GROUNDWATER RESOURCE INFORMATION PROJECT
EASTERN CAPE PROVINCE

GROUNDWATER INFORMATION SOURCE REFERENCE SHEET

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A: SOURCE DESCRIPTION

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Ukhahlamba		Cacadu		Alfred Nzo	

Local Municipality: Nkonkobe

Institution where Information is held: AGES EC CC

Branch of Institution: East London

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Report Nr: 2004/02/07/GENV Date: February 2004

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Specify Other:					

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Pump Testing Data		X		
Chemical Water Analysis Data	X			X
Geohydrological Data	X			X
Spring Data	X			X
Remote Sensing Data		X		
Map Data	X			X

Comments:

Reviewed by: F. de Jager Date: 12/3/04 Signed: [signature]

SOUTHERN AFRICA GEOCONSULTANTS (PTY) LTD

GeoCon

FINAL REPORT: **2004/02/07/GENV**

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HYDROGEOLOGICAL & ENGINEERING GEOLOGICAL SURVEY FOR THE CONSTRUCTION OF PIT LATRINES AT UPPER GQUMASHE VILLAGE, NKONKOBE LOCAL MUNICIPALITY - EASTERN CAPE PROVINCE

February 2004

Project team:

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IMPORTANT NOTICE:

Southern Africa GeoConsultants (Pty) Ltd has reached the point, in its more than fifteen year history, where the spectrum of scientific services offered, can no longer be contained in its current structure.

In this regard - Africa Geo-Environmental Services Pty Ltd – AGES , is becoming the name under which all Geo-Environmental services will be offered throughout Africa, from our offices based in South Africa as well as in Namibia and Zambia.

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Project report: **2004/02/07/GENV**

HYDROGEOLOGICAL & ENGINEERING GEOLOGICAL SURVEY FOR THE CONSTRUCTION OF PIT LATRINES AT UPPER GQUMASHE VILLAGE, NKONKOBE LOCAL MUNICIPALITY - EASTERN CAPE PROVINCE

February 2004

Conducted on behalf of:

ATS Rural Development Services
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1 INTRODUCTION

1.1 General

A detailed hydrogeological and engineering geological investigation was conducted at Upper Gqumashe village in the Nkonkobe local municipality of the Amatola district municipality, with the aim of determining and evaluating the hydrological and engineering geological characteristics of the project area for the construction of proposed VIP latrines.

1.2 Terms of reference

Southern Africa GeoConsultants (PTY) Ltd – hereafter referred to as GeoCon - was appointed by ATS Rural Development Services to carry out a hydrogeological and geotechnical investigation to verify the potential of groundwater pollution from on site sanitation systems and to address technical issues from which decisions can be made regarding appropriate sanitation technology options at Upper Gqumashe village.

The investigation reported on in this report included detailed soil profiling, laboratory analysis of soil samples and in-situ permeability testing. A Desktop Study Sanitation Report in which preliminary terrain verification was discussed along with proposed actions for the detailed investigation preceded this investigation. Phase 1 community awareness creation also formed part of the desktop study phase.

1.2 Scope of investigation

GeoCon was appointed to render the following hydrogeological and engineering geological consultation services in the project area:

- Assessment of groundwater potential
- Evaluation of Groundwater usage
- Geohydrological community awareness creation – Phase 2
- Application of the groundwater protocol for sanitation
- Evaluation of pollution risk
- Geotechnical survey
- Reporting - Delineation of zones where different construction methods will be applicable – e.g. lining of pits, excavatability problems, sensitive areas to be protected from possible pollution, etc.

1.3 Location of study area

The village of Upper Gqumashe is located in the Nkonkobe local municipality of the Amatole district municipality in the Eastern Cape Province, approximately 3.5 km east northeast of the town Alice (Figure 1). The village are situated at an elevation of between 620 and 650 m above mean sea level.

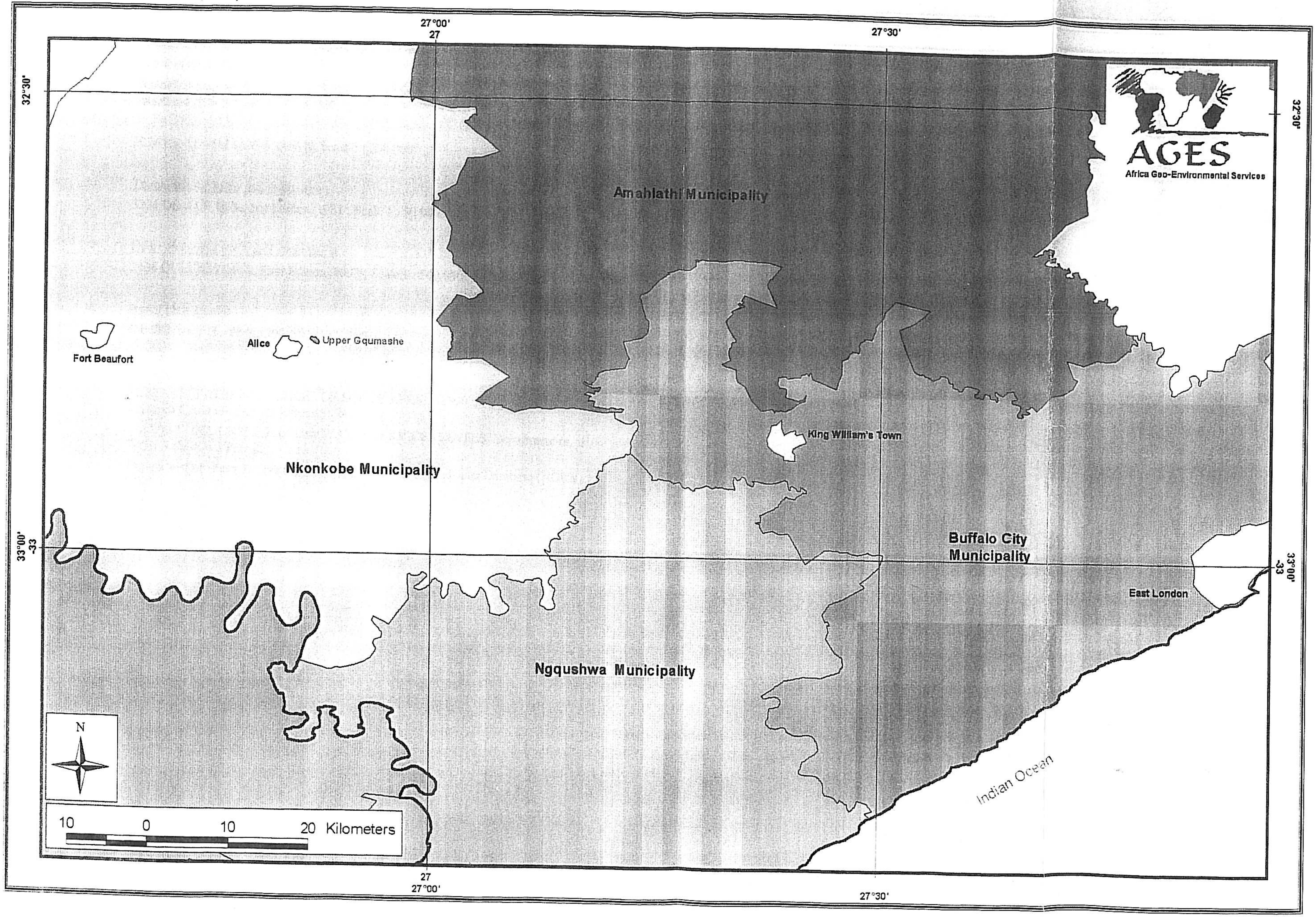
1.4 Available Information

Community liaison and terrain observations were used to verify historical data regarding existing water sources as well as terrain conditions. This was mainly done during the Desktop Study phase preceding this report but additional actions were carried out during site visits that were made during the phase 2 community awareness creation, as well as during the geotechnical surveying. Liaison documentation is attached in Appendix A for reference.

The following sources of information were used during the investigation:

PROJECT: UPPER GQUMASHE SANITATION - PHASE 2

Figure 1: Regional locality map



- Geological maps and information
  - Geological map of the Republic of South Africa and the kingdoms of Lesotho and Swaziland, 1997 ; Scale 1 : 1 000 000
  - 3226 KING WILLIAM'S TOWN; Scale 1 : 250 000
- Topographical maps and information
  - 3226 DD ALICE, Second Edition, 1981 ; Scale 1 : 50 000
- Hydrogeological maps and information
  - 3126 QUEENSTOWN, First Edition, 1997 ; Scale 1 : 500 000
- Aerial photographs
  - Job 981, strip 11, photos 300, 301, 302, Scale 1 : 50 000
- Other information
  - SURFACE WATER RESOURCES OF SOUTH AFRICA 1990, *VOLUME 5*. Water Research Commission, First Edition 1994.
  - Guide to COMMUNITIES and their WATER SERVICES LEVELS, Department of Water Affairs and Forestry; Version 2.
  - Department of Water Affairs and Forestry's National Groundwater Database (NGDB)

2 SITE DESCRIPTION AND INFORMATION

2.1 Site geology and hydrogeological setting

Geology:

According to the geological map, Upper Gqumashe village is underlain by sedimentary rocks of the Balfour formation (Figure 2). This formation is part of the Adelaide subgroup that is part of the Beaufort group of the Karoo Supergroup. These rocks are mainly grey mudstone, shale and sandstone. The sedimentary rocks typically form horizontally orientated alternating rock layers of varying thickness. The formation dips toward the north at an angle between 1 and 3 degrees.

Dolerite, in the form of sills, dykes and sheets intruded the strata during the late Karoo volcanism. A prominent dolerite sill intrusion occurs towards the north of the study area. No prominent faults and shear zones were noted in the study area.

Hydrogeology:

The Queenstown 1 : 500 000 hydrogeological map describes the study area as being underlain by predominantly argillaceous rocks with groundwater expected in intergranular and fractured zones with expected yields of between 0.5 l/s to 2.0 l/s at successful boreholes. The groundwater potential of the study area can be described as *low* to *moderate*.

Soils:

According to the WRC report, SURFACE WATER RESOURCES OF SOUTH AFRICA, referred in paragraph 1.4, the soils in the study area can be described as moderate to deep with a sandy loamy texture with the relief of the area classified as being steep.

2.2 Topography

The study area exhibits morphological elements of typical hillslope development under semi-humid conditions. The village is generally located on the central northern section of a fairly prominent, basically eastwardly trending ridgecrest. Due to the drainage characteristics of the area only a small variety of landforms are present.

