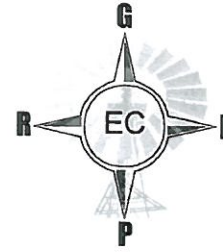


**GROUNDWATER RESOURCE INFORMATION PROJECT
EASTERN CAPE PROVINCE**

GROUNDWATER INFORMATION SOURCE REFERENCE SHEET



SOURCE REF NR:	KV153 <i>2.2(2701)</i>	Own Archive	<input checked="" type="checkbox"/>	Copy attached	<input type="checkbox"/>
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A: SOURCE DESCRIPTION

District Municipality:	Amatole	<input checked="" type="checkbox"/>	Chris Hani	<input type="checkbox"/>	O.R Tambo	<input type="checkbox"/>
	Ukhahlamba	<input type="checkbox"/>	Cacadu	<input type="checkbox"/>	Alfred Nzo	<input type="checkbox"/>
Local Municipality:	Mbashe					
Institution where Information is held:	Khulani VSA Groundwater Consultants					
Branch of Institution:	East London					
Contact details:	Contact person:	E Goossens				
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B: TYPE OF INFORMATION

Information format:	Hard copy	<input checked="" type="checkbox"/>	Data Summary	<input type="checkbox"/>	Electronic Report	<input type="checkbox"/>
	Specify Other:					
Report / Info Title:	Mbashe Local Municipality					
Report Nr:	TR/KVSA/EC/003/06	Date:	Feb-06			
Author Details:	E. Goossens					
Author's Qualification:	Hydrogeologist	<input checked="" type="checkbox"/>	Govt Dept	<input type="checkbox"/>	Project Manager	<input type="checkbox"/>
	Engineer	<input type="checkbox"/>	Technician	<input type="checkbox"/>	Other	<input type="checkbox"/>
	Specify Other:					
Captured by:	Dané von Berg	Date:	Signed: DVB			

C: GEOHYDROLOGICAL CATEGORIZATION

Project Type	Source development	<input checked="" type="checkbox"/>	Feasibility Study	<input type="checkbox"/>	Sanitation Study:	<input type="checkbox"/>
	Specify Other:					
Reference Co-ordinate:	Latitude			Longitude		
Lithological & Construction Logs	Yes	No	Complete	<input checked="" type="checkbox"/>	Incomplete	<input type="checkbox"/>
Hydrocensus Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pump Testing Data	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Chemical Water Analysis Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Geohydrological Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Spring Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Remote Sensing Data	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Map Data	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comments:

Reviewed by: _____ Signed: _____

MBASHE LOCAL MUNICIPALITY
WARD 3 & 6 VILLAGES

Bolotwa Village – Ward 3

Lencane and Newtown Villages Ward 6

SANITATION PROTOCOL



Report number: TR/KVSA/EC/003/06

Date: 27 February 2006

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MAP 2 - COMMUNITY POPULATION

MAP 3 - GEOLOGY MAP

MAP 4 - VULNERABLE AREAS

CD (ATTACHED ENVELOPE)

Report.pdf

Appendixes: **APPENDIX A-** Field data tables.xls
APPENDIX B- Field report.pdf and photos (jpg)
APPENDIX C- Groundwater Quality Results

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1. INTRODUCTION

1.1. FOREWORD

*"Water supply and sanitation are **inextricably linked** as these two aspects impact on each other. Water supply, especially the quality of water, is dependent on the country's available water resources. Adequate sanitation is linked to water supply and it impacts on the state of the health and well being of the population."*

(Department of Water Affairs and Forestry, "Business Plan for Sanitations' Communications Campaign" Rachele Seymore, WS: Communications Coordinator, June 2003)

*"The Groundwater Protocol aims to **provide simple tools** for groundwater and sanitation planners and practitioners to ensure that the development programmes for communities continue to place a high value on the groundwater resources, and hence protect them from contamination from sanitation practices and other potential contaminants."*

(Department of Water Affairs and Forestry, "A Protocol to Manage the Potential of Groundwater Contamination from on Site Sanitation" Edition 2, February 2003)

1.2. PROJECT BACKGROUND

ARCUS GIBB appointed Khulani VSA Groundwater Consultants (Pty) Ltd, a professional hydrogeological consulting firm, to conduct a hydrogeological investigation for three villages in Mbashe Local Municipality and Amathole District Municipality. Bolotwa village is situated in Ward 3, and Lencane and Newtown in Ward 6.

The final output of this study is to produce a groundwater protection protocol (sanitation protocol) document that will be compliant with the standards set by Department of Water Affairs and Forestry in their document: **"A Protocol to Manage the Potential of Groundwater Contamination from on site Sanitation" (Edition 2, March 2003)**.

1.3. GUIDING PRINCIPALS

A two stage approach was introduced by DWAF: (1) area based assessment [aerial "first pass" by specialists] and (2) a project based assessment using outputs of the area based assessment.

<p>[1] The revised GW Protocol falls under the overall provisions of three government Acts: National Water Act (Act 36 of 1998), the National Environmental Management Act (Act 107 of 1998) and the</p>

Environment Conservation Act (Act 73 of 1989).
[2] The GW Protocol forms part of a set of procedures for the provision of sanitation and the protection of water resources, and should not in itself be used to justify a particular choice of action without the financial and socio-economic assessments required for holistic decision making.
[3] The GW Protocol is intended to permit assessments of environmental impact of sanitation systems to be carried out using the lowest skills levels feasible. Where resources are limited, effort in assessment needs to be in proportion to impact.
[4] GW Protocol procedures are to be integrated into regional institutional structures to ensure that the responsible authorities are informed of all studies and outcomes. Responsibilities for the various tasks of the GW Protocol need to be allocated in conjunction with institutional structuring.
[5] Impacts cannot generally be resolved in absolute terms, but are resolved in a water resources strategy. While certain practices are better than others, and there are certain interventions that can be made to further protect groundwater from contamination, <i>absolute</i> protection from <i>any</i> contamination by sanitation systems is unrealistic - certainly in the context of developing areas.
[6] Communities should be involved in the site assessments to be carried out, including the hydro census, and made aware of the health impacts related to contamination of the groundwater resources. They should also be involved in the longer term monitoring of the groundwater and the potential sources of contamination.
[7] Factors affecting the performance of sanitation systems (and the extent of contamination) are not only related to their theoretical performance, but also how carefully the systems are designed, managed and used.
[8] Groundwater resources are likely to become more valuable in the future, even in urban areas where piped water is supplied from surface sources. For this reason appropriate steps to ensure reasonable protection should always be taken.

