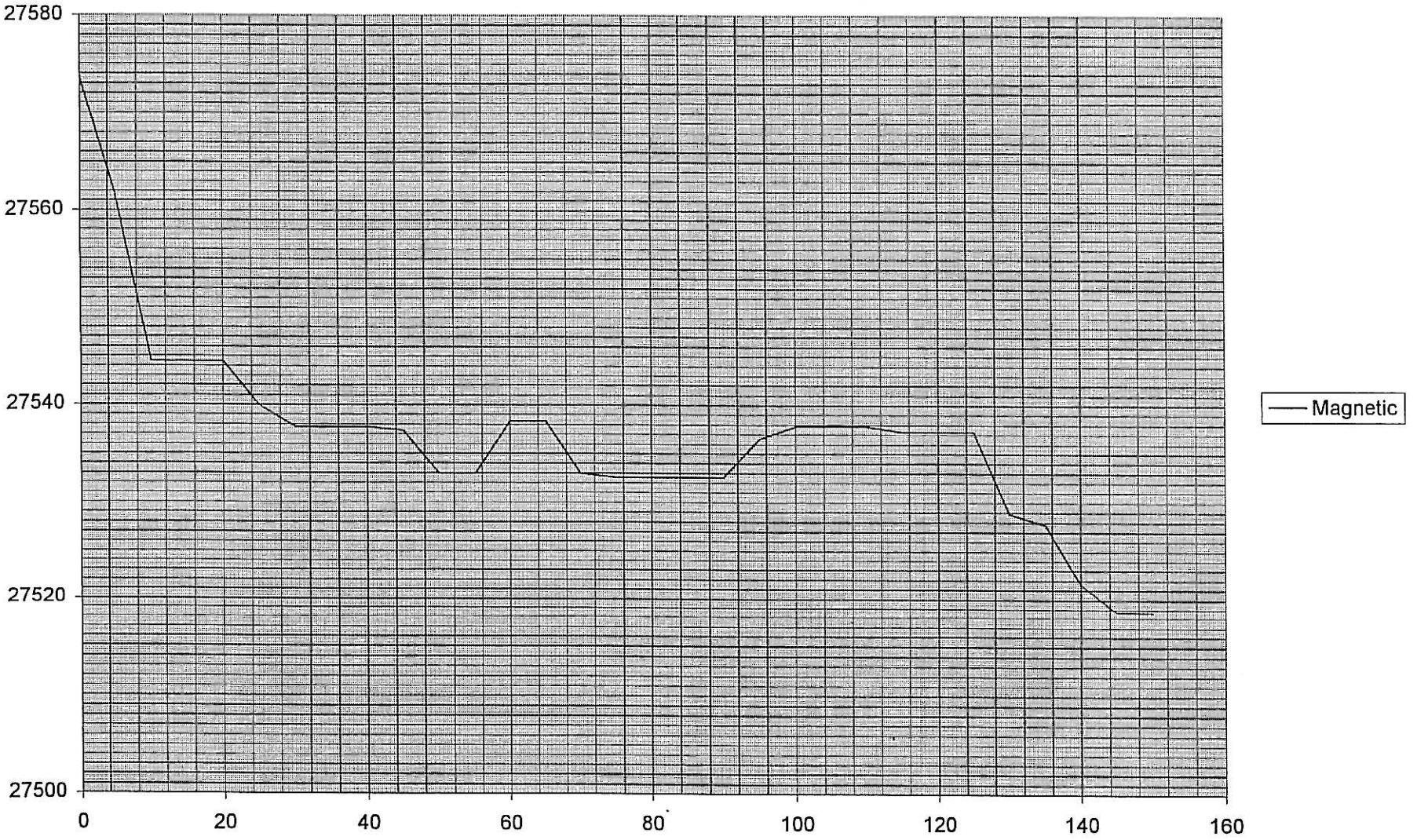
150	27518.6

150	27507.9	26	20	24	13
155	27507.9				
160	27527.8	25	17	20	12
165	27527.8				
170	27527.8	23	18	21	10
175	27529.1				
180	27529.1	23	20	20	15
185	27519.1				
190	27519.1	21	16	20	13
195	27521.3				
200	27528	20	20	15	19
205	27533.5				
210	27533.5	19	16	19	14
215	27518.3				
220	27518.3	21	14	14	13
225	27507.6				
230	27507.6	21	18	13	11
235	27507.6				
240	27513.5	22	18	11	11
245	27518.9				
250	27533.4	21	13	11	10
255	27533.4				
260	27532.8	23	13	21	15
265	27532				
270	27532	23	13	23	12
275	27534.9				
280	27534.9	28	15	25	15
285	27534.2				
290	27527.7	25	12		
295	27528.9				
300	27528.9	29			