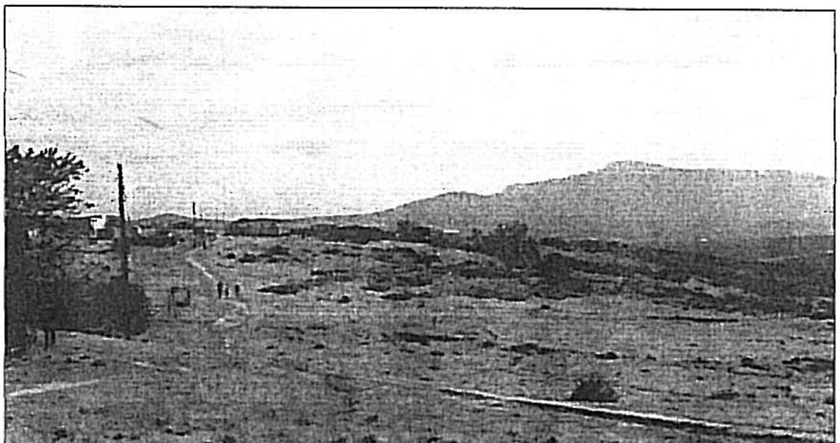
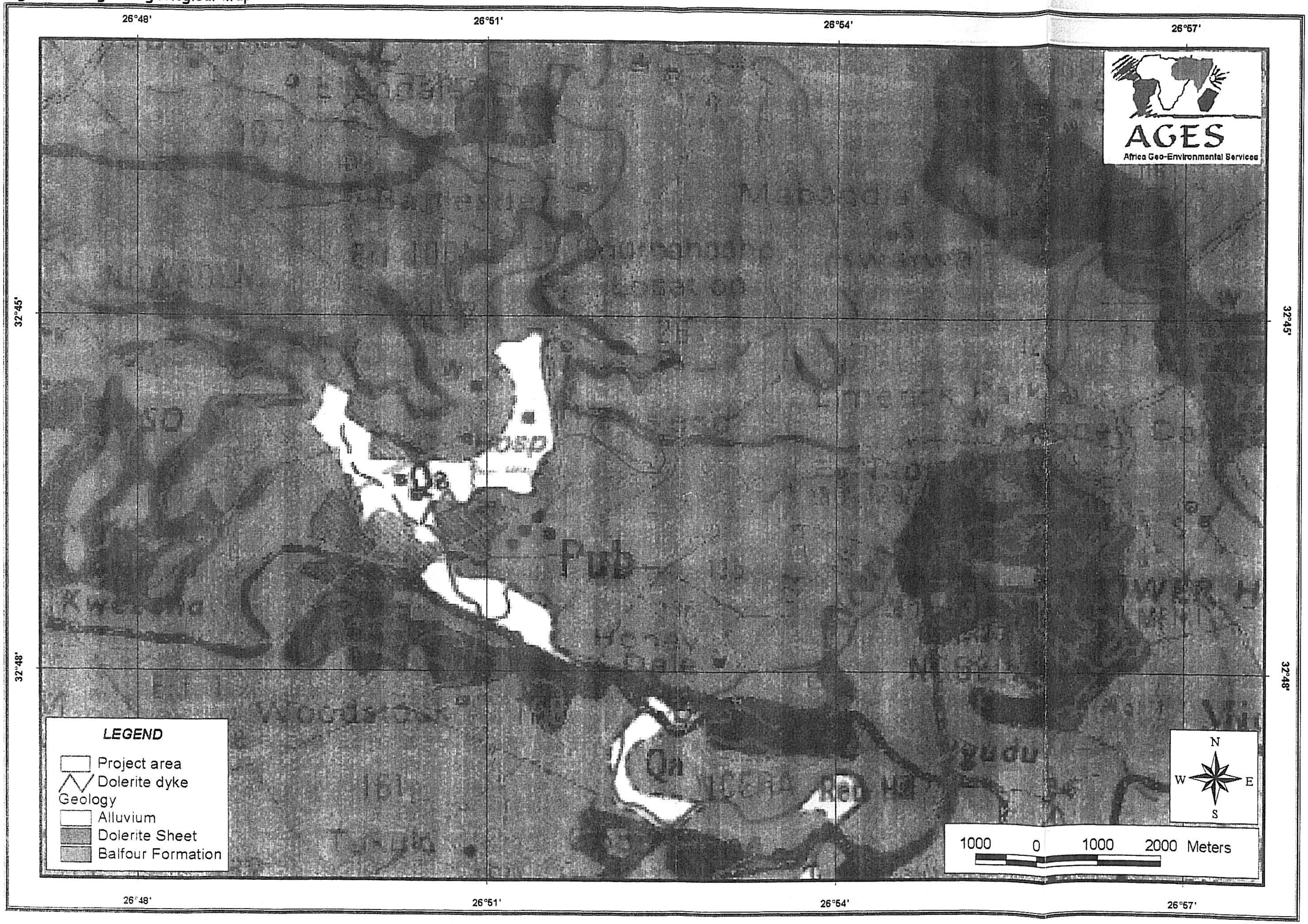


Photo 1: General topography of the study area

PROJECT: UPPER GQUMASHE SANITATION - PHASE 2

Figure 2: Regional geological map



The slopes throughout the study area are gentle to moderate, with steep slopes on the southern section of the local ridgecrest. The study area is located at an elevation of between 620 and 650 m above mean sea level.

2.3 Drainage

Surface water drainage in the project area is in basic northern direction to the Gqumahashe River and in a southern direction towards the Furrow River. Both these small non-perennial rivers drain water in a westwardly direction towards the Tyume River that drains water in a basic southern direction towards the larger and regionally important Keiskamma River.

No major dams occur near the village and the surface water that the community use occur in small streams and marshes as well as in a small embankment dams in the direct vicinity of the villages. Unprotected riverbanks may lead to extensive soil erosion in the study area.

2.4 Climate

The study area is located in the Summer Rainfall Zone of the Republic of South Africa.

According to SURFACE WATER RESOURCES OF SOUTH AFRICA 1990, Saki village is located within the R10E quaternary sub-catchment of the Keiskamma River. The village lies within the R1B rainfall zone and receives a mean annual precipitation of approximately 500-600 mm, and has a mean annual evaporation of between 1500 to 1600 mm. The mean annual runoff is approximately 20 - 50 mm.

Weinert's N-value for the area is between 2 and 5, indicating that the dominant mode of weathering is chemical decomposition of the constituent minerals, rather than mechanical disintegration.

2.5 Vegetation

The natural vegetation occurring in the study area has been extensively disturbed due to urban development in its direct vicinity. The area is currently covered by grassland with scattered examples of indigenous trees and scrubs and forest plantations.

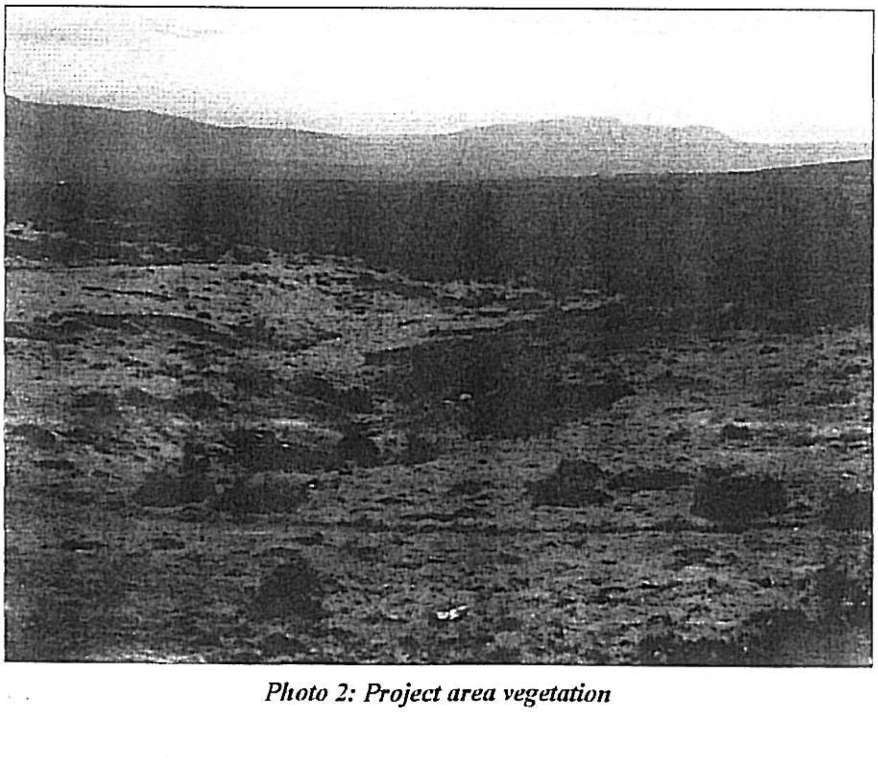


Photo 2: Project area vegetation

2.6 Existing water sources

Surface water drainage in the area is associated with the catchment of the Keiskamma River. The Tyume- and Furrow rivers, which are minor tributaries of the Keiskamma River, runs through the Upper Gqumashe village project area and drains surface water generally to the west. Gradients are low to moderate over the majority of the study area, with steep gradients occurring on the southern sections of the village. The area can generally be characterised as slightly undulating terrain. The community in Upper Gqumashe village is currently mainly relying on a bulk water supply system. Community members are still using local springs when the bulk water system is in disrepair. None of the identified boreholes are currently in use.

3 INVESTIGATIVE METHODOLOGY AND TECHNIQUES

3.1 Hydrogeological survey

Geological mapping entailed a walk-over survey of the study area during which rock outcrops were visited and geological formations identified by means of visual identification and the use of available geological maps as mentioned in paragraph 1.4. Geological mapping forms an integral part in the investigation stage to assess the groundwater potential in the area and identify sensitive aquifers and zones where pollution can take place.

A brief hydrocensus was carried out to identify boreholes and prominent springs in the study area. This is done to aid in the assessment of the groundwater potential in the area and community members play a vital role. These boreholes and springs are investigated and important information regarding the water levels: quality and previous usage are annotated.

Remote sensing of the study area was done using stereoscopic aerial photographs as mentioned in paragraph 1.4. Stereoscopic aerial photography is used to delineate geological contacts and identify possible structures that may have an influence on the local underground water potential. These aerial photographs allow the viewer to see the photographed region three dimensionally. The viewer looks down on the photographed area, and can identify landforms, dolerite dykes, sills and linear features that may predict the existence of possible water-bearing features and structures.

3.2 Aquifer Characterisation

The survey aims to evaluate and define a conceptual model of the aquifers present in the study area. It embodies all the important features of the groundwater flow system, while incorporating simplifying assumptions, which include:

(a) a definition of the study area (*modelling domain*);

(b) the known geological and hydrogeological features and characteristics of the area (*geometry*);

(c) the static water levels/piezometric surfaces of the study area (*initial conditions*);

(d) the interaction of the geology and hydrogeology on the boundary of the study area (*boundary conditions*);

(e) a description of the processes and interactions taken place within the study area that will influence the movement of groundwater (*groundwater flow dinamics*)

The conceptual model consists of all relevant ideas, incorporated into an idealisation to develop a better understanding of site conditions, and to be able to communicate this understanding. A groundwater model is a representation of the real system. It is therefore at most an approximation, and the level of accuracy depends on the quality and quantity of the data that is available. The groundwater model in this investigation should therefore *not be seen as a predictive tool*, but rather as a prospective evaluation tool to determine the potential behaviour of the system with time, given a set of changing parameters.

Should pump testing data be available from any existing boreholes in the project area, this data can be used to better understand and characterize the aquifer. Different methods are used to analyze pump-testing data. Two parameters are used to describe the physical properties of an aquifer, namely transmissivity (T) and storativity (S). The first of these [illegible] quantifies the rate at which water moves through the aquifer and the latter quantifies the aquifer's ability to release water.

3.3 Engineering geological survey

An engineering geological survey was conducted throughout the study area. Geotechnical surveying entails the identification of the different landforms in the area by means of remote sensing as mentioned in paragraph 3.1. After the relevant landforms have been identified on the different geological formations, test pits are excavated on each landform to determine the sub-surface soil conditions. The individual soil layers in the test pits are described according to the following parameters, which constitute the soil profiling system proposed by Jennings, Brink and Williams (1973): **Moisture, Colour, Consistency, Structure, Soil type** and **Origin**, known as the **MCCSSO** system.

Disturbed soil samples are taken of the most important soil layers that will have an influence on the proposed development. The samples are submitted to a soils laboratory and analysed for the determination of its grading characteristics and basic mechanical properties.

Photo 3: Profile pit constructed by the community in project area

3.4 In-situ permeability testing

In-situ permeabilities of the most prominent soil horizons were determined by means of double-ring infiltrometer testing. The test is basically conducted as follows:

After profiling of the soil horizons are conducted, a test pit is excavated into the top portion of the soil layer that is to be tested. Two steel rings, comprising an inner and outer ring of known diameter is driven into the soil layer to prevent water from seeping out underneath the rings. The outer ring is filled with water. The inner ring is then filled with water to the exact level as the outer ring. As soon as the levels are the same, the test commences. (It is very important that the water level in the outer ring is kept at the same level as the inner ring in order to prevent a difference in height that will influence the accuracy of the test).

The water level in the inner ring is measured on certain time intervals. The test is completed when a linear correlation between the infiltration rate and time is reached for a minimum of 30 minutes. The data is represented on a graph of time (s) over infiltration (mm). The permeability of the soil layer is then determined with an equation that is based on Darcy's permeability equation.

3.5 Community awareness creation

Community awareness creation plays a very prominent role throughout all the project phases, but is especially important during the hydrocensus and soil surveying phases. Members of the community are requested by the project team to be present during the implementation of the hydrogeological and geotechnical techniques. The actual techniques that are used are explained to the community while the actual investigation is conducted and the importance and relevance of the techniques are envisaged. Community members are also given the opportunity to ask questions that are answered by the consulting hydrogeologist and/or engineering geologist.