1.4. GUIDING PROCEDURES

The following procedures have been set up by DWAF to provide the background approach and hence to assist those using the protocol to be able to take the correct decisions at all stages of the assessment.

[1] A hydro census should be undertaken of all water sources within a 2 km radius of the area being developed. (The size of the area may be reduced or decreased, as long as a representative number of boreholes are assessed).
[2] The community should be involved in the hydro-census and made aware of the health impacts related to contamination of groundwater resources used for water supply purposes.
[3] No on-site sanitation systems system should be installed within 50 m of a water supply source

(spring or borehole) and vice versa.
[4] No high loading (schools, clinic etc.) sanitation system should be installed within 75 m of a groundwater supply source and visa versa.
[5] All boreholes should be completed with a sanitary seal and appropriate wellhead construction aimed at preventing surface water from entering the borehole.
[6] No activity should be allowed within 30 m of a borehole other than those associated with collecting water.
[7] If appropriate and practical, new boreholes should be sited outside of villages and up-gradient of potential sources of contamination. Borehole site selection must take into account geohydrological criteria and potential sources of contamination which could impact on the suitability of the water for consumption.
[8] All failed or abandoned boreholes should be backfilled and sealed after the project manager and/or the client has had an opportunity to measure that the borehole was drilled to specification.
[9] All groundwater supply systems must have regular monitoring of the water quality.

2. LOCATION AND TOPOGRAPHY OF THE STUDY AREA

Bolotwa is situated approximately 32 km north of Dutwya while Lencane and Newtown are situated approximately 7 km south of Dutwya. The population figures were obtained from the 2001 Census data from Stats SA. The community boundaries were verified on site.

Table 1: Community List

Nr	Ward	Main Community	Sub-Community	Population	Households (6 people)	Area (ha)	Households / Area (ha)
1	3	Bolotwa	eMlenzeni	606	101	67	1.5
			Komkhulu	399	67	65	1.0
			eQhokama	558	93	85	1.1
			Matolweni	460	77	106	0.7
2	6	Lencane		583	98	284	0.3
3	6	Newtown		563	94	118	0.8

Refer to **Appendix B**: Detail community reports.

Refer to **MAP 1** – Ward 3/6 LOCALITY MAP, HYDROCENSUS; BOREHOLES AND SPRINGS.

Refer to **MAP 2** – Ward 3/6 COMMUNITY POPULATION.

The Krweleda River is towards the east of the Bolotwa villages and the Ngcingwana River forms the southern boundary for Newtown and Lencane. Bolotwa village is within the T12G catchment area and Newtown and Lencane in T90A.

The altitude of Bolotwa varies between 2200 – 2500 mamsl and at Newtown and Lencane the altitude varies between 780 and 820 mamsl. Topographically the whole area is undulating with ridges and valleys. A detailed description of each village can be found in **Appendix B**.



Photo 1: Topography at Bolotwa

3. PRINCIPLE OF RISK

The assessments associated with the Groundwater Protocol are based on the level of risk of groundwater contamination presented by the sanitation systems, in relation to the risk of contamination from other sources.

The risk levels are based on three factors:

- The vulnerability of groundwater resources (aquifers).
- The contamination load from the specified sanitation system.
- This overall risk provides the risk of contaminating the groundwater at the zone of the sanitation systems.

4. TECHNICAL CONSIDERATIONS

4.1. WASTE DISPOSAL RATE

The loading in specific areas depends on the density of latrines per hectare and the number of people utilizing each pit:

- 50 houses/ha : Low
- 50- 150 houses/ha : Medium
- 150-300 houses/ha : High
- >300 houses/ ha : Very high

In rural communities, population densities tend to be lower. Densities below 5 houses/ha are common within the project area, while densities above 50 houses/ha are regarded as uncommon.

Refer to **Table 1** – Community List

Refer to **MAP 2** – Ward 3/6 COMMUNITY POPULATION

Loading should take into account the population density and total size of the settlement. The amount of nitrogen leached out of the pits to groundwater depends not only on hydraulic loading, but also on the **prevailing geological conditions**.

4.2. SPECIAL ADAPTATIONS OF SANITATION SYSTEMS TO REDUCE CONTAMINATION

The choice of sanitation systems could significantly influence the degree of contamination of the groundwater, therefore other systems will need to be considered to reduce or prevent contamination of the groundwater.

In the case of pit toilets, adapting can take place in three main ways:

- Increasing the depth of the unsaturated zone by reducing the depth of the pit
- Sealing the pit due to the water level close to the surface
- Converting the sanitation system so that the pit only contains dry solids

“The depth of the pit may be reduced by either building a part of the pit above ground, or alternatively by digging a wider, shallower pit. In each of these cases the volume of the pit should not be reduced.”

“Sealing the pit has a similar impact as reducing the depth of the pit. In this case the pit fills up with a mixture of liquids and solids, but the liquid is drained off near the top of

the pit. The drain pipe may be lead to a garden or grass patch, but should not be used on edible plants.”

“Options for converting the sanitation system so that the pit only receives dry solids include the urine diversion toilet, high rate aeration or desiccation toilets, and composting toilets.”

“A Protocol to Manage the Potential of Groundwater Contamination from on site Sanitation” (Edition 2, March 2003).

4.3. AQUIFER VULNERABILITY AND RISKS TO GROUNDWATER SUPPLIES

Aquifer vulnerability is the possibility of an aquifer being affected by a contaminant load imposed by human activities at ground surface. Proper management of groundwater and control of hazardous activities on vulnerable aquifers is essential for the protection and sustainability of the groundwater resource.

4.4. GEOLOGICAL CONDITIONS

This plays a major role in attenuating pollutants entering the subsurface system. Some of the attenuation processes are dependent on the chemical nature of the rock, and the physical conditions. As a basic principle, the longer it takes the contaminants to reach the groundwater, the lower the impact on water quality.