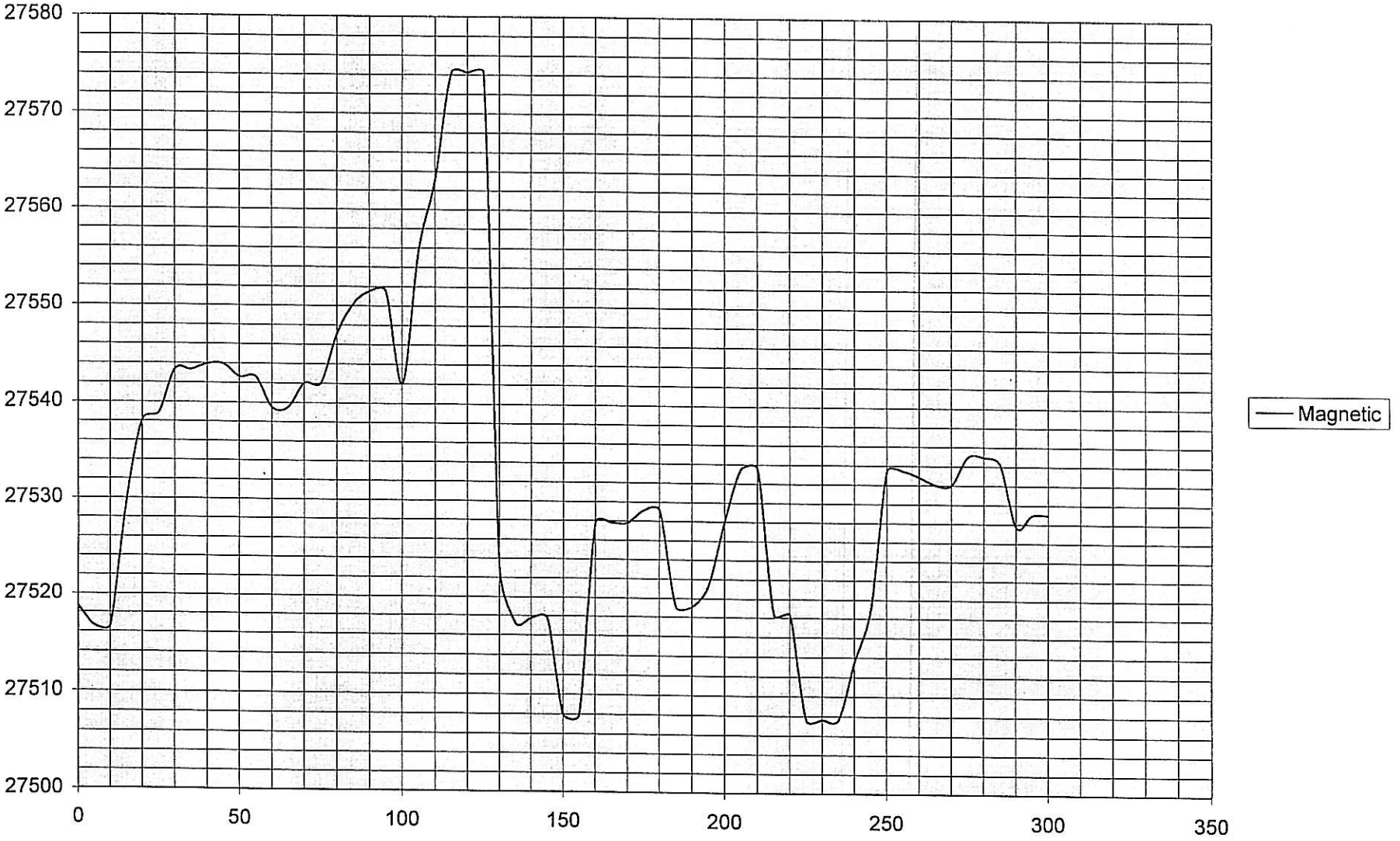
Tsolo Magnetic Traverse 1



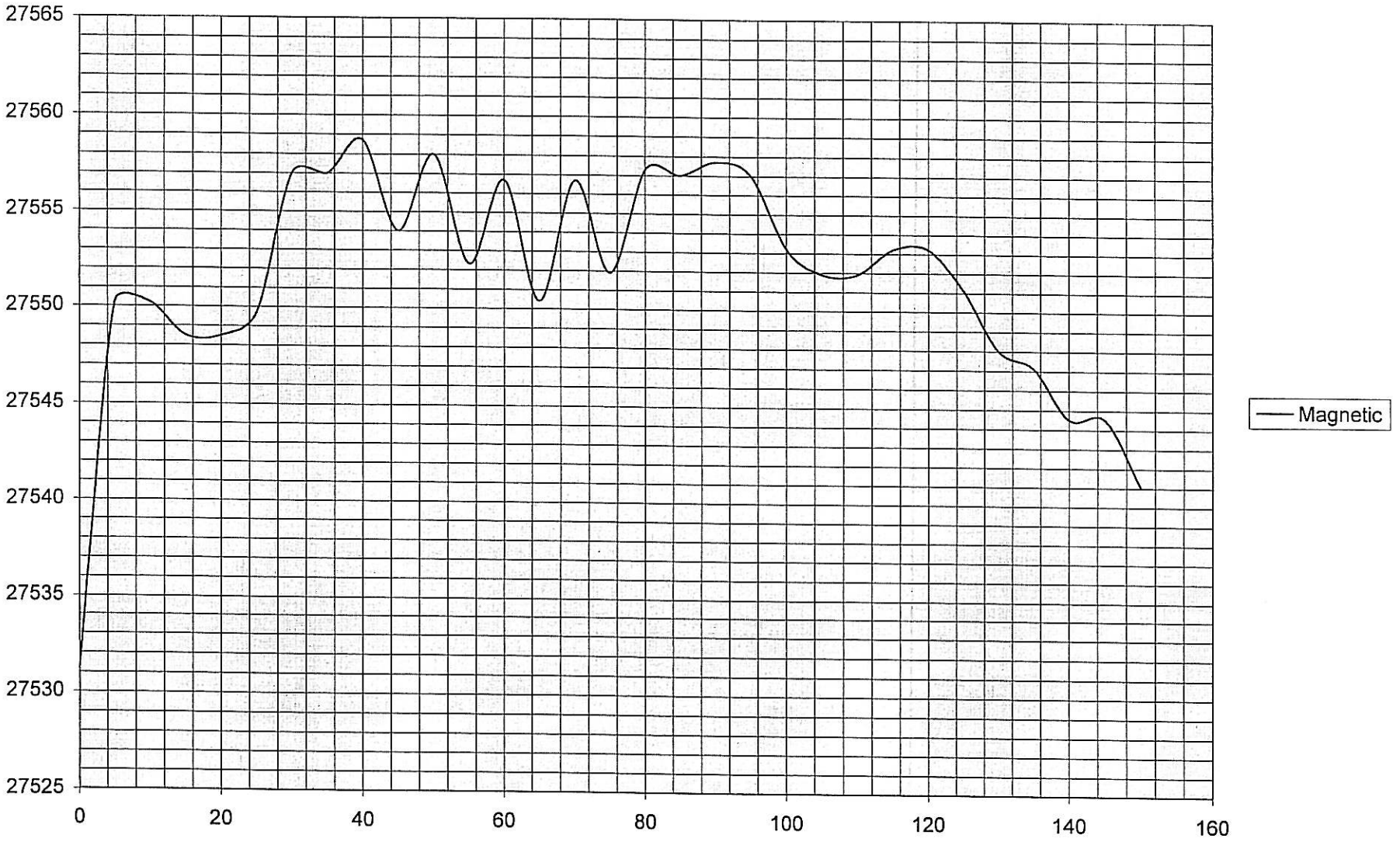
Tsolo Magnetic, Traverse 2



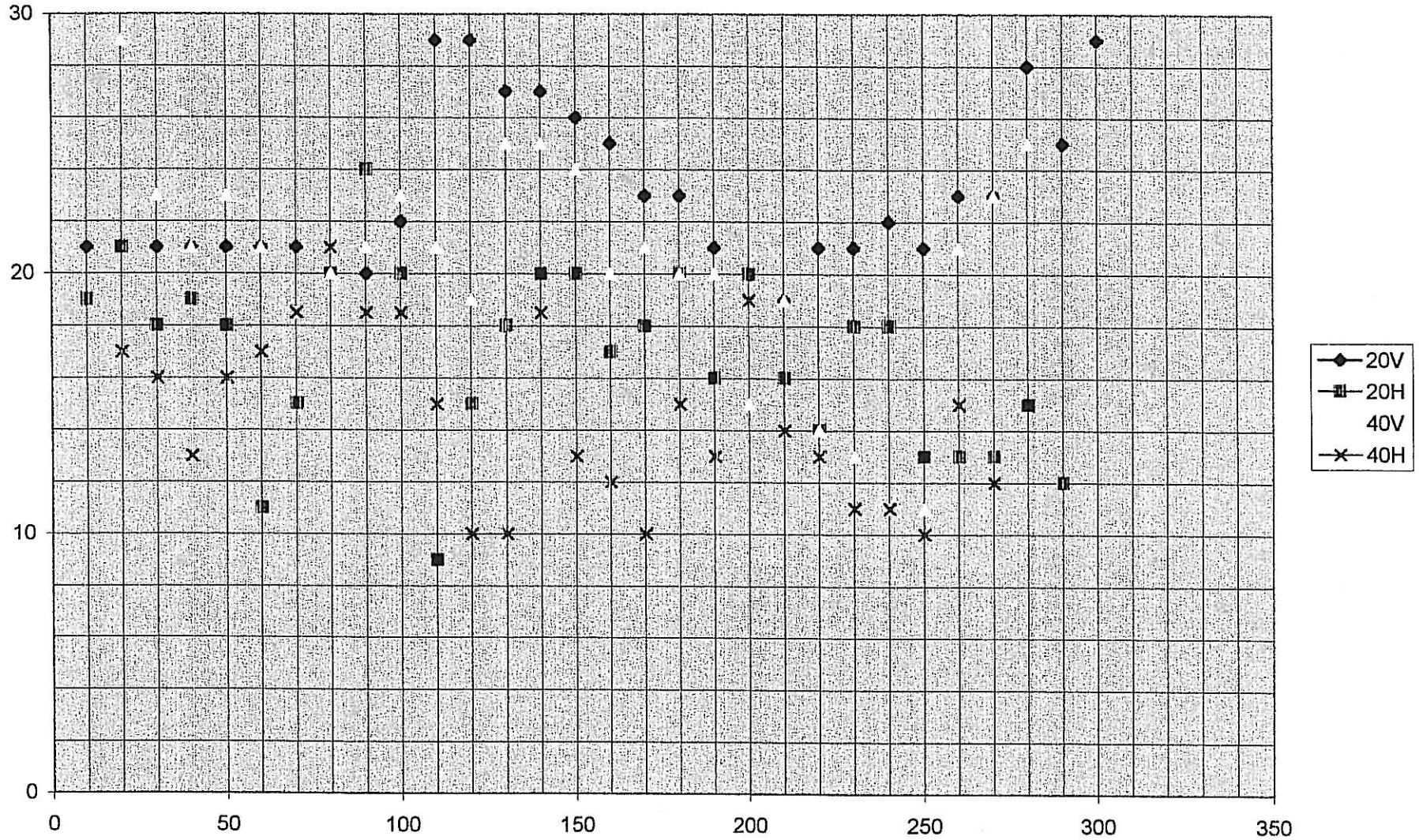
Tsolo Magnetic, Traverse 3



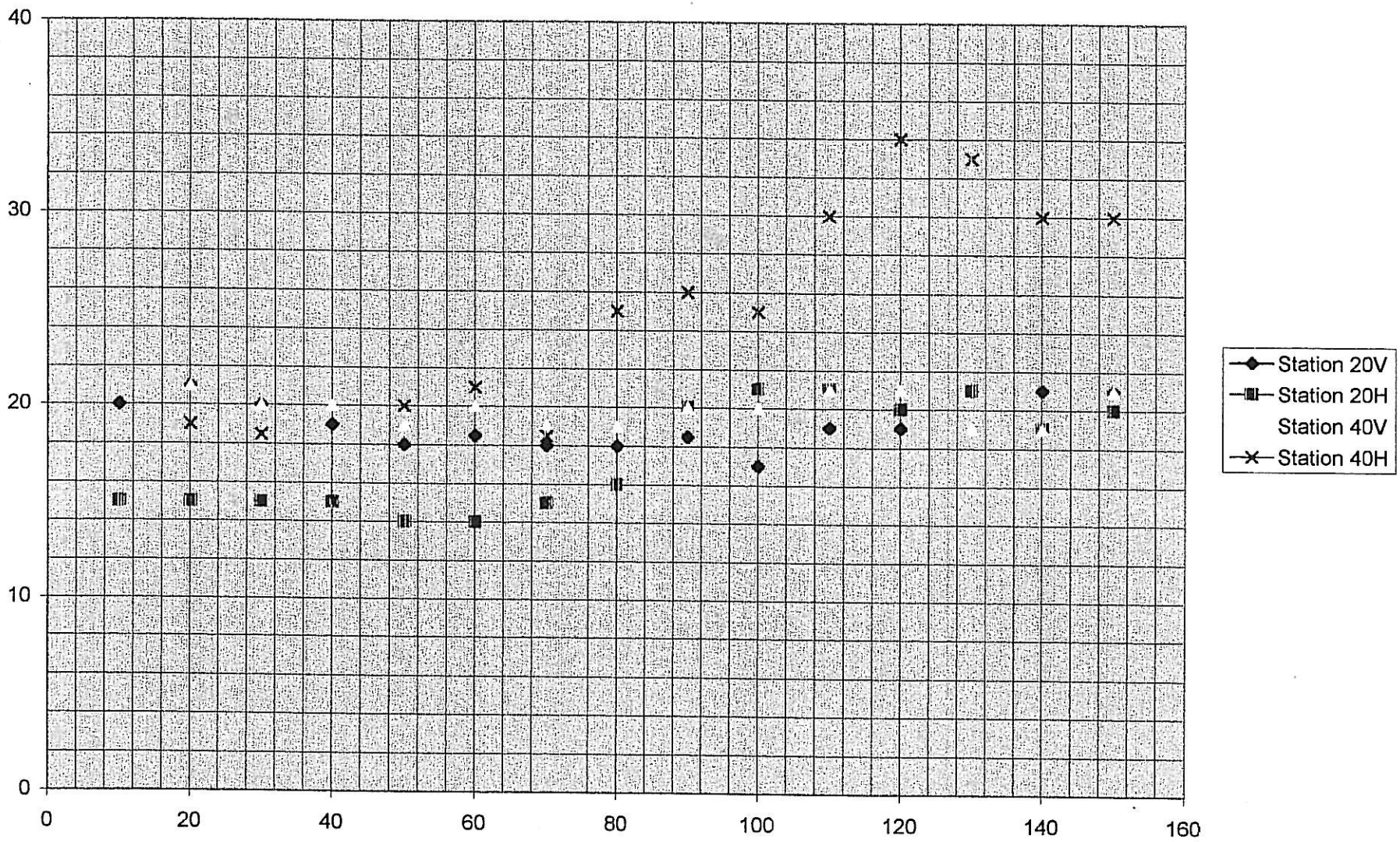
Tsolo Magnetic Traverse 4



Tsolo EM-34, Traverse 3



Tsolo EM-34, Traverse 4



APPENDIX C: WATER CHEMISTRY RESULTS

Chemical analyses of water

Borehole No.	Stream upstream						
Project	Tsolo						
District	0.00						
Constituent (mg/l)	Tested	Class	Class 0	Class 1	Class 2	Class 3	Class 4
TDS		-	450	1000	2400	3400	3400
pH	8.06	0	5-9.5	4.5-5 or 9.5-10	4-4.5 or 10-10.5	3-4 or 10.5-11	<3 or >11
Turbidity (NTU)	47.50	3	0.10	1.00	20.00	50.00	50.00
EC (mS/m)	80.60	1	70	150	370	520	520
Alkalinity	180.00						
Total hardness (T.H.)	175.00	0	200	300	600	600	600
Calcium (Ca)	36.30	0	80	150	300	300	300
Magnesium (Mg)	20.80	0	70	100	200	400	400
Sodium (Na)	62.20	0	100	200	400	1000	1000
Iron (Fe)	1.70	2	0.50	1.00	5.00	10.00	10.00
Manganese (Mn)		-	0.10	0.40	4.00	10.00	10.00
Nitrate (as N)	0.40	0	6	10	20	40	40
Chloride (Cl)	81.20	0	100	200	600	1200	1200
Fluoride (F)	0.62	0	0.70	1.00	1.50	3.50	3.50
Sulphate (SO4)	30.30	0	200	400	600	1000	1000
Total coliforms (T.col)	20.00	2	0	10	100	1000	1000
Faecal coliforms (Fc)	0.00	-	0	1	10	100	100
Potassium (K)	1.89	0	25	50	100	500	500
Zinc (Zn)		-	3	5	10	20	20
Arsenic (As)		-	0.01	0.05	0.20	2.00	2.00
Cadmium (Cd)		-	0.00	0.01	0.02	0.05	0.05
Copper (Cu)		-	1.00	1.30	2.00	15.00	15.00

Class of water 3

Nitrate (as N)*4.42 = Nitrate (as NO3)

Class 0	Ideal water quality-suitable for lifetime use.
Class 1	Good water quality-suitable for use, rare instances of negative effects.
Class 2	Marginal water quality-conditionally acceptable. Negative effects may occur in some sensitive groups.