Photo 4: Community awareness creation

4 RESULTS

4.1 Hydrogeological survey

4.1.1 Community awareness creation

Community awareness creation played an important role in the geohydrological and geo-environmental investigation that was conducted at Upper Gqumashe Village. Community awareness creation data and results are attached in Appendix D for reference.

4.1.2 Site Geology

Geological mapping of the project area was conducted during the respective site visits of December 2003. Terrain boundaries and conditions were verified and current water sources were inspected and evaluated. Attention was given to the presence of dolerite dykes and sheets and the different landforms that are present on the geological formations.

It was determined that the study area is underlain by mudstone and sandstone of the Balfour Formation. The strata generally dip to the north at an angle of between 1 and 3 °.

No ***dolerite sill intrusions*** and ***dolerite dyke intrusions*** are present in the study area. A relatively prominent east west trending dolerite dyke intrusion occurs to the north of the village.

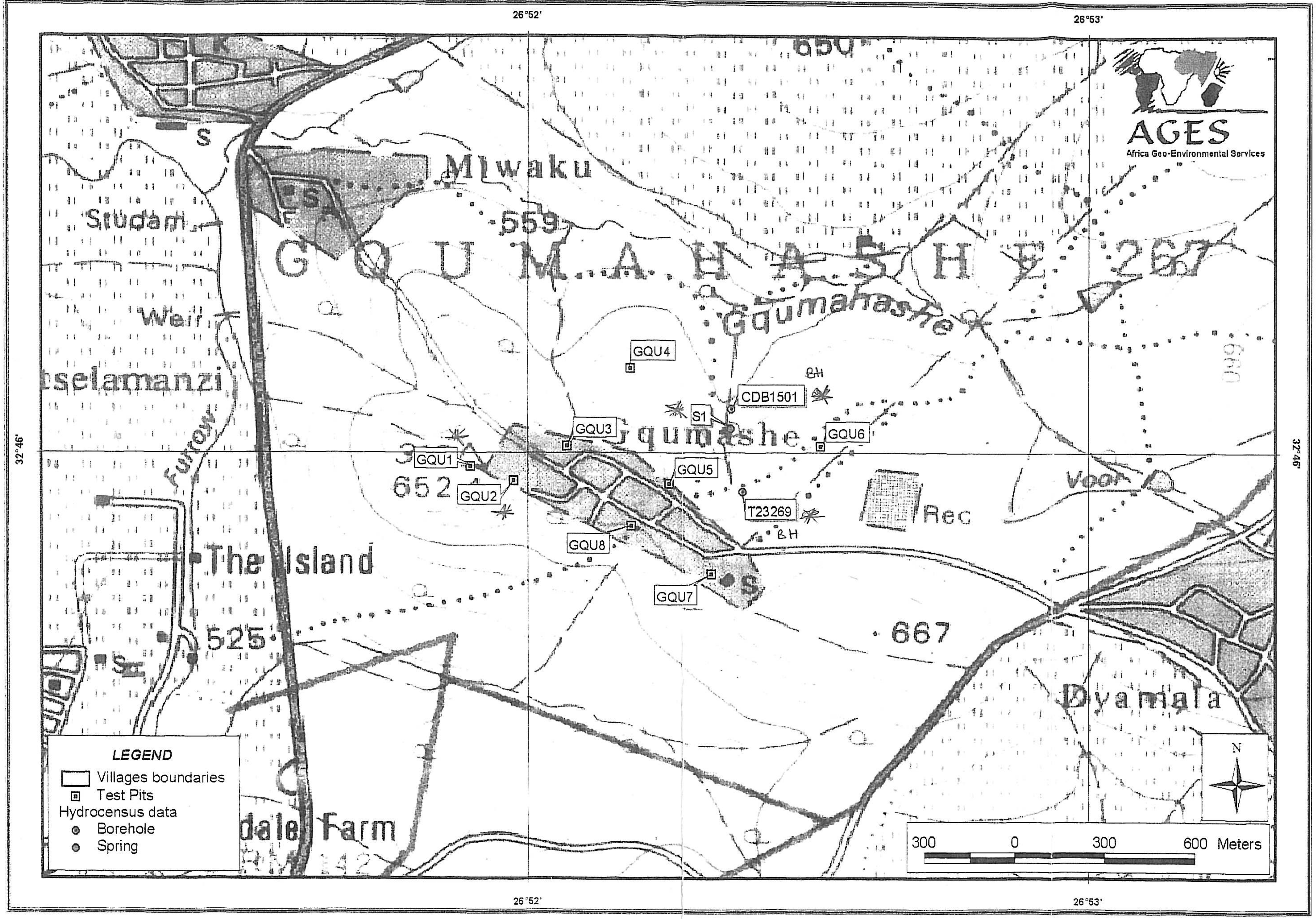
4.1.3 Hydrocensus

A preliminary hydrocensus of the project area was conducted during the first phase of the project carried out in 9 July 2003. A more detailed hydrocensus was conducted during the site visits of December 2003. A total of two existing boreholes and one "prominent" spring were identified within the boundaries of the study area. The relative position of existing water sources are indicated in Figure 3.

Photo 5: Spring S1 located in Upper Gqumashe village

PROJECT: UPPER GQUMASHE SANITATION - PHASE 2

Figure 3: Detailed site layout map



Hydrocensus results are summarised in Table 1 below.

NR	LAT	LONG	PUMP TYPE	SWL (mbgl)	YIELD EST (l/s)	COMMENTS
T23269	32°46'44.1"	26°52'21.7"	Windmill	43.14	< 10 kl/day	Windmill in disrepair
CDB1501	32°05'56.5"	26°52'20.9"	Windmill	8.4	< 10 kl/day	Windmill in disrepair. Situated 50 m down-gradient of cemetery site
S1	32°45'58.9"	26°52'21.3"	-	N/A	< 0.1 l/s	Spring located 40 m from borehole CDB1501, down-gradient from cemetery site

Table 1: Hydrocensus summary table

None of the existing boreholes, or the spring, was found to be currently in use. The boreholes are both in disrepair, and due to the low yield of the spring, community members prefer walking down to the river. Over the coarse of this project a bulk water system was installed at Upper Gqumashe village. The local spring is still being used for livestock watering.

It was noted during the hydrocensus that the community graveyards are situated along streams and drainages throughout the villages, mostly within a distance of less than the required 60 m as proposed by DWAF. The proximity of the graveyards to borehole CDB1501 is indicated in photo 6.

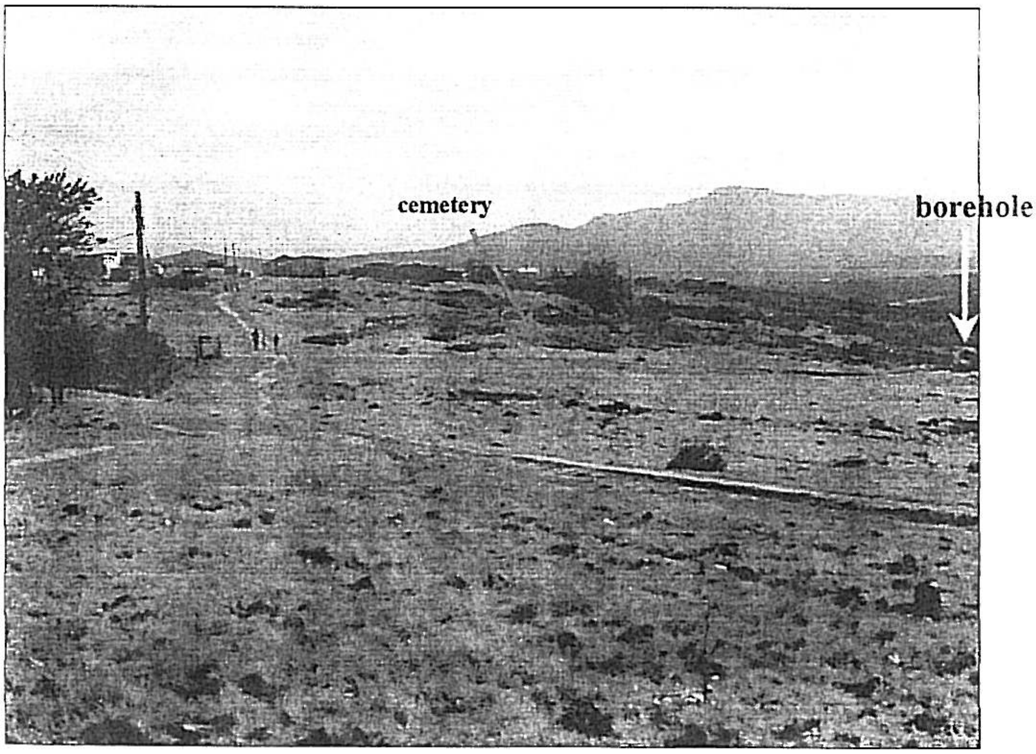


Photo 6: Graveyards near spring and borehole CDB1501

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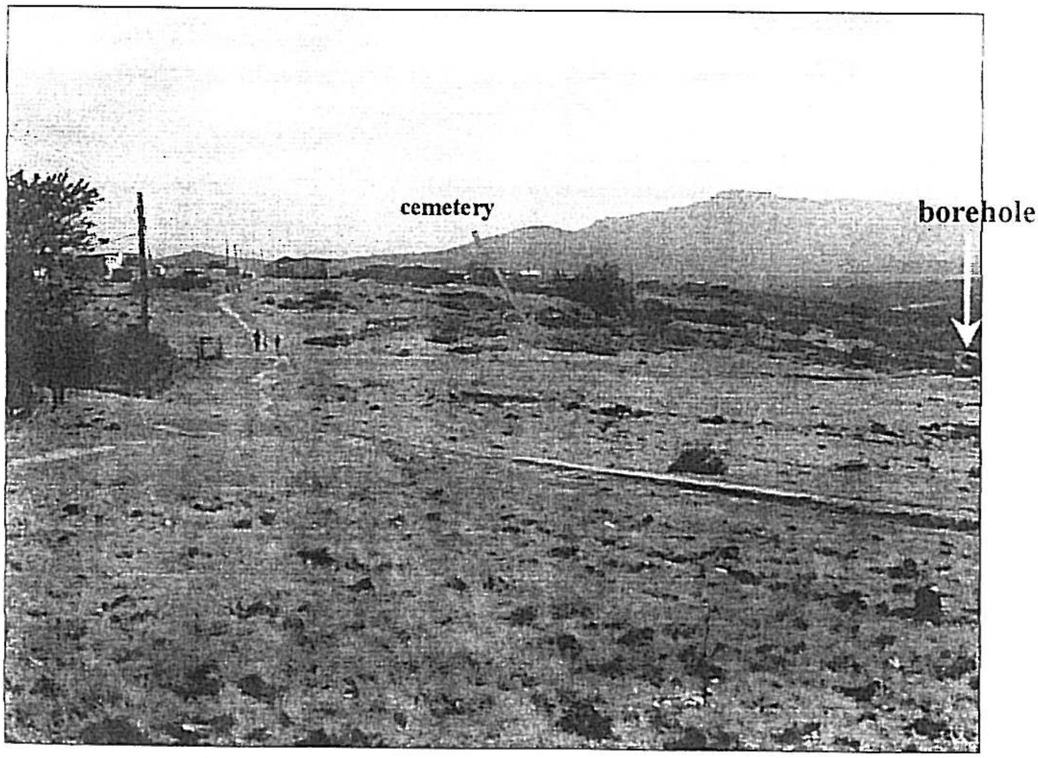


Photo 6: Graveyards near spring and borehole CDB1501

4.1.4 Aquifer characteristics

The hydrocensus that was conducted in December 2003 revealed that two boreholes and one spring exist in Gqumashe village. These boreholes could not be tested due the boreholes being in disrepair. It was also decided not to test the boreholes due to the possibility that information from previous studies could theoretically be available. Due to the limited amount of available hydrogeological information, the aquifer characterization discussed in this paragraph is based on the occurrence of springs in the project area.