Travel time for contaminants to pass through the unsaturated zones has previously been used as an indicator of attenuation potential. Travel times of between 30 – 50 days are considered suitable for the die-off of bacteria and viruses. A travel time in excess of 30 days from base of pit to groundwater level appears reasonable. (***“A Protocol to Manage the Potential of Groundwater Contamination from on site Sanitation” (Edition 1, 1997) DWAF.***).

5. METHODOLOGY

An **area-base assessment** of the geology and aquifers was undertaken. The main aim of this assessment is to identify the aquifers and determine sensitive areas where the risk of pollution will be high.

The following **methodology** was followed:

- A Desktop Study in which the following information was collected:
 - Information on existing groundwater sources from the local database (Aquabase).
 - Information on the geology, hydrogeology and topography of the area obtained from local GIS data.
- A detailed field investigation to verify the following information:
 - Springs
 - Boreholes (Waterlevels and Water Quality)
 - Community activities likely to impact groundwater sources include stock water dams, grave sites, dipping tanks, ect.
- Data synthesis.
- Compilation of a Sanitation Protocol Report.
- Maps indicating potential problems in the area.

SANITATION PROTOCOL INVESTIGATION

The investigation is aimed at establishing a simplified draft sanitation protocol to reduce the risk of groundwater contamination from on-site household sanitation and to establish a discussion document for liaison with DWAF geohydrologists.

The risk of groundwater contamination is related to a number of factors, but essentially depends on **aquifer vulnerability** and the magnitude of the pollutant threat.

The biggest sanitation pollution risk often originates from high load situations being close to community water sources and/ or favorable geohydrological zones, such as structures, e.g. dolerite dykes, lineament, joints, and faults.

It is essential that aquifer and source protection zones are identified, not only for sanitation purposes but also other community activities such as stock watering, waste disposal sites, dipping tanks and cemeteries.

6.1. IDENTIFICATION OF VILLAGE AND POPULATION DENSITY

Bolotwa is covered by 3128CD (1:50 000 topo-cadastral map) and Lencane and Newtown by 3228AB. Refer to **APPENDIX A**-Field tables (Table 1) for village co-ordinates.

A detailed description of each village can be found in **Appendix B** – Detail community reports.

The groundwater contamination risk from on-site dry sanitation household systems of rural communities are a function of the pollution load, which is based on the community's population figure and density.

From the on site visit it was determined that the low population density within the study area indicates that there are less than 5 household per hectare. The sanitation pollution load is therefore classified as **low**.

Refer to **Table 1** – Community List

Refer to **MAP 2** – Ward 3/6 COMMUNITY POPULATION

From the site visit it was clear that none of the communities are fully equipped with sanitation units.



Photo 2: Community Toilet

6.2. VILLAGE WATER SUPPLY SOURCES

From a field investigation that took place on the 31st of January and 1st of February 2006 the following information were gathered.

- Bolotwa – 5 boreholes
- Newtown – 1 borehole and 1 spring
- Lencane – 1 borehole and 1 spring

Refer to **APPENDIX A**-Field tables (Table 3 and 4).

Bolotwa has no reticulation network. One borehole is equipped with a hand pump. There is no other water source for this community.

Newtown is supplied with 1 borehole drilled in Lencane. A functional reticulation network with four tap stands was constructed. The date of construction is not known.

Lencane relies on the one tap stand closest to it from the Newtown reticulation network. There is one spring within the villages and is also utilised by the community and stock for water supply.

Springs occur where permeable (fractures) and impermeable rock mass (dolerite sheets) are positioned in such a way that the natural movement of water through the rock is deflected by the impermeable material and is forced to emerge at the surface i.e. lithologically controlled.

Springs and boreholes are very vulnerable, and should be protected at all times. Note should be taken that for future groundwater development and existing boreholes and springs, placement of sanitation systems should be done carefully and according to this proposed sanitation protocol.

Refer to **MAP 1** – Ward 3/6 LOCALITY MAP, HYDROCENSUS; BOREHOLES AND SPRINGS.



Photo 3: Unprotected Spring (Lencane)



Photo 4: Hand pump at Bolotwa

6.3. COMMUNITY ACTIVITIES

It is essential that aquifer and source protection zones are identified, not only for sanitation purposes but also other community activities such as stock watering, waste disposal sites, dipping tanks and cemeteries.

Within the Bolotwa study area, 3 grave sites and 1 dipping tank were detected. At Lencane only 1 grave site was surveyed. Refer to **APPENDIX A**-Field tables (Table 2 and 4). Refer to **MAP 1** – Ward 3/6 LOCALITY MAP, HYDROCENSUS; BOREHOLES AND SPRINGS.

A high density of cattle kraals or feedlots where cattle and other livestock are kept within confined space could result in significant contamination of groundwater during the wet seasons. The typical hydraulic load (infiltration - rate of change of hydraulic head per unit distance in a particular direction – contaminants moving downwards in millimeters per day) from cattle kraals is 1-10mm/d in dry seasons and up to 100mm/d in wet seasons. 1mm/day should be added for every additional 20 cattle above 50.

Graveyards and grave sites pose a negligible threat to groundwater due to the very slow rate of decay and the rapid die-off of bacteria and viruses.

6.4. GEOLOGY OF STUDY AREA

Bolotwa is underlain by the following geological units, listed in a chronological (age) order.

- **Alluvium (Al)** can be found adjacent to some of the rivers, this can cause problems for the installation of wet systems (normal VIP's) and should not be erected in these areas.
- Dolerite **dykes**.
- The study area is characterised by massive, shallow-dipping **dolerite (Jd)** sheets.
- **Katberg formation (TRk)**: Sandstone, and brownish-red and grey mudstone. The whole area is underlain by this unit.

Newtown and Lencane are underlain by the following geological units, listed in a chronological (age) order.

- **Alluvium (Al)** can be found adjacent to some of the rivers, this can cause problems for the installation of wet systems (normal VIP's) and should not be

erected in these areas.

- Dolerite **dykes**.
- **Adelaide Subgroup (Pa)**: This subgroup consists essentially of grey and brownish-red mudstone and sandstone. The whole area is underlain by this unit.

Refer to **MAP 3** – Ward 3/6 GEOLOGY MAP and **APPENDIX A**-Field tables (Table 2 and 4).