Class 3	Poor water quality-unsuitable for use without treatment. Chronic effects may occur.
Class 4	Dangerous water quality-totally unsuitable for use. Acute effects may occur.

Class 0	Drinking health :	No effects, suitable for many generations.
	Drinking Aesthetic :	Waters is pleasing.
	Food preparation :	No effects.
	Bathing :	No effects.
	Laundry :	No effects.
Class 1	Drinking health :	Suitable for lifetime use. Rare instances of sub-clinical effects.
	Drinking Aesthetic :	Some aesthetic effects may be apparent.
	Food preparation :	Suitable for lifetime use.
	Bathing :	Minor effects on bathing or on bathing or on bath fixtures.
	Laundry :	Minor effects on laundry or on fixtures.
Class 2	Drinking health :	May be used without health effects by majority of individuals of all ages, but may cause effects in some individuals in sensitive groups. Some effects possible after lifetime use
	Drinking Aesthetic :	Poor taste and appearance are noticeable.
	Food preparation :	May be used without health or aesthetic effects by the majority persons
	Bathing :	Slight effects on bathing or on bath fixtures.
	Laundry :	Slight effects on bathing or on bath fixtures.
Class 3	Drinking health :	Poses a risk of chronic health effects, especially in babies, children and the elderly.
	Drinking Aesthetic :	Bad taste and appearance may lead to rejection of the water.
	Food preparation :	Poses a risk of chronic health effects, especially in children and elderly
	Bathing :	Significant effects on bathing or on bath fixtures.
	Laundry :	Significant effects on laundry or on fixtures.
Class 4	Drinking health :	Severe acute health effects, even with short-term use.
	Drinking Aesthetic :	Taste and appearance will lead to rejection of the water.