In many cases the sustainability and the flow rate of springs depends mainly on permeability of the aquifer, recharge rate and groundwater reservoir. The hydraulic head above the spring also plays a major role in sustaining the flow rates of the springs. The presence of springs in the project area signifies shallow groundwater conditions and connections with surface conditions. Due to the presence of springs in the project area, the underlying aquifer can be assumed to be permeable, hence feeding water to the spring. The above conditions are said to take place in the project area during rainy season where the underlying aquifer gets rainfall recharge. During dry periods, the groundwater levels decrease thus responding to unavailability of recharge, resulting to insignificant contribution of groundwater to flow rate of the spring.

Based on the information discussed above, it can be said that the chances that underlying aquifer may be polluted during rainy season are high- taking into consideration the rise in groundwater levels responding to rainfall recharge as well the presence of springs which directly and/or indirectly link the surface and groundwater conditions. It is therefore recommended that the underlying aquifer be protected to avoid anticipated groundwater pollution in the project area taking into account the permeable nature of the underlying aquifer.

Water quality

No samples from the existing boreholes were taken due to the fact that the boreholes were in disrepair for a long period and are no longer being used by the community. Indication is that the drinking water quality of these sources is expected to be marginal to poor, with contamination by faecal coliforms. Possible high nitrate levels at the sources can be expected as a result of migration of contaminants from the nearby cemetery. Water samples from the boreholes should be taken if and when they are rehabilitated for possible future use. Contamination from faecal coliforms is also noted. The spring zone is indicated in Photo 7 below.

Photo 7: Spring zone in Upper Gqumashe village

4.2 Engineering geological survey

4.2.1 Landforms

In the light of the available physiographic information, the study area can be divided into the following landforms (i.e.: areas with similar topography, drainage regime and geological character) according to the systems devised by the National Data Bank for Roads of the Council for Scientific and Industrial Research (CSIR):

- 1/3 - Ridge crests
- 3/ - Convex and concave side slopes

The extent of the different landforms is the basis for the correlation and extrapolation of the engineering geological results within each landform.

4.2.2 Soil profiles

A total of 8 test pits were profiled during the site visit of 10 December 2003. The test pits were excavated by utilising local labour. The test pits were specifically placed to obtain a detailed overview of the succession of soil and rock layers underlying each identified landform, and to delineate changes in the soil character. Test pits were placed as indicated in Figure 3. Detailed test pit profile logs are attached in Appendix B for reference.

4.2.2.1 Generalised soil profile on Sedimentary Formations

The majority of the project area was generally found to be covered by hillwash composed of sandy clay with scattered angular siltstone gravel, exhibiting a firm consistency and micro-shattered structure that extends from the surface to a depth of between 0.10 and 0.75 m (mean 0.32 m).

The hillwash is underlain in localised areas by ferruginised reworked hillwash and residual siltstone, composed of abundant ferricrete nodules with a diameter up to 5 mm and scattered siltstone gravel, moderately densely packed in a matrix of sandy clay. This layer generally has a thickness of between 0.05 m and 0.25 m (mean 0.15 m).

The transported material is generally underlain by siltstone bedrock, with the exception of test pit GQU/TP/7 where residual material composed of silty clay with a soft to firm consistency and micro-shattered structure was encountered. The residual material has a thickness of approximately 0.45 m.

Highly to moderately weathered siltstone bedrock was encountered in all of the test pits excavated on sedimentary formations. The bedrock material is generally very fine-grained, very thinly jointed and fractured, exhibiting a very soft rock to soft rock hardness. The joint surfaces are generally narrow and stained with rough joint surfaces. Some joints were observed to be clay filled. The depth to bedrock material varied between 0.10 m and 0.90 m (mean 0.46 m).

The generalised soil profile on sedimentary formations can be observed in the Photo 8 below.

Photo 8: General soil conditions encountered on sedimentary formations

4.2.2.2 Generalised soil profile on Igneous Formations

The remainder of the project area was generally found to be covered by hillwash composed of sandy clay, exhibiting a firm consistency and micro-shattered structure that extends from the surface to a depth of between 0.30 and 0.40 m (mean 0.35 m).

The hillwash is underlain by highly to moderately weathered dolerite bedrock that was encountered in all of the test pits excavated on igneous formations. The dolerite bedrock is generally fine-grained, very thinly jointed and fractured, exhibiting a very soft rock to soft rock hardness. The joint surfaces are generally narrow and stained with rough joint surfaces. Some joints were observed to be partially clay filled. The bedrock shows classical "onion peel" weathering pattern. The depth to bedrock material varied between 0.30 m and 0.40 m (mean 0.35 m).

The generalised soil profile on igneous formations can be observed in the Photo 9 below.

Photo 9: General soil conditions encountered on igneous formation

4.2.3 Laboratory analysis

Two disturbed samples were taken of the most prominent soil horizons that will be influenced by on-site sanitation and were submitted to Messrs. Controlab Civil Engineering Materials and Geotechnical Laboratory (East London) for the determination of the standard foundation indicator values (liquid limit. plasticity index & grading) of the different soil materials. A double hydrometer test was also carried out on the samples for determination of the soil dispersivity. Laboratory results are attached in Appendix C for reference.

Detailed processed laboratory results are summarised in the table below:

TABLE 1 Summarised soil test results

SAMPLE NUMBER	SAMPLE DEPTH (m - m)	ORIGIN	GRADING ANALYSES				ATTERBERG LIMITS			LS	MATERIALS CLASSIFICATION		POTENTIALLY ADVERSE GEOTECHNICAL CHARACTERISTICS				CALCULATED PERMEABILITY (cm/sec)
			Gravel %	Sand %	Silt %	Clay %	LL % 1	PI	PI* 2	% 3	A.S.T.M. 4	A.A.S.H.T.O. 5	Expansiveness 6	Collapse Potential 8	Compressibility 9	Dispersiveness 7	1E+01
GQU1	0.00 - 0.40	Hillwash	1	26	46	27	33	16	14.2	8.0	CL: Lean clay with sand	N/T	**Medium Risk**	Slight Risk	N/T	**Moderate Risk**	4E-07
GQU2	0.35 - 0.60	Reworked residual mudstone	4	32	41	23	26	13	9.0	6.5	CL: Sandy lean clay	N/T	Low Risk	Slight Risk	N/T	**High risk**	4E-07

1 Liquid Limit
2 Weighted Plasticity Index (corrected to represent the whole sample)
3 Linear Shrinkage
4 According to the A.S.T.M. Standard on the Unified Soil Classification System
5 According to the American Association of State Highway and Transportation Officials
N/T Not tested
6 Calculated by means of the method proposed by Van der Merwe (1964), as modified by Wilson (1976)
7 Determined by means of the Emmerson Crumb Test
8 Determined by comparing the grain size distribution with grain size limits defined by Knight and Errera
9 Determined by means of special tests
10 Calculated by means of Hazen's permeability equation: $k = 100 \times D_{10}^2$

4.2.4 Excavatability

Excavatability plays an important role in the determination of the type of sanitation system that will be implemented. Pit latrines are generally required to be excavated to a depth ranging between 1.50 and 2.00 metres (ideally 1.80 m), into a suitable permeable soil at the base; while a septic tank system requires at least 2.00 metres of suitable permeable soil from the surface to the base, implying depths in excess of 2.00 metres.

It was generally possible to excavate the test pits to a depth ranging between 0.65 and 2.0 m (mean 1.32 m), after which bedrock with a soft rock consistency prevented further excavation. Excavation refused in all of the test pits on sedimentary or igneous bedrock with a soft rock consistency.

The sidewalls of the test pits remained stable during the profiling and the sampling of the test pits, with little or no collapse occurring.

4.2.5 Groundwater occurrences

Slight groundwater seepage was encountered in test pit GQU/TP4 at a depth of 0.9m in fractured siltstone bedrock. Seepage occurred through fractures and joints within the bedrock. Groundwater seepage was not encountered in any of the other test pits.

Ferruginised material was however encountered in four test pits (GQU/TP4, GQU/TP5, GQU/TP6 and GQU/TP7), which is indicative of seasonal perched groundwater table conditions. Liaison with the community revealed that seasonal groundwater seepage does also take place in localized areas during the rainy season.

Static groundwater levels recorded in the study area vary between 8.4 and 43 mbgl as recorded at boreholes T23269 and CDB1501.

4.2.6 Permeability

The soils must have permeabilities sufficient to adsorb and drain away the liquid waste but not so high as to pollute the groundwater. Percolation takes place through the base of the pit and through the lower part of the sidewalls. In a fine, homogenous sandy soil for instance, bacteria are generally filtered out within less than 3 metres although viruses travel much further. However, once a pollutant has entered the groundwater it can remain active for a long time.

Pollution of the groundwater via an excessively permeable soil in an area where boreholes and/or springs are used can present a serious health hazard to water consumers.

The following permeability limits for residential and industrial areas utilising *septic tank systems* area proposed by Warwick and Gregg (1971):

- Less than 4×10^{-3} cm/sec to prevent pollution
- Greater than 5×10^{-4} cm/sec to be sufficiently permeable

A lower permeability value can be tolerated in the case of pit latrines and a higher value is permissible where the water table is very deep and there are no boreholes and/or springs in the immediate vicinity of the pit.

4.2.6.1 Double Ring Infiltrometer Testing

Double ring infiltrometer tests (DRIT) were conducted on the most prominent soil horizons as described in paragraph 3.4. A total of three double-ring infiltrometer in-situ permeability tests were conducted on selected soil horizons identified during the soil-profiling phase. Results are summarised in the following table with detailed results attached in Appendix E for reference:

TEST NR	MATERIAL	PERMEABILITY	CLASSIFICATION
DRIT 1	Hillwash	5.0×10^{-4} cm/s	Slightly permeable
DRIT 2	Siltstone Bedrock	1.2×10^{-3} cm/s	Slightly permeable
DRIT 3	Dolerite Bedrock	9.4×10^{-4} cm/s	Slightly permeable

Table 2: Summary of double-ring infiltrometer tests

4.2.6.2 Calculated permeability using Hazen's equation

Coefficients of permeability for the disturbed samples submitted to Controlab, as mentioned in paragraph 4.2.3, were calculated by using Hazen's permeability equation:

$$k = 100 D_{10}^2$$

Where: k = coefficient of permeability in cm/sec

D_{10} = maximum particle size (in cm) of the smallest 10 % of the sample

(Holtz and Kovacks (1981) noted that this equation is not very reliable for permeabilities below 10^{-3} cm per second.)

Calculated permeabilities of the six samples range between 2×10^{-3} cm/sec and 4×10^{-7} cm/sec, which classifies the material as being ***slightly permeable*** to ***practically impermeable***. This value is affected by the grading characteristics of the sample and it is expected that the permeability of this horizon is much lower. The soil structure of the horizons also influences the permeability and it is very likely that permeabilities for the other samples can be expected to be slightly greater than the abovementioned values as were found with the double ring infiltrometer testing.

SAMPLE NUMBER	SAMPLE DEPTH (m - m)	ORIGIN	GRADING ANALYSES				ATTERBERG LIMITS			LS	CALCULATED PERMEABILITY (cm/sec)
			Gravel %	Sand %	Silt %	Clay %	LL % 1	PI	PI' 2	% 3	1E-01
GQU1	0.00 - 0.40	Hillwash	1	26	46	27	33	16	14.2	8.0	4E-07
GQU2	0.35 - 0.60	Reworked residual mudstone	4	32	41	23	26	13	9.0	6.5	4E-07

Table 3: Summary of calculated permeabilities

5 APPLICATION OF THE GROUNDWATER PROTOCOL

5.1 Assessment of groundwater potential

Regional strategic value:

According to the Aquifer Classification Map of South Africa, the Upper Gqumashe Village project is located in an area that is classified as a *MINOR* aquifer.

Local value of the aquifer:

Although the aquifer is not currently being fully utilised - the value of the local aquifer is seen as *moderate to low*. A large percentage of the community's water demand can be met from utilising local groundwater sources. Chemical water quality is expected to be marginal to poor due to expected elevated levels of faecal coliforms counts, most likely due to influences from cattle waste and poor sanitation practises. Protection of the aquifer at present and future groundwater abstraction points is therefore seen as important.