Photo 5: Geology – Dolerite dyke at Bolotwa

6.5. DEPTH OF GROUNDWATER LEVEL

Only one borehole (Bol-8 a privately owned borehole) at Bolotwa was accessible where a groundwater level was measured. The water level at this borehole was **21**mbgl (meters below ground level). The existing database indicates that a water level of **17**mbgl was measured in 1998.

No boreholes were accessible for the measuring of a water level at Newtown and Lencane. Borehole 108-0023 was sampled for water quality purposes, but had no access

for the measuring of a water level. From the existing database one borehole had a measured water level of **34**mbgl (measured in 1998).

Refer to **APPENDIX A**-Field tables (Table 3).

The water level is a critical factor in ascertaining the risk related to on-site household sanitation. This is related to human excreta and associated health risks in the event of groundwater contamination. The required unsaturated thickness (depth to water level) previously reported for South African conditions include **10 to 20 meters**.

"A Protocol to Manage the Potential of Groundwater Contamination from on site Sanitation" (Edition 1, 1997) DWAF.

6.6. GROUNDWATER QUALITY

A total of two boreholes were sampled, one borehole at Lencane (Borehole number 108-0023) and one at Bolotwa (Borehole number Bol-12). Refer to **APPENDIX A**-Field tables (Table 3) for the borehole numbers and the maps for the positioning of the boreholes.

The groundwater quality at Bolotwa is a **Class 2** (due to a high Electrical Conductivity value, Chloride content, Turbidity reading and Total coliforms count). Groundwater quality at Lencane was shown to be **Class 2** (due to a high Turbidity reading and Total coliforms count)

Refer to **APPENDIX C** - Groundwater Quality Results.

From Khulani VSA database (existing borehole information) an average groundwater quality was found to be in the range of a Class 2. This includes old boreholes that could be destroyed.

6.7. AQUIFER VULNERABILITY

"Aquifer vulnerability is the likelihood of an aquifer being affected by a contaminant load imposed by human activities at ground surface. The assessment of the vulnerability is based on the estimated travel time for water to move from the ground surface to the water table. As the water moves through the ground, natural processes reduce (or attenuate) the concentration of many contaminants"

According to the map "**An evaluation of groundwater vulnerability and pollution risk assessment in the preparation of a groundwater protection strategy for South Africa**" (Reynders, A.G., 1996), the groundwater vulnerability underlying all three communities are of **medium** pollution risk.

From the site visit, geology, community activities, positioning of the water sources, groundwater quality and depth of water levels the groundwater vulnerability are of medium pollution risk.

6.8. AQUIFER ZONES

Both areas of investigation contain predominantly compact arenaceous and argillaceous strata from the Tarkastad subgroup (Bolotwa) and Adelaide subgroup (Newtown and Lencane). The geology is mainly mudstone, sandstone; intruded by dolerite dykes and sheets. The rock is a decomposed / partly decomposed sedimentary rock and has water bearing fractures principally restricted to a shallow zone below groundwater level. (Seymour A., 1995. **Groundwater Harvest Potential of South Africa. Unpubl. Prelim. map. DWAF**). A moderate groundwater potential ranging between 30-40% probability of a successful borehole (yield > 2l/s) is found within the Bolotwa area and 20-30% within the Newtown and Lencane area (Vegter, J.R., Seymour A., 1995. **Groundwater Resources of the Republic of South Africa – Two Map sheets and explanatory brochure. DWAF**).

The unsaturated zones which consist of fractured and weathered sandstone will have medium transmissivities (0.1 - 10mm/d). This will create high reduction conditions under which the bacteria and possible viruses will be minimized. Therefore the capacity of the media to absorb contaminants and create an effective barrier is medium. This aquifer zone forms a **fair barrier** to the movement of contaminants, but little reduction in chemical contaminants. (**Assessment of the reduction of contaminants in the unsaturated zone-DWAF**).

If the following **recommendations** are adhered to, then the risk of possible groundwater contamination will be medium to low. Due to the low density of the population (<5 households/ha), the risk of aquifer pollution can be classified as low.

- **No wet sanitation systems on the alluvium.**
- **No high loading (schools, clinic etc.) sanitation system should be installed within 75 m of a groundwater supply source (borehole or spring)**
- **No pit latrines to be located within 50 m of a water supply source (spring or borehole)**
- **No pit latrines to be located upstream (groundwater flow direction) from any spring**

All of the above vulnerable areas are highlighted in **MAP 4** – Ward 3/6 VULNERABLE AREAS and appropriate development constraints must be adhered to.

9. REFERENCES

1. Department of Water Affairs and Forestry, Edition 1, 1997, A Protocol to Manage the Potential of Groundwater Contamination from On Site Sanitation.
2. Reynders A. G., 1998, An Evaluation of Groundwater Vulnerability and Pollution Risk Assessment in the Preparation of Groundwater Protection Strategy for South Africa.
3. DWAF, Vegter, J.R., Seymour A., 1995, Groundwater resources of the Republic of South Africa – Two map sheets and explanatory brochure.
4. DWAF, Assessment of the reduction of contaminants in the unsaturated zone.
5. Department of Water Affairs and Forestry, Edition 2 (Draft Version), Feb 2003, A Protocol to Manage the Potential of Groundwater Contamination from On Site Sanitation.