	Food preparation :	Severe acute health effects, even with short-term use.
	Bathing :	Serious effects on bathing or on bath fixtures.
	Laundry :	Serious effects on bathing or on bath fixtures.

Comments

Chemical analyses of water

Borehole No.	Stream: Gqwede						
Project	Tsolo						
District	0.00						
Constituent (mg/l)	Tested	Class	Class 0	Class 1	Class 2	Class 3	Class 4
TDS		-	450	1000	2400	3400	3400
pH	7.54	0	5-9.5	4.5-5 or 9.5-10	4-4.5 or 10-10.5	3-4 or 10.5-11	<3 or >11
Turbidity (NTU)	2.00	2	0.10	1.00	20.00	50.00	50.00
EC (mS/m)	165.50	2	70	150	370	520	520
Alkalinity	248.00						
Total hardness (T.H.)	243.00	1	200	300	600	600	600
Calcium (Ca)	29.50	0	80	150	300	300	300
Magnesium (Mg)	41.10	0	70	100	200	400	400
Sodium (Na)	121.50	1	100	200	400	1000	1000
Iron (Fe)	0.01	0	0.50	1.00	5.00	10.00	10.00
Manganese (Mn)		-	0.10	0.40	4.00	10.00	10.00
Nitrate (as N)	0.60	0	6	10	20	40	40
Chloride (Cl)	177.20	1	100	200	600	1200	1200
Fluoride (F)	0.83	1	0.70	1.00	1.50	3.50	3.50
Sulphate (SO4)	31.60	0	200	400	600	1000	1000
Total coliforms (T.col)	60.00	2	0	10	100	1000	1000
Faecal coliforms (Fc)	14.00	3	0	1	10	100	100
Potassium (K)	1.94	0	25	50	100	500	500
Zinc (Zn)		-	3	5	10	20	20
Arsenic (As)		-	0.01	0.05	0.20	2.00	2.00
Cadmium (Cd)		-	0.00	0.01	0.02	0.05	0.05
Copper (Cu)		-	1.00	1.30	2.00	15.00	15.00

Class of water: 3

Nitrate (as N)*4.42 = Nitrate (as NO3)

Class 0	Ideal water quality-suitable for lifetime use.
Class 1	Good water quality-suitable for use, rare instances of negative effects.
Class 2	Marginal water quality-conditionally acceptable. Negative effects may occur in some sensitive groups.
Class 3	Poor water quality-unsuitable for use without treatment. Chronic effects may occur.
Class 4	Dangerous water quality-totally unsuitable for use. Acute effects may occur.