5.2 Evaluation of groundwater use

The hydrocensus that was carried out revealed that only two existing boreholes occur in the study area but are mainly in disrepair. The use of groundwater in the study area is deemed to be slight, due to bulk water systems that are installed and fed by water from the Sandile dam.

Water from springs and rivers is currently being used by the community for drinking and stock watering purposes when the bulk water system is inoperative or in disrepair.

The potential for future use of groundwater in the study area is deemed to be moderate.

5.3 Assessment of flag situations

The following flag-situations occur and must be taken note of:

- The base of all pit latrines will be in fractured and weathered sedimentary or igneous bedrock
- Shallow groundwater levels (0-10 m below the base of pits) can be expected in localized areas of the study area but is not very likely
- The formation of contaminated perched water tables at shallow depth within slightly permeable soil material is likely to occur
- The formation of perched water tables in fractured sedimentary bedrock is very likely to take place after heavy precipitation events. Seepage was encountered in one of the excavations during the soil-profiling phase
- Water abstraction points are not fenced off and not used exclusively for water collection purposes
- Existing small cemetery sites were observed within a radius of 75 m of existing boreholes
- Ferruginised soil material was encountered in several test pits in the study area and is indicative of seasonal perched groundwater conditions

5.4 Assessment of the vulnerability of the aquifer

The vulnerability of the underground water source is related to the distance that the contaminant must flow to reach the water table, and the ease with which it can flow through the soil and rock layers above the water table.

Evaluating the project area according to the Groundwater Protocol's (Edition 1) Risk Assessment Table, it is seen that a *LOW TO POSSIBLE RISK* exists as far as ground water pollution is concerned throughout the study area.

The vulnerability of the aquifer in the project area can be classified as HIGH according to the Groundwater

Protocol Second edition), due to highly fractured rock and (high water tables in localised areas). The aquifer may be vulnerable to many pollutants except those highly absorbed, filtered and/or readily transformed. The overall risk of contamination of the groundwater is deemed to be HIGH. Remedial measures should be implemented where necessary in high to medium load risk areas and necessary precautionary measures should be implemented where contaminant load risk is deemed to be minimal.

5.5 Strategic classification of the groundwater

The strategic value of the groundwater is a function of the potential yield of the aquifer, the present or probable future use off the groundwater, and the existence of alternative water source.

At Upper Gqumashe village the potential yield of the aquifer is considered to be 0.1 to 1 Ml/day. Groundwater is not currently a water source in the community and it is possible that the source will be developed in future. Bulk water from Sandile Dam is the only alternative water source in the area, along with water from nearby Rivers.

Taking the above-mentioned into consideration the relevance of threat of contaminants for the project area can be defined as follow:

- Bacterial and viruses – High risk
- Nitrates – Medium risk
- Chlorides – Minimal risk

5.6 Evaluation of measures to reduce the risk

Due to the classification of the terrain as a HIGH OVERALL RISK, the following approach will have to be taken to reduce this High risk. These should be negotiated and decided on by the sanitation engineer in consultation with the Geohydrologist and the community. Risks can be reduced by taking one or more of the following remedial- or precautionary measures:

- Increase the path length of contaminants to groundwater table by shallower pits, raised pits or partially sealed pits.
- Adopt eco-san sanitation systems
- Minimise infrastructure such as pit latrines, cattle kraals, sewer pipes, etc close to sensitive areas and areas where groundwater recharge is likely to take place
- Move or install water abstraction points sufficiently far from pollution sources
- Water from groundwater sources that will be used for drinking purposes should be chlorinated before consumption.

5.7 Groundwater monitoring and sanitary surveillance programme

Monitoring of both the quality and quantity of groundwater at the point of abstraction forms a very essential basis of sustainable management of the resource. Effective and accurate monitoring requires that boreholes and pump operators should be equipped with the essential monitoring equipment:

<u>Measurement of quantity pumped and water table levels</u>

- Water level monitoring-Piezometer Tube of 25 mm or 32 mm diameter must be installed in boreholes for measuring water levels
- Dip meter for measuring borehole water depth

<u>Measurement of water quality</u>

- A sample tap must be supplied close to the borehole to allow direct sampling of water from the borehole. Alternatively grab-samples should be taken every four months for detailed analysis

- Sterile sample bottles for microbiological analysis
- Clean sample bottles for chemical analysis
- Basic testing equipment for on-site measurement of temperature, pH, conductivity and active chlorine

Pump operators or whoever is responsible for groundwater monitoring should be issued with the relevant monitoring equipment including a dip meter and a record book. It is also very important that the person or people responsible for this exercise should be properly trained for this responsibility and be regularly evaluated to ensure a good quality data is collected.

A sanitation engineer and hydrogeologist should conduct a site inspection in order to assess the continued use of the two boreholes at Upper Gqumashe village and to recommended further actions required to ensure a acceptable water supply to the village.

6 SANITATION DEVELOPMENT POTENTIAL EVALUATION

The development potential of the study area is assessed based on the intended construction of a pit latrine sanitation system.

The results of this hydrogeological and geo-environmental investigation reveal that the study area can be divided into the following development potential zones: (Figure 4)

6.1 Zone A1

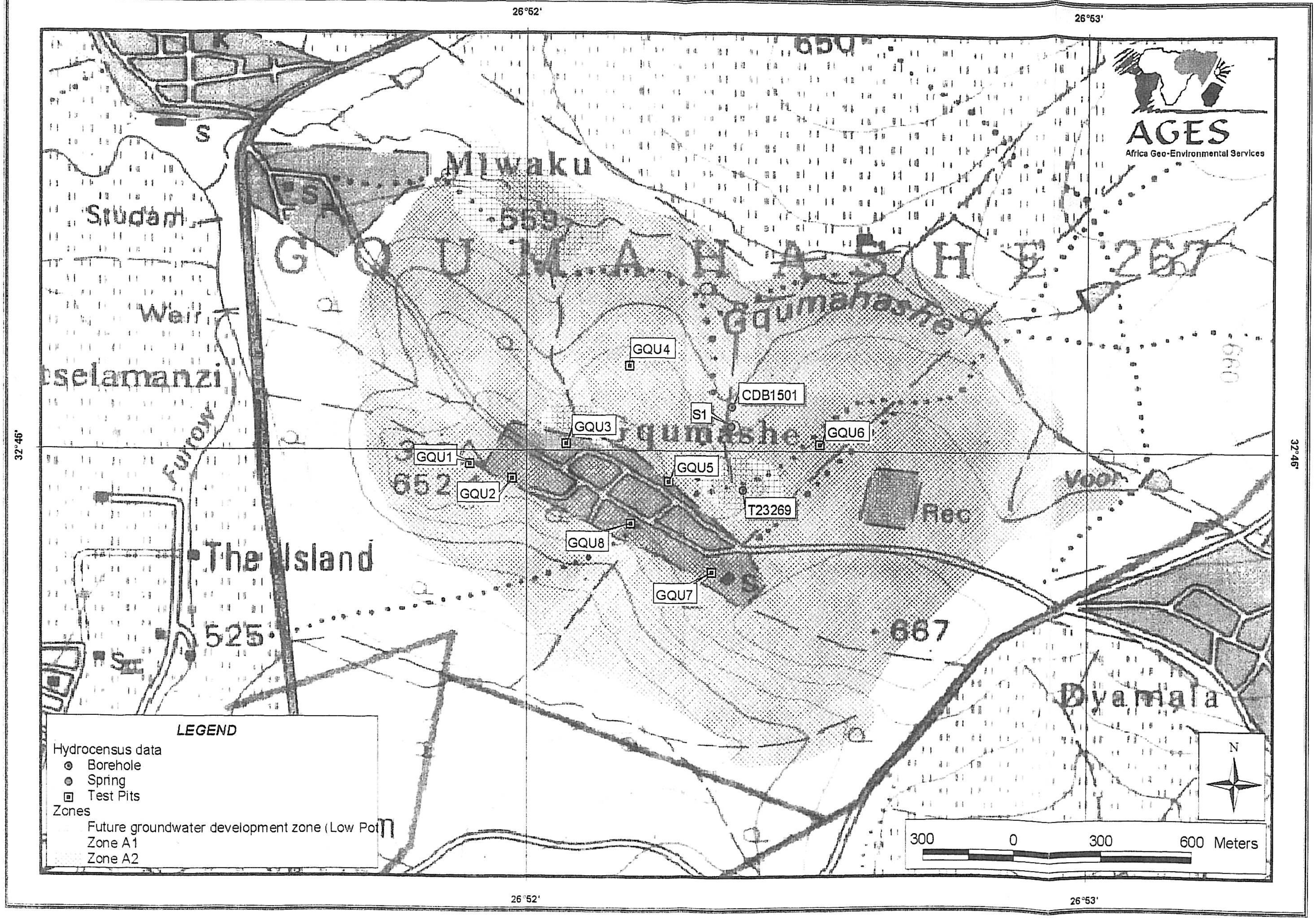
The areas defined as ***Zone A1*** is deemed suitable for the development of a pit latrine sanitation system, provided due cognisance is given to the following:

- *a risk of excavatability problems at or near the surface in localised areas due to the presence of fractured bedrock with a very soft rock to soft rock consistency. This is expected over the entire zone*
- *a high risk of pollution of the deep aquifer.*
- *Permeability problems are foreseen throughout this zone due to the presence of slightly permeable to practically impermeable soil material that may lead to the flooding of the pit latrines.*
- *A risk of pollution of local aquifers in the areas targeted for future groundwater source development*
- *Areas around existing boreholes, springs and streams that are being utilised for drinking purposes or may possibly be utilised in future for drinking purposes*
- *Areas demarcated for future groundwater development programmes*
- *The presence of extensively ferruginised material from which seepage could take place could be encountered during excavation – it is recommended that the specific pit be lined or partially lined to prevent the ingress of seepage into the pit and to prevent pollutants from seeping out of the pit.*
- *The following recommendations are made for this zone:*
    - *The use of power tools or a mechanical excavator may be required in cases where the required depth cannot be reached in the area, alternatively the pit latrine has to be elevated to obtain the required depth.*
    - *It is recommended that a rudimentary sewerage system that does not rely on seepage for the disposal of liquids be installed. These generally include:*
        - *Ventilated Improved Pit latrines*
        - *Ventilated Improved Vault latrines*
        - *The EnviroLoo*
        - *Aquaprivis*
    - *The pit opening must be protected such that no surface water is allowed to enter the hole.*
    - *Localised rock outcrops have to be avoided by moving pit latrine sites.*
    - *Should extensively ferruginised material from which seepage takes place be encountered during excavation – it is recommended that the specific pit be lined to prevent the ingress of seepage into the pit or the ferruginised material will have to removed within a radius of at least 1 metre of the edges of the pit and replaced with an impermeable soil material.*
    - *No pit latrine should be excavated into fractured bedrock. If this is unavoidable, the specific pit should be lined to prevent the possible pollution of the deep aquifer. Alternatively pits should be constructed shallower and wider to allow for shallow bedrock conditions*

From the preliminary results it is recommended that ***all latrines in this zone must be lined*** or partially lined to prevent the movement of liquids to and from the pit due to its proximity to groundwater recharge and

PROJECT: UPPER GQUMASHE SANITATION - PHASE 2

Figure 4: Development potential zonation map



surface water features. It is recommended that a system be implemented that does not rely on seepage for the disposal of liquids or sealed units be installed.