APPENDIX A

Field tables

1. Village co-ordinates
2. Geological outcrops and Community Activities co-ordinates
3. Water sources
4. List of Photos

Table 2: Geological outcrop and Community Activities co-ordinates

Rock type	Point Type	Description	Latitude			Longitude		
			°	'	"	°	'	"
Bolotwa								
Dolerite Sill	Sill	Sill	31	55	28.6	28	17	30.3
Sandstone	Graveyard	Grave site	31	54	55.1	28	16	47.7
Sandstone	Graveyard	Grave site	31	56	56.5	28	17	40
Sandstone	Graveyard	Grave site	31	56	10.8	28	17	28.5
Dolerite Dyke	Contact zone	Contact with Sandstone	31	55	5.4	28	17	20
Dolerite Outcrop	Dolerite Dyke	Outcrop	31	54	54.1	28	17	7.7
Mudstone & Sandston	Dipping Tank	Dipping tank	31	56	26	28	17	54.6
Lencane								
Sandstone	Kraal	Kraal for cattles	32	8	17.2	28	20	40.7
Newtown								
No geological outcrop or problematic community activities								

Table 3: Water sources

Borehole No./ ID No.	Type	Description	Latitude			Longitude			Water level (m)	Depth (m)	Yield (l/s) [hr]	Class (Element)	Geology / Aquifer
			o	'	"	o	'	"					
BOLOTWA													
Bol-4	Borehole	Broken windmill	31	56	18	28	17	47.6				Sandstone	
Bol-6	Reservoir	Old cement reservoir	31	55	37.2	28	17	32.9				Sandstone	
Bol-8	Borehole	Equipped with Mono pump (Private)	31	55	3.1	28	17	21.1	21	54		Sandstone	
Bol-9	Borehole	Broken windmill, filled with soil	31	55	7	28	17	19.8				Sandstone	
Bol-10	Borehole	Broken windmill	31	55	6.4	28	17	19				Sandstone	
Bol-12	Borehole	Hand pump (Sampled)	31	54	9	28	17	5.6			2	Sandstone	
LENCANE													
108-0023	Borehole	Equipped with Submersible pump	32	8	21.5	28	21	52.3		81	2.5 [12]	2	Sandstone
Len-1	Spring	Unprotected Spring	32	8	3.4	28	21	40.3					Sandstone
Len-2	Reservoir	Concrete reservoir	32	8	18.5	28	20	43.7					Sandstone
NEWTOWN													
New-1	Tank	Plastic tank	32	8	25.7	28	20	5.5					Sandstone
T90116	Borehole	Was equipped with windmill	32	8	45.7	28	20	43.3			0.6		Sandstone
New-2	Spring	Unprotected Spring	32	8	47.7	28	20	14.6			0.01		Mudstone

02/2006 - Groundwater analysed

- Borehole
- Spring
- Reservoir

Table 4: List of photos

Photo No./ ID	Latitude			Longitude			Image	Description
	o	'	"	o	'	"		
Botswana								
3 / 4 & 5	31	54	55.1	28	16	47.7	Grave Site	Poorly fenced Grave yard located 1km from the first homestead
2 / 6 & 20							Village	Village photo
7	31	56	46.5	28	17	40	Grave Site	Unfenced Grave yard
8	31	56	26	28	17	54.6	Dipping Tank	Cattle dipping tank
9	31	56	18	28	17	47.6	Broken Windmill	Bol-4: Old borehole equipped with windmill, broken at the moment.
10	31	56	10.8	28	17	28.5	Grave Site	Unfenced Grave yard located inside the village
11	31	55	37.2	28	17	32.9	Reservoir	Concrete Reservoir
12	31	55	28.6	28	17	30.3	Dolerite	Exposed dolerite sill
13 & 14	31	55	35.5	28	17	31.2	Pit Latrine	Self constructed Pit Latrine
15	31	55	3.1	28	17	21.1	Borehole	Bol-8: Private Borehole equipped with mono pump
16	31	55	7	28	17	19.8	Borehole	Bol-9: Was equipped with windmill, destroyed and filled with stones and soil
17	31	55	6.4	28	17	19	Broken Windmill	Bol-10: Old borehole equipped with windmill and concrete reservoir
18	31	55	5.4	28	17	20	Contact zone	Dolerite (dyke) contact with Sandstone
19 & 21	31	54	54.1	28	17	7.7	Dolerite	Dolerite (dyke) outcrop
22	31	54	9	28	17	5.6	Borehole	Bol-12: Equipped with handpump and located 1km from the first homestead
Lesotho								
Lencane								
1 & 32							Village	Village photo
23	32	8	21.5	28	21	52.3	Borehole	108-0023: equipped with Submersible pump.
0024 & 0025	32	8	3.4	28	21	40.3	Spring	Len-1: Unprotected spring.
0026 & 0027							Pit Latrine	Self constructed Pit Latrine
28	32	8	18.5	28	20	43.7	Reservoir	Concrete Reservoir
29	32	8	17.2	28	20	40.7	Kraal	Cattle kraal
Newton								
30	32	8	45.7	28	20	43.3	Borehole	T90116: was equipped with windmill.
31	32	8	25.7	28	20	5.5	Tapstand	Newton Tapstand
33	32	8	25.7	28	20	5.5	Tank	Newton water tank and tapstand
34	32	8	31.9	28	20	11.9	Pit Latrine	Self constructed Pit Latrine
35	32	8	47.7	28	20	14.6	Spring	New-2: Unprotected spring.
36							Village	Village photo

APPENDIX B

1. Bolotwa
2. Lencane
3. Newtown

1. Bolotwa Village

Settlement:

- Relatively big settlement
- The surrounding topography is mountainous and the village located in the valley.
- The accessibility of the village is in moderate condition (gravel road).
- The population density is not more than 5 households per hectare
- About 25% of the homesteads have self-constructed pit latrines
- 90% of these pit latrines are in bad condition.

Water Status:

- Community rely on one borehole, equipped with hand pump located at the Northern side of the village, about 1 km from the first homestead.
- It is the main sources at this moment.
- Two broken windmills exists, both are out of order.
- One existing concrete reservoir of which the water supply source was the windmill (Bol - 10).
- There is no tap stand in the village.
- There are no spring sources in this village.

Grave Yard:

- Three small grave sites in the village.
- Two of these grave sites are located outside the village, about 1 km from the homesteads.
- And one is inside the village, about 100m from a house.

Geology:

- Bolotwa Village is underlain by sandstone, and grey and brownish red mudstone.
- There are two dolerite structures crossing the village.
- The first one is a dolerite sill with a strike direction of W - E, and the other is a dolerite dyke striking NW - SE.

Sandstone, brownish-red and grey mudstone

Water Sources:

- Water Storage Reservoir
Dimensions: Height = 2.5m
Diameter = 10m
- Reservoir Source – is a borehole (Bol - 10) equipped with windmill, but broken at the moment.

2. Newtown Village

Settlement:

- Relatively small settlement
- The topography is relatively flat with some valleys towards the stream.
- About 4% of the homesteads have self-constructed pit latrines
- These pit latrines are in bad condition.