Class 0	Drinking health :	No effects, suitable for many generations.
	Drinking Aesthetic :	Waters is pleasing.
	Food preparation :	No effects.
	Bathing :	No effects.
	Laundry :	No effects.
Class 1	Drinking health :	Suitable for lifetime use. Rare instances of sub-clinical effects.
	Drinking Aesthetic :	Some aesthetic effects may be apparent.
	Food preparation :	Suitable for lifetime use.
	Bathing :	Minor effects on bathing or on bath fixtures.
	Laundry :	Minor effects on laundry or on fixtures.
Class 2	Drinking health :	May be used without health effects by majority of individuals of all ages, but may cause effects in some individuals in sensitive groups.
	Drinking Aesthetic :	Some effects possible after lifetime use
	Food preparation :	Poor taste and appearance are noticeable.
	Bathing :	May be used without health or aesthetic effects by the majority persons
	Laundry :	Slight effects on bathing or on bath fixtures.
		Slight effects on bathing or on bath fixtures.
Class 3	Drinking health :	Poses a risk of chronic health effects, especially in babies, children and the elderly.
	Drinking Aesthetic :	Bad taste and appearance may lead to rejection of the water.
	Food preparation :	Poses a risk of chronic health effects, especially in children and elderly
	Bathing :	Significant effects on bathing or on bath fixtures.
	Laundry :	Significant effects on laundry or on fixtures.
Class 4	Drinking health :	Severe acute health effects, even with short-term use.
	Drinking Aesthetic :	Taste and appearance will lead to rejection of the water.
	Food preparation :	Severe acute health effects, even with short-term use.
	Bathing :	Serious effects on bathing or on bath fixtures.
	Laundry :	Serious effects on bathing or on bath fixtures.

Comments

Chemical analyses of water

Borehole No.	Maqungo						
Project	Tsolo						
District	0.00						
Constituent (mg/l)	Tested	Class	Class 0	Class 1	Class 2	Class 3	Class 4
TDS		-	450	1000	2400	3400	3400
pH	7.31	0	5-9.5	4.5-5 or 9.5-10	4-4.5 or 10-10.5	3-4 or 10.5-11	<3 or >11
Turbidity (NTU)	2.50	2	0.10	1.00	20.00	50.00	50.00
EC (mS/m)	153.50	2	70	150	370	520	520
Alkalinity	244.00						
Total hardness (T.H.)	413.00	2	200	300	600	600	600
Calcium (Ca)	81.70	1	80	150	300	300	300
Magnesium (Mg)	50.80	0	70	100	200	400	400
Sodium (Na)	71.00	0	100	200	400	1000	1000
Iron (Fe)	0.09	0	0.50	1.00	5.00	10.00	10.00
Manganese (Mn)		-	0.10	0.40	4.00	10.00	10.00
Nitrate (as N)	1.50	0	6	10	20	40	40
Chloride (Cl)	2.06	0	100	200	600	1200	1200
Fluoride (F)	0.63	0	0.70	1.00	1.50	3.50	3.50
Sulphate (SO4)	38.40	0	200	400	600	1000	1000
Total coliforms (T.col)	0.00	-	0	10	100	1000	1000
Faecal coliforms (Fc)	0.00	-	0	1	10	100	100
Potassium (K)	0.90	0	25	50	100	500	500
Zinc (Zn)		-	3	5	10	20	20
Arsenic (As)		-	0.01	0.05	0.20	2.00	2.00
Cadmium (Cd)		-	0.00	0.01	0.02	0.05	0.05
Copper (Cu)		-	1.00	1.30	2.00	15.00	15.00

Class of water: 2

Nitrate (as N)*4.42 = Nitrate (as NO3)

Class 0	Ideal water quality-suitable for lifetime use.
Class 1	Good water quality-suitable for use, rare instances of negative effects.
Class 2	Marginal water quality-conditionally acceptable. Negative effects may occur in some sensitive groups.
Class 3	Poor water quality-unsuitable for use without treatment. Chronic effects may occur.
Class 4	Dangerous water quality-totally unsuitable for use. Acute effects may occur.

Class 0	Drinking health :	No effects, suitable for many generations.
	Drinking Aesthetic :	Waters is pleasing.
	Food preparation :	No effects.
	Bathing :	No effects.
	Laundry :	No effects.
Class 1	Drinking health :	Suitable for lifetime use. Rare instances of sub-clinical effects.
	Drinking Aesthetic :	Some aesthetic effects may be apparent.
	Food preparation :	Suitable for lifetime use.
	Bathing :	Minor effects on bathing or on bathing or on bath fixtures.
	Laundry :	Minor effects on laundry or on fixtures.
Class 2	Drinking health :	May be used without health effects by majority of individuals of all ages, but may cause effects in some individuals in sensitive groups. Some effects possible after lifetime use
	Drinking Aesthetic :	Poor taste and appearance are noticeable.
	Food preparation :	May be used without health or aesthetic effects by the majority persons
	Bathing :	Slight effects on bathing or on bath fixtures.
	Laundry :	Slight effects on bathing or on bath fixtures.
Class 3	Drinking health :	Poses a risk of chronic health effects, especially in babies, children and the elderly.
	Drinking Aesthetic :	Bad taste and appearance may lead to rejection of the water.
	Food preparation :	Poses a risk of chronic health effects, especially in children and elderly
	Bathing :	Significant effects on bathing or on bath fixtures.
	Laundry :	Significant effects on laundry or on fixtures.
Class 4	Drinking health :	Severe acute health effects, even with short-term use.
	Drinking Aesthetic :	Taste and appearance will lead to rejection of the water.
	Food preparation :	Severe acute health effects, even with short-term use.
	Bathing :	Serious effects on bathing or on bath fixtures.
	Laundry :	Serious effects on bathing or on bath fixtures.