6.2 Zone A2

Those areas defined as *Zone A2* are deemed *suitable* for the development of a pit latrine sanitation system, provided due cognisance is given to the following:

- *a risk of excavatability problems at or near the surface in localised areas due to the presence of fractured bedrock with a very soft rock to soft rock consistency. This is expected in the entire zone*
- *a moderate to high risk of pollution of the deep aquifer*
- *Permeability problems are foreseen throughout this zone due to the presence of slightly permeable to practically impermeable soil material that may lead to the flooding of the pit latrine.*
- *The presence of extensively ferruginised material from which seepage could take place could be encountered during excavation – it is recommended that the specific pit be lined to prevent the ingress of seepage into the pit and to prevent pollutants from seeping out of the pit.*
- *The following recommendations are made for this zone:*
    - *It is recommended that a system be implemented that does <u>not</u> rely on seepage for the disposal of liquids. These generally include:*
        - *Ventilated Improved Pit latrines*
        - *Ventilated Improved Vault latrines*
        - *The EnviroLoo*
        - *Aquaprivi.*
    - *Localised rock outcrops have to be avoided by moving pit latrine sites.*
    - *It is recommended that excavation will take place beyond the bottom of impermeable hardpan ferricrete (when encountered) so that the pit base is in more permeable ground. These pits should however be lined.*
    - *The pit opening must be protected such that no surface water is allowed to enter the hole.*
    - *No pit latrine should be excavated into fractured bedrock. If this is unavoidable, the specific pit should be lined to prevent the possible pollution of the deep aquifer. Alternatively pits should be constructed shallower and wider to allow for shallow bedrock conditions*

From the preliminary results it is recommended that if ferruginised material is encountered during construction, lining must be considered to prevent the movement of liquids to and from the pit. It is recommended that in such instances - a system must be implemented that does not rely on seepage for the disposal of liquids or sealed units be installed.

7 CONCLUSIONS AND RECOMMENDATIONS

- The study area is underlain by mudstone and sandstone of the Balfour Formation. The most western portion of the village is underlain by a small dolerite sill intrusion. No dolerite dyke intrusions are present in the study area.
- A total of two existing boreholes and one spring were identified within the project boundaries. The community members currently rely on bulkwater for all household purposes. Local streams and springs are still being used to some extent when the bulk water system is in disrepair.
- Due to the underlying geology of the project area in combination with the groundwater recharge potential from surrounding rivers and streams, the groundwater potential of the area is considered to by low to moderate.
- Static groundwater levels were available from boreholes in the area and were measured between approximately 8.4 mbgl and approximately 43.14 mbgl. Due to the existence of springs in the lower lying portions of the study area it is obvious that shallow groundwater is an important aspect to be noted regarding groundwater in the study area. Static water levels in localised areas of the inhabited part of the study area are expected within the first 10m from surface.
- The general groundwater flow direction is expected to be in an northwardly direction, associated with the local and regional topography.
- No water samples were taken at the existing boreholes and spring due to the boreholes being in disrepair and the spring showing obvious evidence of bacteriological and other contamination. Groundwater in the study area is expected to be of Marginal to Poor drinking water quality
- A thin layer of hillwash generally covers the project area. The hillwash tends to become reworked with residual siltstone material and is generally slightly ferruginised. Transported material in localised sections of the project area is underlain by residual material that is slightly ferruginised in localized areas, and by siltstone bedrock in the remainder of the study area. Highly weathered and fractured sandstone and/or mudstone bedrock was encountered in test pits GQU/TP3 to GQU/TP8. Highly fractured and jointed very soft rock to soft rock dolerite bedrock was encountered in test pits GQU/TP1 and GQU/TP2. Detailed generalised soil profile descriptions are made in paragraph 4.2.2.
- It was generally possible to excavate the test pits to a depth ranging between 0.65 and 2.0 m (mean 1.32 m), after which bedrock with a very soft rock to soft rock consistency prevented further excavation. Excavation refused in all of the test pits on bedrock with a very soft rock to soft rock consistency. The sidewalls of the test pits remained stable during the profiling and the sampling of the test pits, with little or no collapse occurring. Slight groundwater seepage was only encountered in test pit GQU/TP4 at a depth of 0.9 m in fractured siltstone bedrock. Groundwater seepage was <u>not</u> encountered in any of the other test pits. Ferruginised material was however encountered in test pits, which is indicative of seasonal perched groundwater table conditions.
- Measured and calculated permeabilities of the three double ring infiltrometer tests and two siol samples range between 1.2 X 10^{-3} cm/sec and 4 X 10^{-7} cm/sec, which classifies the material as being ***slightly permeable*** to ***practically impermeable***.
- Although the aquifer is not currently being fully utilised - the value of the local aquifer is seen as moderate to low. A portion or even a large degree of the local community's water demand can be met from utilising local groundwater sources. Chemical water quality is expected to be of marginal to poor quality. Protection of the aquifer at abstraction points is therefore seen as important.
- It must further be noted that springs occurring in the project area are seen as part of the groundwater regime – the local value of the aquifer is seen as HIGH.

- Recommendations regarding the protection of local groundwater sources is given in **chapter 5**
- Recommendations regarding the delineation of the project area with the identification of sensitive areas as well as zones where future groundwater development is likely is given in **chapter 6**

8 BIBLIOGRAPHY

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APPENDIX A

LIAISON DOCUMENTATION

LIAISON - LOCAL AUTHORITIES

S. A. GeoConsultants (Pty) Ltd
P / Bag X9063, Postnet 203
East London
Tel: 043 - 726 2070

Date: 3 DECEMBER 2003

District: Amatole

Community: Upper Gqumashe

Project: Upper Gqumashe Sanitation - Phase 2

Objectives - GeoCon: Siting of test pits and arrangements for community awareness creation

Objectives - Community:

Authorities:

Name:	Position:	Signature:	Date:	Remarks:
F. DE JAGER	GeoCon	[signature]	3/12/2003	
CHRIS MABUJA	SECRETARY	[signature]	3/12/003	

LIAISON - LOCAL AUTHORITIES

S. A. GeoConsultants (Pty) Ltd
P / Bag X9063, Postnet 203
East London
Tel: 043 - 726 2070

GeoCon

Date:	04 DECEMBER 03
District:	
Community:	UPPER GQUMASHE
Project:	
Objectives - GeoCon:	To dig the pits for soil sampling.
Objectives - Community:	

Authorities:

Name:	Position:	Signature:	Date:	Remarks:
ZUKILE NGWATI	GEOCON	[signature]	09/12/03	
MANDISI MJEKULA	SECRETARY	[signature]	04-12-03	073 2832 014

APPENDIX B

DETAILED TEST PIT PROFILE LOGS

PROJECT:	**UPPER GQUMASHE SANITATION**		
CLIENT:	ATS Rural Development Services	LATITUDE:	32.76708 ° S
CONTRACTOR:	Local Labour	LONGITUDE:	26.56496 ° E
MACHINE TYPE:	Hand dug	ELEVATION:	

TEST PIT NO.:	**GQU/TP1**
DATE EXCAVATED:	8 December 2003
DATE PROFILED:	10 December 2003

Depth	Lithology	Description	Sampling
0 – 400 (40cm)		Moist, brown, in profile dusky brown, firm, micro-shattered, sandy clay. Roots. HILLWASH	Disturbed sample GQU1
400 – 1100 (1,10m)		Orange and olive brown, highly weathered, fine-grained, thinly jointed, very soft rock DOLERITE BEDROCK with onion peeled weathering. Joint surfaces are narrow, stained and rough. Scattered hard rock dolerite boulders	
1100	EOH	Excavation refused on DOLERITE BEDROCK with a very soft rock consistency	

Depth scale: 0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200

Southern Africa GeoConsultants (PTY) Ltd

GeoCon

Polokwane East London Pretoria
Potchefstroom Bloemfontein

Notes:
Groundwater seepage was NOT encountered
The sidewalls remained stable during profiling
One disturbed sample was taken
Bedrock topography irregular

PROJECT:	**UPPER GQUMASHE SANITATION**		**TEST PIT NO.:** **GQU/TP2**
CLIENT:	ATS Rural Development Services	LATITUDE: 32.76750 ° S	
CONTRACTOR:	Local Labour	LONGITUDE: 26.86624 ° E	DATE EXCAVATED: 8 December 2003
MACHINE TYPE:	Hand dug	ELEVATION:	DATE PROFILED: 10 December 2003

Depth	Lithology	Description	Sampling
0 – 300		Moist, brown, in profile dusky brown, firm, micro-shattered, sandy clay. Roots. HILLWASH	
300 – 1000		Orange and olive brown, highly weathered, fine-grained, thinly jointed, very soft rock DOLERITE BEDROCK with onion peeled weathering. Joint surfaces are narrow, stained and rough. Scattered hard rock dolerite boulders	
1000	EOH	Excavation near refusal on DOLERITE BEDROCK with a very soft rock consistency	

Depth scale: 0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200

Southern Africa GeoConsultants (PTY) Ltd

GeoCon

Polokwane East London Pretoria Potchefstroom Bloemfontein

Notes:

Groundwater seepage was NOT encountered

The sidewalls remained stable during profiling

No samples

Bedrock topography irregular

PROJECT:	**UPPER GQUMASHE SANITATION**		
		TEST PIT NO.:	**GQU/TP3**
CLIENT:	ATS Rural Development Services	LATITUDE:	32.76650 ° S
CONTRACTOR:	Local Labour	LONGITUDE:	26.86734 ° E
DATE EXCAVATED:	8 December 2005		
MACHINE TYPE:	Hand dug	ELEVATION:	
DATE PROFILED:	10 December 2005		

Depth	Lithology	Description	Sampling
0 – 200		Moist, brown, in profile dusky brown, firm, micro-shattered, sandy clay with scattered angular siltstone gravel. Roots. HILLWASH	
200 – 650		Yellowish brown, highly weathered, very fine grained, very thinly jointed, very soft rock SILTSTONE BEDROCK. Joint surface are narrow, stained and rough.	
650	EOH	Excavation refused on SILTSTONE BEDROCK with a very soft rock consistency	

Depth scale: 0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200

Southern Africa GeoConsultants (PTY) Ltd

GeoCon

Polokwane East London Pretoria Potchefstroom Bloemfontein

Notes:

Groundwater seepage was NOT encountered

The sidewalls remained stable during profiling

No samples

Bedrock topography irregular

PROJECT:	**UPPER GQUMASHE SANITATION**		
CLIENT:	ATS Rural Development Services	LATITUDE:	32.76421 ° S
CONTRACTOR:	Local Labour	LONGITUDE:	26.86973 ° E
MACHINE TYPE:	Hand dug	ELEVATION:	

TEST PIT NO.:	**GQU/TP4**
DATE EXCAVATED:	8 December 2003
DATE PROFILED:	10 December 2003

Depth	Lithology	Description	Sampling
0 – 2200 (scale)		Moist, brown, in profile dusky brown, firm, micro-shattered, sandy clay with scattered angular siltstone gravel. Roots. HILLWASH	
		Abundant ferricrete nodules with a diameter up to 5 mm and scattered siltstone gravel moderately densely packed in a matrix of sandy clay. FERRUGINISED REWORKED HILLWASH AND RESIDUAL SILTSTONE	
		Yellowish brown, highly weathered, very fine grained, very thinly jointed, very soft rock SILTSTONE BEDROCK. Joint surface are narrow, stained and rough.	
	EOH	Excavation refused on SILTSTONE BEDROCK with a very soft rock consistency	

Depth scale: 0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200

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GeoCon

Polokwane East London Pretoria
Potchefstroom Bloemfontein

Notes:

Slight groundwater seepage encountered at 0.9 m

The sidewalls remained stable during profiling

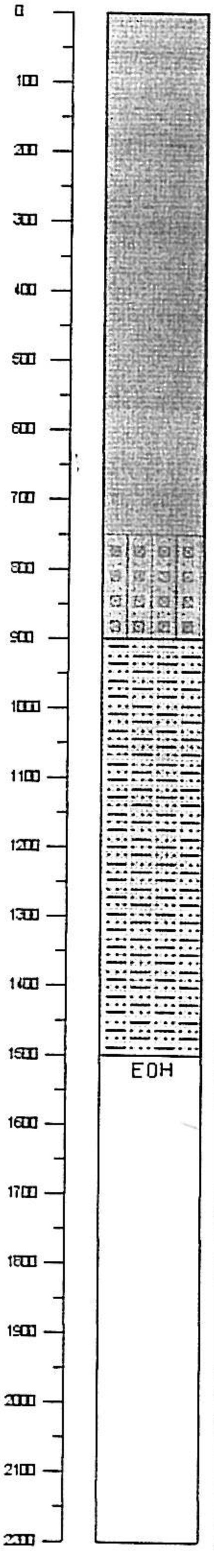
No samples

Bedrock topography irregular

PROJECT:	**UPPER GQUMASHE SANITATION**		
CLIENT:	ATS Rural Development Services	LATITUDE:	32.76759 ° S
CONTRACTOR:	Local Labour	LONGITUDE:	26.37087 ° E
MACHINE TYPE:	Hand dug	ELEVATION:	

TEST PIT NO.:	**GQU/TP5**
DATE EXCAVATED:	3 December 2003
DATE PROFILED:	10 December 2003

Depth **Lithology**



Description

Moist, brown, inprofile dusky brown, firm, micro-shattered, sandy clay with scattered angular siltstone gravel. Roots. HILLWASH

Abundant ferricrete nodules with a diameter up to 5 mm and scattered siltstone gravel moderately densely packed in a matrix of sandy clay. FERRUGINISED REWORKED HILLWASH AND RESIDUAL SILTSTONE

Yellowish brown, highly weathered, very fine grained, very thinly jointed, very soft rock SILTSTONE BEDROCK. Joint surface are narrow, stained and rough.