Water Status:

- Community is serviced by a borehole drilled in Lencane Village.
- Four tap stands were constructed in this village.
- In cases of interruption of the water supply system, the community is dependant on a spring.
- The spring is not protected and is used by the community and the animals.
- Borehole (T90116) was drilled during the old Transkei Government and is being rehabilitated for an agricultural Project.
- This borehole was equipped with a windmill before.

Geology:

- Newtown Village is underlain by grey and brownish red mudstone and sandstone.
- There is no dolerite intrusion in this village.

Water Sources:

- Water Storage Tank
Dimensions: Height = 3m
Diameter = 8.5m
- Tank Source – is a borehole drill at Lencane village, across the main road from town.

3. Lencane Village

Settlement:

- Relatively small settlement
- With steep slopes towards the Ngcingwane river.
- Village accessibility is in moderate condition.
- About 10% of the homesteads have self-constructed pit latrines
- These pit latrines are in bad condition.

Water Status:

- Community is served by one tap stand located at Newtown village.
- No reticulation network exists in this village.
- Borehole 108-0023 pumps the water to a tank in Newtown village and is equipped with a submersible pump.
- Some community members are dependent on a spring.
- The spring is not protected and is used by the community and the animals.

Geology:

- Lencane Village is underlain by grey and brownish red mudstone and sandstone.
- No geological structures cut across the village.

Water Sources:

- Water Storage Reservoir
Dimensions: Height = 3m
Diameter = 8.5m
- Reservoir Source – borehole (T32561) drilled in Newtown and was equipped with windmill.

APPENDIX C

Groundwater Quality Results

CHEMISTRY REPORT

BASIC SITE INFORMATION: Site Identifier: 3128CDV0051 Number: BOL -12 Site type: Borehole

Distr./Farm No.: BOLOTWA Site Name/Des.: DUTYWA/BOLOTWA

Region Type: Local Municipality Region Descr.: MBASHE LOCAL MUNICIPALITY

Latitude [°]: 31.902500

Reg./BB.:

Topo-set.: Valley

Depth [m]:

Longitude [°]: 28.284889

G-Nr.:

Site status: In use

Col. ht. [m]:

Altitude [m]:

Site purp.: Production (water supply)

Diam. [mm]:

Coord. acc.: Accurate to within 100 units

Use applic.: Domestic - all purposes

Drain. reg.: T12G

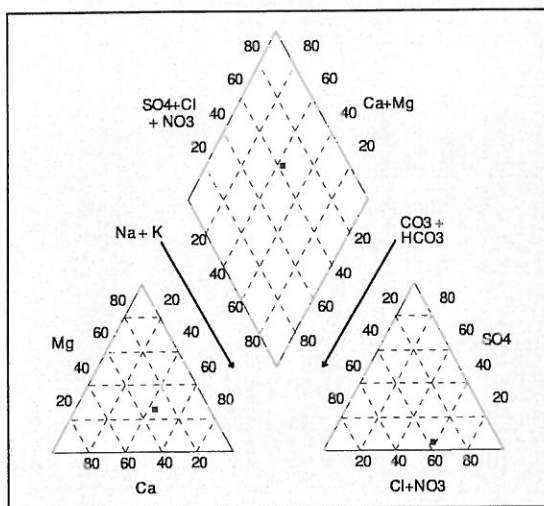
Coord. meth.: Global Positioning System

Equipment: Hand pump

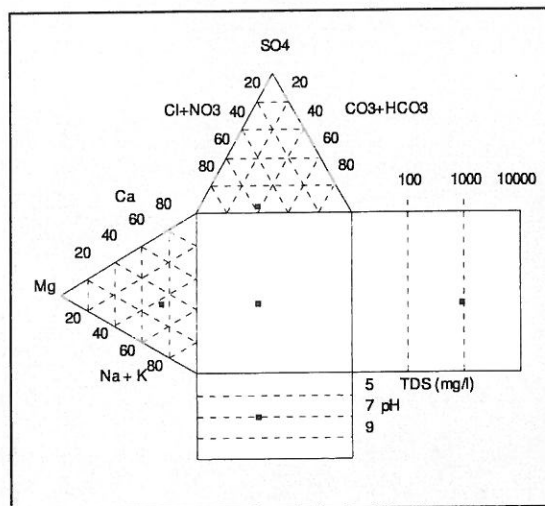
Rep. inst.: KVSA

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Piper Diagram



Durov Diagram



SAMPLE INFORMATION:

Chem. ref.	Sample	Meth. sampled	Sample Type	Date sampl.	Time samp.	Time pump.	Depth sampl. [m]	Date analysed	Laboratory
94366	BOL -12	Pump	Drinking water	20060202	1500	20	0	20060202	AMATOLA

MAIN PARAMETERS: EC mS/m

Chem. ref. nr.	pH	TDS	Ca	Mg	Na	K	P. Alk.	T. Alk.	P. Acid.	M. Acid.
94366	6.97	188 †	940 †	102	50	149 †	22	310		
Chem. ref. nr.	Si	Cl	SO4	NO3 as N	F	CO3	HCO3	Al	Mn	Fe
94366		339 †	34	0.23	0.56					0.303

ADDITIONAL PARAMETERS:

Chem. ref. nr.	NH4 as N	NO2 as N	PO4	S	CN	B	As	Sb	Bi	Cu	Pb
94366	0.04										
Chem. ref. nr.	Zn	Cr	Ni	Ti	Hg	Mo	Co	Ba	Sr	Cd	
94366											

ORGANIC PARAMETERS:

Chem. ref. nr.	COD	Cl2	DOC	TOC	DO	BOD	H2S	Phenols	Tot.	Oil	Soap	Kjeldl-N
94366												

BACTERIOLOGICAL PARAMETERS:

Chem. ref. nr.	E.Coli	Faec. co	Col	Som.	Total Co	Faec. St	SPC	Prot. Pa	Ent. Vir	TVO
94366	< 1				20					

PHYSICAL PROPERTIES AND ISOTOPES:

Chem. ref. nr.	Colour	Odour	Taste	S. Grav.	Temp.	Turb.	Susp. So	C14	H2	H3	O18
94366				MBAS	22.6	14 ‡					