Comments

Chemical analyses of water

Borehole No.	Stream: downstream						
Project	Tsolo						
District	0.00						
Constituent (mg/l)	Tested	Class	Class 0	Class 1	Class 2	Class 3	Class 4
TDS		-	450	1000	2400	3400	3400
pH	7.54	0	5-9.5	4.5-5 or 9.5-10	4-4.5 or 10-10.5	3-4 or 10.5-11	<3 or >11
Turbidity (NTU)	2.00	2	0.10	1.00	20.00	50.00	50.00
EC (mS/m)	165.50	2	70	150	370	520	520
Alkalinity	248.00						
Total hardness (T.H.)	243.00	1	200	300	600	600	600
Calcium (Ca)	74.00	0	80	150	300	300	300
Magnesium (Mg)	41.10	0	70	100	200	400	400
Sodium (Na)	121.50	1	100	200	400	1000	1000
Iron (Fe)	<0.01	4	0.50	1.00	5.00	10.00	10.00
Manganese (Mn)		-	0.10	0.40	4.00	10.00	10.00
Nitrate (as N)	0.60	0	6	10	20	40	40
Chloride (Cl)	177.20	1	100	200	600	1200	1200
Fluoride (F)	0.83	1	0.70	1.00	1.50	3.50	3.50
Sulphate (SO4)	31.60	0	200	400	600	1000	1000
Total coliforms (T.col)	60.00	2	0	10	100	1000	1000
Faecal coliforms (Fc)	14.00	3	0	1	10	100	100
Potassium (K)	1.84	0	25	50	100	500	500
Zinc (Zn)		-	3	5	10	20	20
Arsenic (As)		-	0.01	0.05	0.20	2.00	2.00
Cadmium (Cd)		-	0.00	0.01	0.02	0.05	0.05
Copper (Cu)		-	1.00	1.80	2.00	15.00	15.00

Class of water: 4

Nitrate (as N)*4.42 = Nitrate (as NO3)

Class 0	Ideal water quality-suitable for lifetime use.
Class 1	Good water quality-suitable for use, rare instances of negative effects.
Class 2	Marginal water quality-conditionally acceptable. Negative effects may occur in some sensitive groups.
Class 3	Poor water quality-unsuitable for use without treatment. Chronic effects may occur.
Class 4	Dangerous water quality-totally unsuitable for use. Acute effects may occur.

Class 0	Drinking health :	No effects, suitable for many generations.
	Drinking Aesthetic :	Waters is pleasing.
	Food preparation :	No effects.
	Bathing :	No effects.
	Laundry :	No effects.
Class 1	Drinking health :	Suitable for lifetime use. Rare instances of sub-clinical effects.
	Drinking Aesthetic :	Some aesthetic effects may be apparent.
	Food preparation :	Suitable for lifetime use.
	Bathing :	Minor effects on bathing or on bath fixtures.
	Laundry :	Minor effects on laundry or on fixtures.
Class 2	Drinking health :	May be used without health effects by majority of individuals of all ages, but may cause effects in some individuals in sensitive groups. Some effects possible after lifetime use
	Drinking Aesthetic :	Poor taste and appearance are noticeable.
	Food preparation :	May be used without health or aesthetic effects by the majority persons
	Bathing :	Slight effects on bathing or on bath fixtures.
	Laundry :	Slight effects on bathing or on bath fixtures.
Class 3	Drinking health :	Poses a risk of chronic health effects, especially in babies, children and the elderly.
	Drinking Aesthetic :	Bad taste and appearance may lead to rejection of the water.
	Food preparation :	Poses a risk of chronic health effects, especially in children and elderly
	Bathing :	Significant effects on bathing or on bath fixtures.
	Laundry :	Significant effects on laundry or on fixtures.
Class 4	Drinking health :	Severe acute health effects, even with short-term use.
	Drinking Aesthetic :	Taste and appearance will lead to rejection of the water.
	Food preparation :	Severe acute health effects, even with short-term use.
	Bathing :	Serious effects on bathing or on bath fixtures.
	Laundry :	Serious effects on bathing or on bath fixtures.

Comments

APPENDIX D: SOIL PROFILE

East London, 5201
P.O. Box 346
East London, 5200
Tel: (043) 722 8565 / 722 5420
Fax: (043) 743 9942

CK 90/12841/23

SOILKOTE LAB CC

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

Port Elizabeth
Tel: (041) 461 1832
Fax: (041) 461 1834
Cape Town
Tel: (021) 469 9111
Fax: (021) 423 1079

CLIENT: Khulani VSA Groundwater Consultants
P O Box 15036
BEACON BAY
5205

ATT : Mr M Madikizela

PROJECT: TSOLO WATER DISPOSAL SITE

DATE: 20-03-2003
REF: 23345

FOUNDATION INDICATOR RESULT SUMMARY

SAMPLE NO:	1248	1249	1250	1251	1252	1253
POSITION	TP 1	TP 2	TP 2	TP 3	TP 4	TP 4
DEPTH:	600-1000	300-600	600-1000	350-600	650-1050	1050-1450
DESCRIPTION:	dk G	dk G	lt G	dk Br	lt G	Pale R
	Ss +	sdy cl +	Ss +	sdy cl +	sdy cl +	Siltstone +
	cly s	Ferr	cly s	Ferr	Ferr	cly s
SIEVE ANALYSIS						
% PASSING 75 mm			87			100
37.5 mm	100	100	60			70
19 mm	73	94	40	100		45
9.5 mm	55	93	32	98	100	32
4.75 mm	46	90	27	95	96	23
2.36 mm	41	83	25	92	88	16
1.18 mm	39	78	24	90	80	13
0.600 mm	38	77	24	89	79	12
0.425 mm	37	76	22	89	78	11
0.300 mm	36	76	21	88	78	11
0.150 mm	32	71	16	81	73	11
0.075 mm	27	66	13	71	67	10
MECHANICAL ANALYSIS						
0.06 mm	20	55	10	55	63	8
0.02 mm	15	46	7	38	50	6
0.006 mm	12	38	6	28	40	4
0.002 mm	8	33	4	20	32	3
SOIL CONSTANTS						
LIQUID LIMIT	38	55	38	43	54	51
PLASTICITY INDEX	17	29	18	26	32	28
LINEAR SHRINKAGE	8.5	14.5	9.0	13.0	16.0	14.0
C B R						
MOD AASHTO	2030	1676			1615	2104
O M C %	10.9	19.0			21.4	8.7
CBR @ 100% COMPACTION	65	3			2	28
CBR @ 98% COMPACTION	61	3			2	24
CBR @ 95% COMPACTION	58	2			2	18
CBR @ 93% COMPACTION	35	2			2	15
CBR @ 90% COMPACTION	13	2			2	12
% SWELL	0.37	3.76			8.30	2.12
POTENTIAL EXPANSIVENESS						
PI WHOLE SAMPLE	6.3	22.0	4.0	23.1	25.0	3.1
ACTIVITY	0.7-1.0	0.6-0.7	1.6	1.0-2.0	0.7-1.0	1.0
POTENTIAL EXPANSIVENESS	Low	Med	Low	Med	High	Low