Excavation refused on SILTSTONE BEDROCK with a very soft rock consistency

Sampling

Southern Africa GeoConsultants (PTY) Ltd

Polokwane East London Pretoria Potchefstroom Bloemfontein

Notes:

Groundwater seepage was NOT encountered

The sidewalls remained stable during profiling

No samples

Bedrock topography irregular

PROJECT:	**UPPER GQUMASHE SANITATION**			**TEST PIT NO.:**	**GQU/TP6**
CLIENT:	ATS Rural Development Services	LATITUDE:	32.76652 ° S		
CONTRACTOR:	Local Labour	LONGITUDE:	26.87537 ° E	DATE EXCAVATED:	8 December 2003
MACHINE TYPE:	Hand dug	ELEVATION:		DATE PROFILED:	10 December 2003

Depth	Lithology	Description	Sampling
0–350		Moist, brown, in profile dusky brown, firm, micro-shattered, sandy clay with scattered angular siltstone gravel. Roots. HILLWASH	
350–600		Moist to very moist, reddish brown, in profile reddish brown, soft to firm, micro-shattered, silty clay. Few roots. REWORKED RESIDUAL MUDSTONE	Disturbed sample GQU2
600–1100		Grey and reddish brown, highly weathered, very fine grained, very thinly jointed and highly fractured, very soft rock MUDSTONE BEDROCK. Joint surfaces are narrow, stained with some clay infilling and rough	
1100	EOH	Excavation refused on MUDSTONE BEDROCK with a very soft rock consistency	

Depth scale: 0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200

Southern Africa GeoConsultants (PTY) Ltd

GeoCon

Polokwane East London Pretoria Potchefstroom Bloemfontein

Notes:
Groundwater seepage was NOT encountered
The sidewalls remained stable during profiling
One disturbed sample was taken
Bedrock topography irregular

PROJECT:	**UPPER GQUMASHE SANITATION**			**TEST PIT NO.:**	**GQU/TP7**
CLIENT:	ATS Rural Development Services	LATITUDE:	32.77024 ° S		
CONTRACTOR:	Local Labour	LONGITUDE:	26.87214 ° E	DATE EXCAVATED:	8 December 2003
MACHINE TYPE:	Hand dug	ELEVATION:		DATE PROFILED:	10 December 2003

Depth	Lithology	Description	Sampling
0 – 300		Moist, brown, in profile dusky brown, firm, micro-shattered, sandy clay with scattered angular siltstone gravel. Roots. HILLWASH	
300 – 650		Moist to very moist, reddish brown, in profile reddish brown, soft to firm, micro-shattered, silty clay. Few roots. Contact with bedrock is slightly ferruginised. REWORKED RESIDUAL MUDSTONE	
650 – 700		Scattered to abundant ferricrete nodules with a diameter up to 10 mm loosely packed and weakly cemented in a matrix as above. FERRUGINISED RESIDUAL MUDSTONE	
700 – 2000		Greyish brown, highly weathered, very fine grained, very thinly jointed and highly fractured, very soft rock becoming soft rock MUDSTONE BEDROCK. Joint surfaces are narrow, stained with some clay infilling and rough	
2000	EOH	Excavation refused on MUDSTONE BEDROCK with a very soft rock to soft rock consistency	

Depth scale: 0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200

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GeoCon

Polokwane East London Pretoria Potchefstroom Bloemfontein

Notes:
- Groundwater seepage was NOT encountered
- The sidewalls remained stable during profiling
- No samples
- Bedrock topography irregular

PROJECT:	**UPPER GQUMASHE SANITATION**		**TEST PIT NO.:** GQU/TP8
CLIENT:	ATS Rural Development Services	LATITUDE: 32.76332 ° S	
CONTRACTOR:	Local Labour	LONGITUDE: 26.36975 ° E	DATE EXCAVATED: 3 December 2003
MACHINE TYPE:	Hand dug	ELEVATION:	DATE PROFILED: 10 December 2003

Depth	Lithology	Description	Sampling
0 – 100		Moist, brown, in profile dusky brown, firm, micro-shattered, sandy clay with scattered angular siltstone gravel. Roots. HILLWASH	
100 – 1800		Yellowish brown, highly weathered, very fine grained, very thinly jointed, very soft rock becoming soft rock SILTSTONE BEDROCK. Joint surface are narrow, stained and rough.	
1800	EOH	Excavation refused on SILTSTONE BEDROCK with a soft rock consistency	

Depth scale: 0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200

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GeoCon

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Notes:
Groundwater seepage was NOT encountered
The sidewalls remained stable during profiling
No samples
Bedrock topography; irregular

GQU/TP8

APPENDIX C

DETAILED SOIL TEST RESULTS

HEAD OFFICE
10 St. Pauls Road
East London, 5201
P.O. Box 346
East London, 5200
Tel: (043) 722 8565 / 722 5420
Fax: (043) 743 9942

CONTROLAB cc

CK 90/12841/23

CIVIL ENGINEERING MATERIALS AND GEOTECHNICAL LABORATORY

BRANCH OFFICES
Cape Town
Kokstad
Port Elizabeth
Umtata

CLIENT: S A Geoconsultants (Pty) Ltd
Private Bag X9063
EAST LONDON
5200

ATT : Mr F de Jager

PROJECT: GQUMASHE

DATE: 13-01-2004

REF: 26806

FOUNDATION INDICATOR RESULT SUMMARY

SAMPLE NO:	9700	9701				
POSITION	GQU 1	GQU 2				
DEPTH:						
DESCRIPTION:	lt R Br	lt R Br				
	sty cl	sdy cl				
SIEVE ANALYSIS						
% PASSING 75 mm						
37.5 mm						
19 mm	100					
9.5 mm	99	100				
4.75 mm	99	96				
2.36 mm	98	88				
1.18 mm	96	75				
0.600 mm	92	70				
0.425 mm	89	69				
0.300 mm	87	68				
0.150 mm	81	68				
0.075 mm	73	64				
MECHANICAL ANALYSIS						
0.06 mm	60	52				
0.02 mm	45	36				
0.006 mm	35	29				
0.002 mm	27	23				
SOIL CONSTANTS						
LIQUID LIMIT	33	26				
PLASTICITY INDEX	16	13				
LINEAR SHRINKAGE	6.0	6.5				
DISPERSIVITY						
DOUBLE HYDROMETER %	38.2	57.1				

REMARKS: Note that 100% indicates a completely dispersive clay sized fraction and 0% indicates completely non dispersive

Checked by: MLP

APPENDIX D

COMMUNITY AWARENESS CREATION RESULTS

1. Introduction:

This is the report on the Upper Gqumashe Sanitation Project community awareness creation. Refer to the geo-hydrology report for the exact position of the community. AGES Eastern Cape was appointed to facilitate the awareness creation for sanitation and groundwater.

2. Terms of Reference:

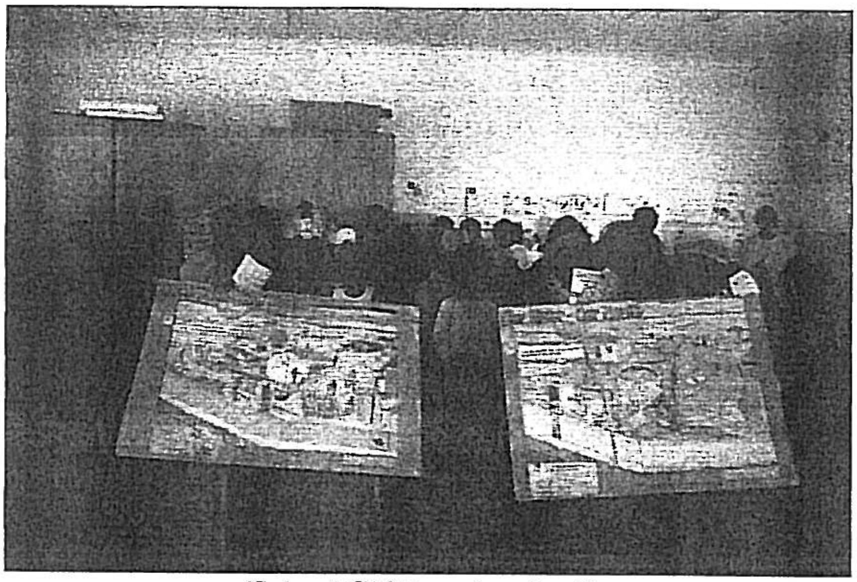
- Liaison with community
- Create awareness of sanitation and the need for healthy sanitation practice
- Create awareness of Groundwater Principles
- Discuss the different sanitation options

3. Methodology:

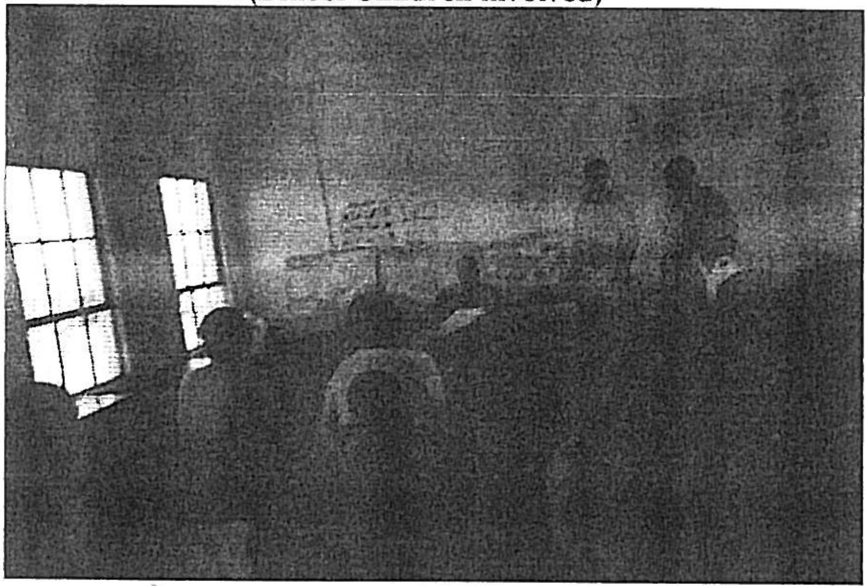
- Establish link within community with relevant people
- Set dates for community consultation
- Facilitate awareness creation day for whole community
- Community Feedback
- Report compilation

4. Results:

- The Upper Gqumashe community was visited on the 3rd of December 2003 and a link was established with the community liaison, which was also the counselor of the ward.
- Dates were set for an awareness day with the whole community.
- An awareness day was facilitated on the 9th of December 2003 at the Local School and the following was presented:
    - Groundwater awareness
    - Sanitation awareness with its impact on the environment.
    - The structure and mechanism of V.I.P latrines was demonstrated to the members present.
    - Community Interaction with questions and answers regarding the construction and maintenance of the latrines.
    - Awareness on the preservation of latrine structures including how to keep the bio system of a latrine healthy.
    - Awareness on cleanliness and healthy sanitation practice
    - Community discussion on the need for latrines



(School Children involved)



(Community Members)

5. Conclusions

- The community has expressed a definite need for latrines.
- The community has shown a high level of awareness of good sanitation practice and a willingness to maintain the latrines.
- The community has a counsel that manages community related issues and the counsel seems to be in good standing with the community.

6. Recommendations

- It is highly recommendable that good latrines are constructed in the Upper Gqumashe community and as the plots are fairly widely spread it is recommended that each site gets it's own latrine for the sake of maintenance and ownership.
- It is recommended that local contractors be involved in the process of constructing the latrines so as to contribute to the income of the community and also for reasons of experience.