Checked By: MLP

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Tel: (021) 469 9111
Fax: (021) 423 1079

CLIENT: Khulani VSA Groundwater Cons
P O Box 15036
BEACON BAY
5205

ATT : Mr M Madikizela

PROJECT: TSOLO WATER DISPOSAL SITE

DATE: 20-03-2003

REF: 23345

VARIABLE HEAD PERMEABILITY TEST RESULTS

POSITION	TP 1	DEPTH mm	600-1000
DESCRIPTION	dk G Ss + cly s	FIELD MOISTURE : %	N/A
INSITU DENSITY : kg / m3	N/A	REMOULDED DENSITY : kg / m3	1858
MOD A.A.S.H.T.O / OMC	2030/10.9	PERCENTAGE COMPACTION	91.5
RELATIVE DENSITY		POROSITY	
PERMEABILITY : cm / second	2.48×10^{-5}		

POSITION	TP 2	DEPTH mm	300-600
DESCRIPTION	dk G sdy cl +Ferr	FIELD MOISTURE : %	
INSITU DENSITY : kg / m3		REMOULDED DENSITY : kg / m3	1518
MOD A.A.S.H.T.O / OMC	1676/19.0	PERCENTAGE COMPACTION	90.6
RELATIVE DENSITY		POROSITY	
PERMEABILITY : cm / second	3.66×10^{-6}		

POSITION	TP 4	DEPTH mm	650-1050
DESCRIPTION	lt G sdy cl + Ferr	FIELD MOISTURE : %	
INSITU DENSITY : kg / m3		REMOULDED DENSITY : kg / m3	1460
MOD A.A.S.H.T.O / OMC	1615/21.4	PERCENTAGE COMPACTION	90.4
RELATIVE DENSITY		POROSITY	
PERMEABILITY : cm / second	6.57×10^{-6}		

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CLIENT: Khulani VSA Groundwater Cons
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BEACON BAY
5205

ATT : Mr M Madikizela

PROJECT: TSOLO WATER DISPOSAL SITE

DATE: 20-03-2003

REF: 23345

VARIABLE HEAD PERMEABILITY TEST RESULTS

POSITION	TP 4	DEPTH mm	1050-1450
DESCRIPTION	Pale R Siltstone + cly s	FIELD MOISTURE :,%	N/A
INSITU DENSITY : kg / m3	N/A	REMOULDED DENSITY : kg / m3	1894
MOD A.A.S.H.T.O / OMC	2104/8.7	PERCENTAGE COMPACTION	90
RELATIVE DENSITY		POROSITY	
PERMEABILITY : cm / second	4.35×10^{-4}		

POSITION		DEPTH mm	
DESCRIPTION		FIELD MOISTURE : %	
INSITU DENSITY : kg / m3		REMOULDED DENSITY : kg / m3	
MOD A.A.S.H.T.O / OMC		PERCENTAGE COMPACTION	
RELATIVE DENSITY		POROSITY	
PERMEABILITY : cm / second			

POSITION		DEPTH mm	
DESCRIPTION		FIELD MOISTURE : %	
INSITU DENSITY : kg / m3		REMOULDED DENSITY : kg / m3	
MOD A.A.S.H.T.O / OMC		PERCENTAGE COMPACTION	
RELATIVE DENSITY		POROSITY	
PERMEABILITY : cm / second			

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TEST PIT PROFILE LOG DATA

CLIENT	Khulani VSA Groundwater Consult.	TRIAL PIT NO:	TP 1
PROJECT:	WASTE DISPOSAL SITE	DATE LOGGED:	26-02-2003
	TSOLO	MACHINE:	TLB
ATT:	Mr M Madikizela	REF: NO.:	23345

Depth (m)	Description (Jennings)
0.0 – 0.6	Moist, light Brown, stiff, fissured, sandy silt :Transported
0.6 – 1.0	Moist, dark Grey, firm, fissured, clayey silt :Transported
1.0 – 1.7	Moist, dark Grey, very hard, fractured, Sandstone + clayey sand :Residual

Refusal @ 1000mm
No ground water
Disturbed sample 1248 taken between 0.60 & 1.00 metres

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Cape Town
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TEST PIT PROFILE LOG DATA

CLIENT	Khulani VSA Groundwater Consult.	TRIAL PIT NO:	TP 2
PROJECT:	WASTE DISPOSAL SITE	DATE LOGGED:	26-02-2003
	TSOLO	MACHINE:	TLB
ATT:	Mr M Madikizela	REF: NO.:	23345

Depth (m)	Description (Jennings)
0.0 – 0.3	Moist, dark Brown, firm, fissured, sandy silt :Transported
0.3 – 0.6	Very moist, dark Grey, soft, fissured, sandy clay + Ferricrete :Transported
0.6 – 1.0	Moist, light Grey, very hard, fractured, Sandstone + clayey sand :Residual

Refusal @ 1000mm
No ground water
Disturbed sample 1249 taken between 0.30 & 0.60 metres
Disturbed sample 1250 taken between 0.60 & 1.00 metres

East London, 5201
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CK 90/12841/23

CIVIL ENGINEERING MATERIALS AND
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Port Elizabeth
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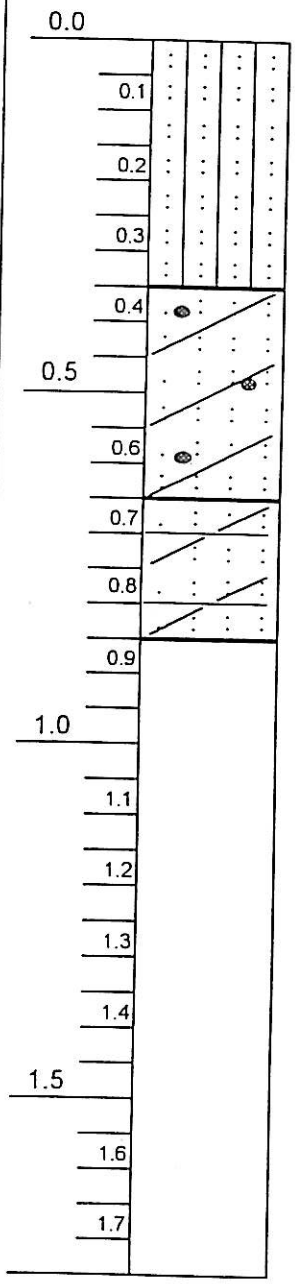
Cape Town
Tel: (021) 469 9111
Fax: (021) 423 1079

TEST PIT PROFILE LOG DATA

CLIENT	Khulani VSA Groundwater Consult.	TRIAL PIT NO:	TP 3
PROJECT:	WASTE DISPOSAL SITE	DATE LOGGED:	26-02-2003
	TSOLO	MACHINE:	TLB
ATT:	Mr M Madikizela	REF: NO.:	23345

Depth (m)	Description (Jennings)
0.0 – 0.4	Moist, dark Brown, firm, fissured, sandy silt :Transported
0.4 – 0.6	Very moist, dark Brown, soft, fissured, sandy clay + Ferricrete :Transported
0.7 – 0.8	Moist, dark Grey, very hard, fractured, Sandstone + clayey sand :Residual



Refusal @ 850mm
No ground water
Disturbed sample 1251 taken between 0.35 & 0.60 metres

P.O. Box 346
East London, 5200
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CK 90/12841/23

CIVIL ENGINEERING MATERIALS AND
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Port Elizabeth
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Cape Town
Tel: (021) 469 9111
Fax: (021) 423 1079

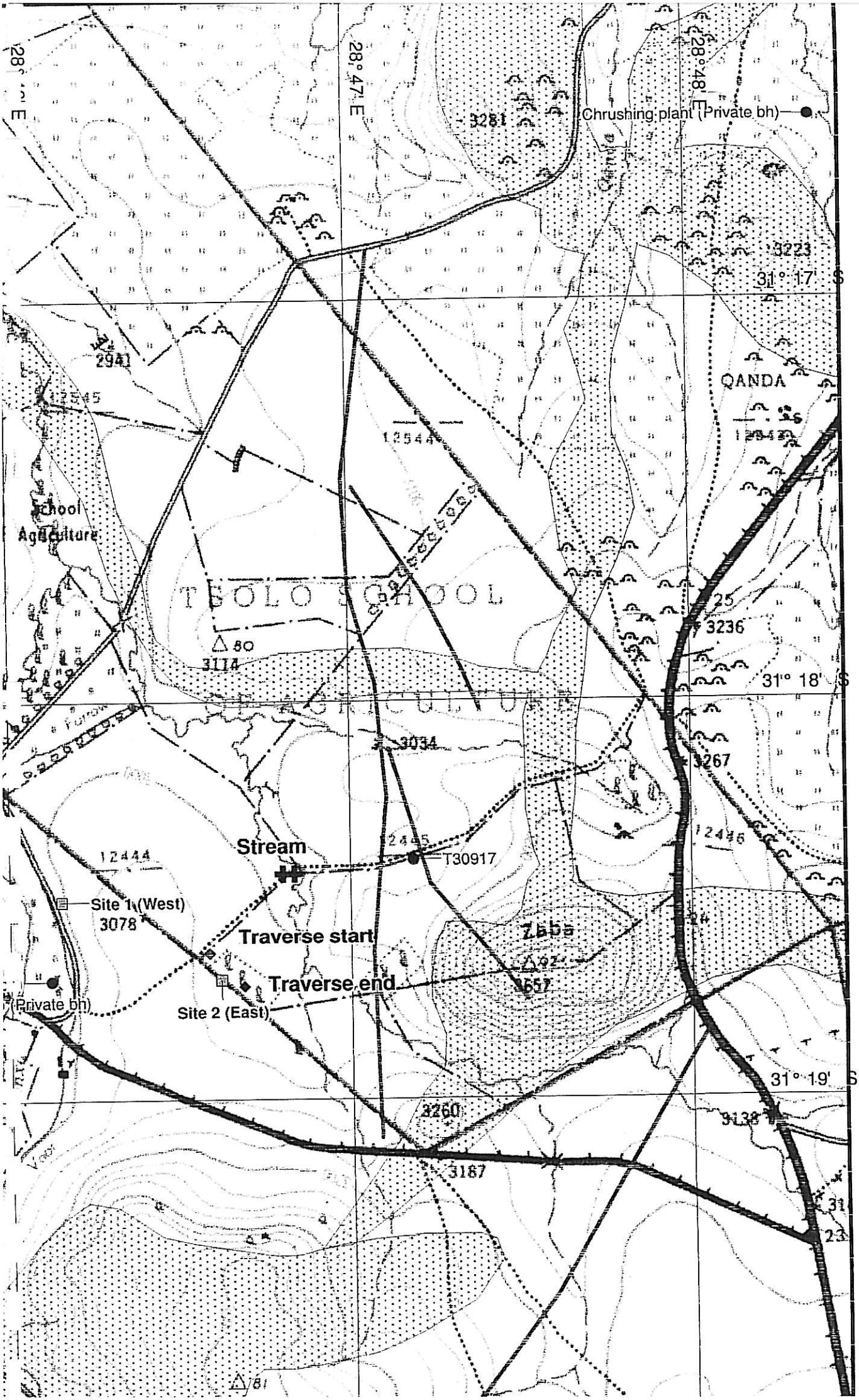
TEST PIT PROFILE LOG DATA

CLIENT	Khulani VSA Groundwater Consult.	TRIAL PIT NO:	TP 4
PROJECT:	WASTE DISPOSAL SITE	DATE LOGGED:	26-02-2003
	TSOLO	MACHINE:	TLB
ATT:	Mr M Madikizela	REF: NO.:	23345

Depth (m)	Description (Jennings)
0.0 – 0.2	Moist, light Brown, firm, fissured, sandy silt :Transported
0.3 – 0.6	Moist, dark Grey, soft, fissured, clayey silt :Transported
0.7 – 1.0	Moist, light Grey, medium dense, fractured, sandy clay + Ferricrete :Transported
1.1 – 1.4	Moist, Pale Red, very hard, fractured, Siltstone + clayey sand :Residual
1.5 – 1.7	

Refusal @ 1450mm
No ground water
Disturbed sample 1251 taken between 0.65 & 1.05 metres
Disturbed sample 1252 taken between 1.05 & 1.45 metres

APPENDIX A: LOCALITY AND GEOLOGICAL MAP


28° 47' E
28° 48' E
Chrushing plant (Private bh)
3281
3223
31° 17' S
2941
12545
QANDA
12544
12543
School
Agriculture
TSOLO SCHOOL
3114
3236
31° 18' S
3034
3267
12445
12444
12446
Stream
T30917
Site 1 (West)
3078
Traverse start
Traverse end
Site 2 (East)
(Private bh)
Zaba
3157
31° 19' S
3260
3138
3187