(Children Participated in the groundwater model exercise)

APPENDIX E

DETAILED DOUBLE RING INFILTROMETER TEST DATA

DOUBLE-RING INFILTROMETER TEST

PROJECT:	Upper Gqumashe Sanitation

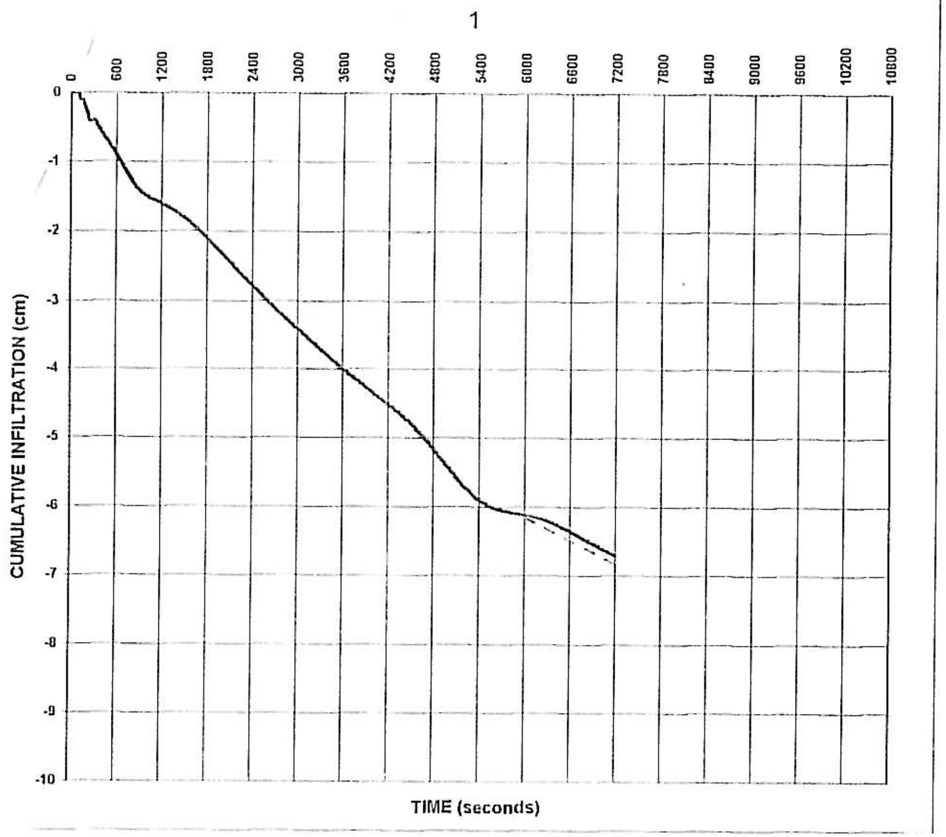
GQU/TP5

Inner Ring Dia.:	28 cm
Ring Height:	24 cm
Test No.:	1
Position:	0.10 m
Material:	Hillwash

Time (sec)	Cum. Infilt	
0	0.0	
15	0.0	
30	0.0	
45	0.0	
60	0.0	1 min
90	0.0	
120	-0.1	2 min
150	-0.1	
180	-0.2	3 min
210	-0.3	
240	-0.4	4 min
270	-0.4	
300	-0.4	5 min
360	-0.5	6 min
420	-0.6	7 min
480	-0.7	8 min
540	-0.8	9 min
600	-0.9	10 min
900	-1.4	15 min
1200	-1.6	20 min
1500	-1.8	25 min
1800	-2.1	30 min
2700	-3.1	45 min
3600	-4.0	1 HOUR
4500	-4.8	1 hr 15 min
5400	-5.9	1 hr 30 min
6300	-6.2	1 hr 45 min
7200	-6.7	2 HOURS
8100		2 hr 15 min
9000		2 hr 30 min
9900		2 hr 45 min
10800		3 HOURS

h_1 =	-6.7	initial height (cm)
h_2 =	-6.1	final height (cm)
σ_t =	1200	time difference (sec)

k_m =	5.0E-04 $cm.s^{-1}$



DOUBLE-RING INFILTROMETER TEST

PROJECT:	Upper Gqumashe Sanitation

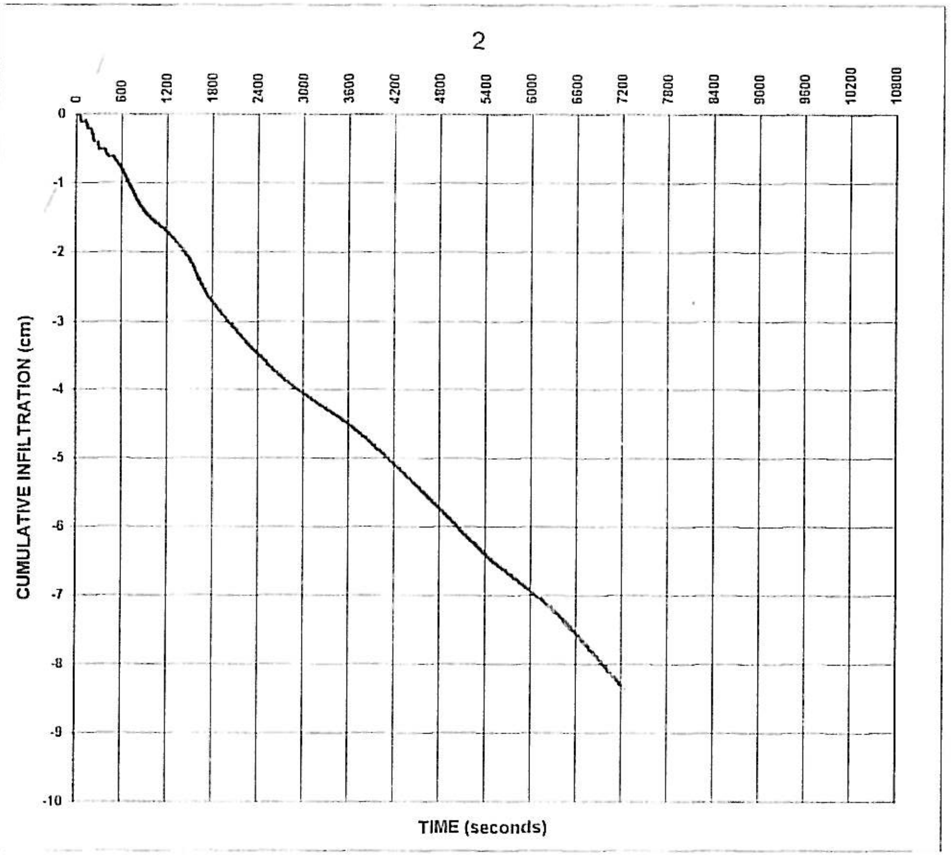
GQU/TP3

Inner Ring Dia.:	28 cm
Ring Height:	24 cm
Test No.:	2
Position:	0.3
Material:	Mudstone bedrock

Time (sec)	Cum. Infilt	
0	0.0	
15	0.0	
30	0.0	
45	0.0	
60	-0.1	1 min
90	-0.1	
120	-0.1	2 min
150	-0.2	
180	-0.2	3 min
210	-0.3	
240	-0.4	4 min
270	-0.4	
300	-0.5	5 min
360	-0.5	6 min
420	-0.6	7 min
480	-0.6	8 min
540	-0.7	9 min
600	-0.8	10 min
900	-1.4	15 min
1200	-1.7	20 min
1500	-2.1	25 min
1800	-2.7	30 min
2700	-3.8	45 min
3600	-4.5	1 HOUR
4500	-5.4	1 hr 15 min
5400	-6.4	1 hr 30 min
6300	-7.2	1 hr 45 min
7200	-8.3	2 HOURS
8100		2 hr 15 min
9000		2 hr 30 min
9900		2 hr 45 min
10800		3 HOURS

h_1 =	-8.3	initial height (cm)
h_2 =	-6.9	final height (cm)
σ_t =	1200	time difference (sec)

k_m =	1.2E-03 $cm.s^{-1}$



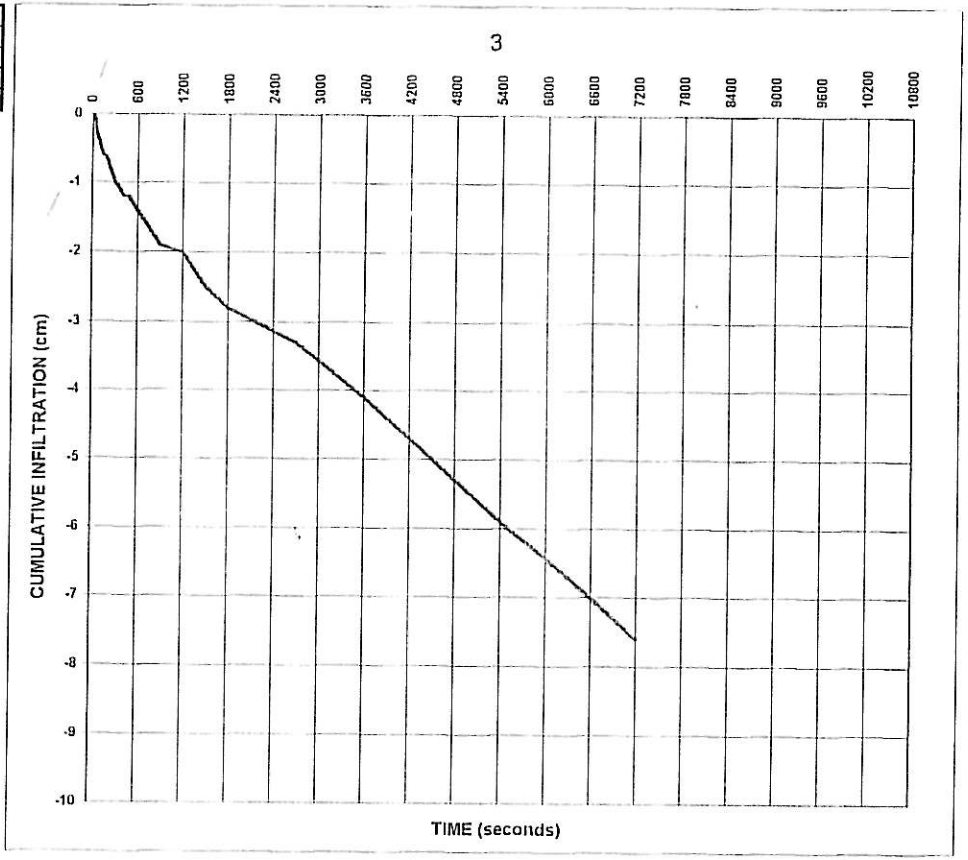
DOUBLE-RING INFILTROMETER TEST

PROJECT:	Upper Gqumashe Sanitation

GQU/TP1

Inner Ring Dia.:	28 cm
Ring Height:	24 cm
Test No.:	3
Position:	0.58 m
Material:	Dolerite bedrock

Time (sec)	Cum. Infilt	
0	0.0	
15	0.0	
30	-0.1	
45	-0.2	
60	-0.3	1 min
90	-0.4	
120	-0.5	2 min
150	-0.6	
180	-0.6	3 min
210	-0.7	
240	-0.8	4 min
270	-0.9	
300	-1.0	5 min
360	-1.1	6 min
420	-1.2	7 min
480	-1.2	8 min
540	-1.3	9 min
600	-1.4	10 min
900	-1.9	15 min
1200	-2.0	20 min
1500	-2.5	25 min
1800	-2.8	30 min
2700	-3.3	45 min
3600	-4.1	1 HOUR
4500	-5.0	1 hr 15 min
5400	-5.9	1 hr 30 min
6300	-6.7	1 hr 45 min
7200	-7.6	2 HOURS
8100		2 hr 15 min
9000		2 hr 30 min
9900		2 hr 45 min
10800		3 HOURS



h_1 =	-7.6	initial height (cm)
h_2 =	-5.0	final height (cm)
σ_t =	1800	time difference (sec)

k_m =	9.4E-04 $cm.s^{-1}$