CALCULATED PARAMETERS:

Chem. ref. nr.	sum TDS	TDS-EC*7	Cations	Anions	Ion-bal	CaCO3	Ca Hard.	Mg Hard.	Aggr- Ind	Langel.	CRT	SAR
94366	1073.70	1316.00	16.25	16.52	-0.82	460.14	310.00	205.80	11.87	-0.26	1.66	3.02

Bact. param. in counts/100ml
Chemistry Standard: SABS for human consumption
† Value exceeds recommended maximum limit
‡ Value exceeds maximum allowable limit
‡ Value exceeds recommended minimum limit
‡ Value exceeds minimum allowable limit



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Chemical analyses of water							
Borehole No.	Bol-12						
Project	Mbashe sanitation protocol						
District	Dutywa						
Constituent (mg/l)	Tested	Class	Class 0	Class 1	Class 2	Class 3	Class 4
TDS	940.00	1	150	1000	2400	3400	3400
pH	6.97	0	5.5-5	4.5-5 or 9-10	4-4.5 or 10-10.5	3-4 or 10.5-11	<3 or >11
Turbidity (NTU)	14.00	2	0-10	1-10	20.00	50.00	50.00
EC (mS/m)	188.00	2	70	150	370	520	520
Alkalinity	310.00						
Total hardness (T.H.)		-	200	300	600	600	600
Calcium (Ca)	102.00	1	20	150	300	300	300
Magnesium (Mg)	50.00	0	70	100	200	400	400
Sodium (Na)	149.00	1	100	200	400	1000	1000
Iron (Fe)	0.30	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)	0.23	0	5	10	20	40	40
Chloride (Cl)	339.00	2	100	200	600	1200	1200
Fluoride (F)	0.56	0	0.70	1.00	1.50	3.50	3.50
Sulphate (SO4)	34.00	0	200	400	600	1000	1000
Total coliforms (T.col)	20.00	2	0	10	100	1000	1000
Faecal coliforms (Fc)		-	0	1	10	100	100
Potassium (K)	22.00	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

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

Comments

CHEMISTRY REPORT

BASIC SITE INFORMATION: Site Identifier: 3228ABV0031 Number: 108-0023 ✓ Site type: Borehole

Distr./Farm No.:

Site Name/Des.: LENCANE/DIS:AMATOLA/FARM:LENCANE

Region Type: District Council

Region Descr.: STORMBERG

Latitude [°]: 32.139471

Reg./BB.:

Topo-set.:

Depth [m]: 81.20

Longitude [°]: 28.364169

G-Nr.:

Site status: In use

Col. ht. [m]:

Altitude [m]: 750.00

Site purp.: Production (water supply)

Diam. [mm]: 165

Coord. acc.: Accurate to within 10 units

Use applic.: Domestic - all purposes

Drain. reg.:

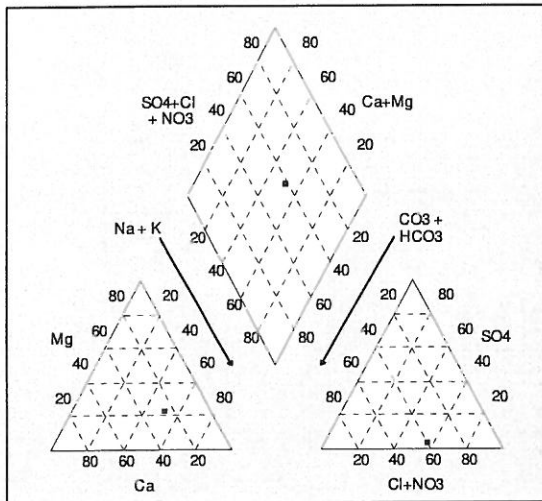
Coord. meth.: Interpolated from map

Equipment: Mono-type pump

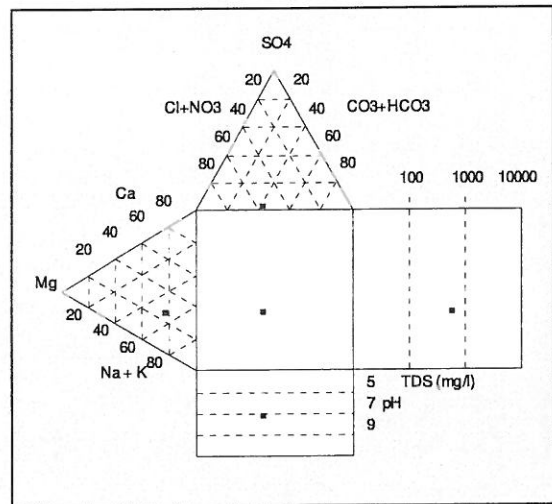
Rep. inst.: VSA

Coordinate System: Geographic Decimal Degrees (Longitude/Latitude), WGS 1984

Piper Diagram



Durov Diagram



SAMPLE INFORMATION:

Chem. ref.	Sample	Meth. sampled	Sample Type	Date sampl.	Time samp.	Time pump.	Depth sampl. [m]	Date analysed	Laboratory
94365	108-0023	Pump	Drinking water	20060201	1400	20	0	20060202	AMATOLA

MAIN PARAMETERS: EC ms/m

Chem. ref. nr.	pH	TDS	Ca	Mg	Na	K	P. Alk.	T. Alk.	P. Acid.	M. Acid.
94365	7.22	116 †	582 †	47	25	107 †	1.4	228		

Chem. ref. nr.	Si	Cl	SO4	NO3 as N	F	CO3	HCO3	Al	Mn	Fe
94365		199	14	9.2	0.45					< 0.0001

ADDITIONAL PARAMETERS:

Chem. ref. nr.	NH4 as N	NO2 as N	PO4	S	CN	B	As	Sb	Bi	Cu	Pb
94365	0.02										0

Chem. ref. nr.	Zn	Cr	Ni	Ti	Hg	Mo	Co	Ba	Sr	Cd
94365										

ORGANIC PARAMETERS:

Chem. ref. nr.	COD	Cl2	DOC	TOC	DO	BOD	H2S	Phenols	Tot.	Oil	Soap	Kjeld-N
94365												

BACTERIOLOGICAL PARAMETERS:

Chem. ref. nr.	E.Coli	Faec. co	Som. Col	Total Co	Faec. St	SPC	Prot. Pa	Ent. Vir	TVO
94365	< 1			10					

PHYSICAL PROPERTIES AND ISOTOPES:

Chem. ref. nr.	Colour	Odour	Taste	S. Grav.	Temp.	Turb.	Susp. So	C14	H2	H3	O18
94365					22.6	1.2 †					

CALCULATED PARAMETERS:

Chem. ref. nr.	sum TDS	TDS-EC*7	Cations	Anions	Ion-bal	CaCO3	Ca Hard.	Mg Hard.	Aggr-Ind	Langel.	CRT	SAR
94365	710.41	812.00	9.09	11.15	-10.15	220.09	220.09	102.90	11.65	-0.43	1.30	3.14

Bact. param. in counts/100ml
 Chemistry Standard: SABS for human consumption
 † Value exceeds recommended maximum limit
 ‡ Value exceeds maximum allowable limit
 † Value exceeds recommended minimum limit
 ‡ Value exceeds minimum allowable limit

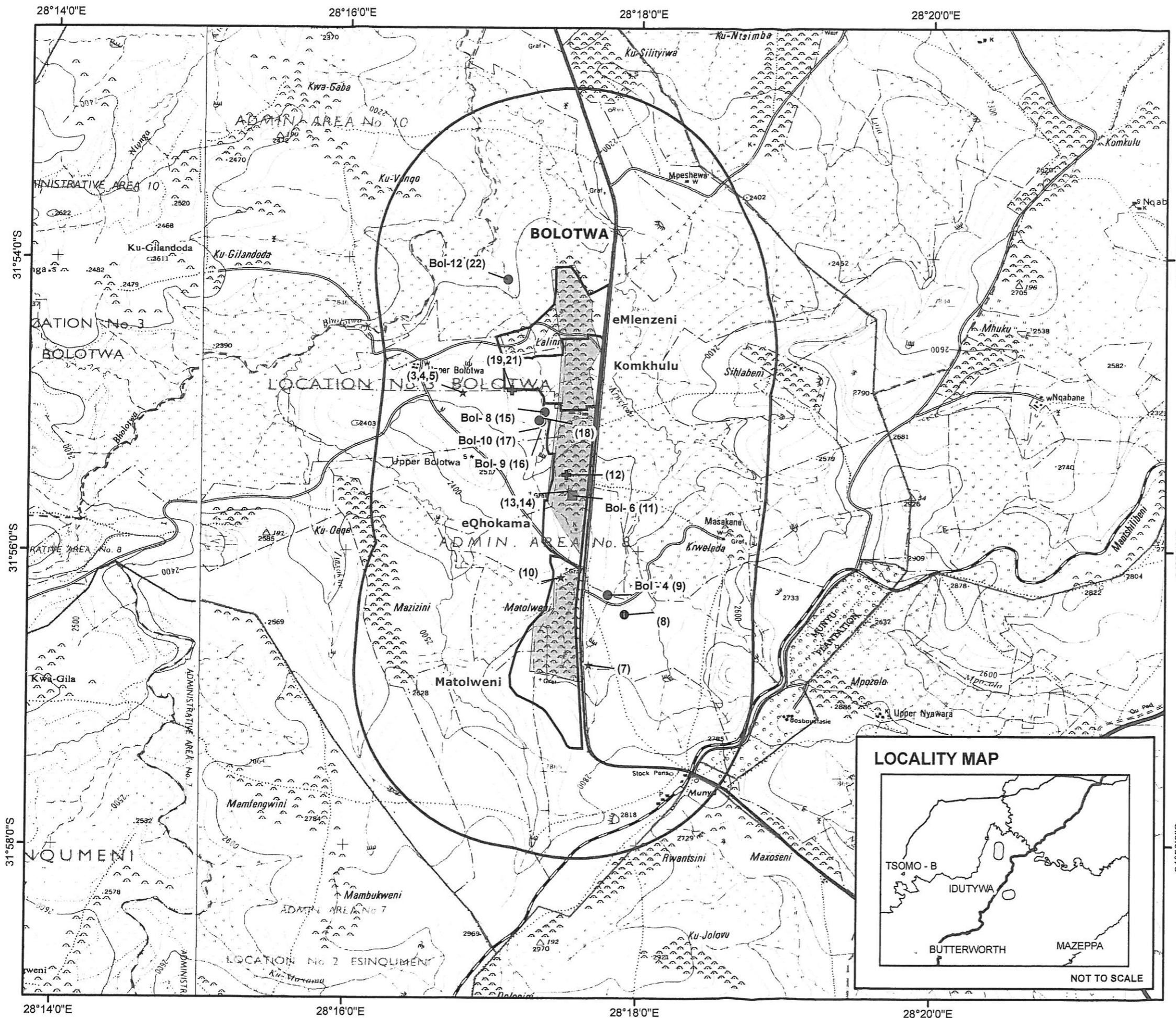


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MAPS

Bolotwa x 4 maps

Lencane & Newtown x 4 maps



LOCALITY MAP, HYDROCENSUS; BOREHOLES AND SPRINGS

PLAN MAP 1

DATE 21 February 2006

LEGEND

- Project community
- Census 2001 -boundary data
- Village 2km buffer zone

Hydro-census data

Labelled with nr and (photo nr)

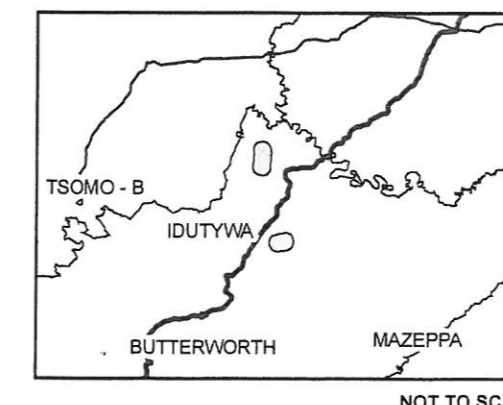
- Borehole
- Spring
- Reservoir
- Tank
- Dipping tank
- Grave site
- Kraal
- Pit Latrine
- Tap stand
- Dolerite

SCALE

1:50,000



LOCALITY MAP



NOT TO SCALE

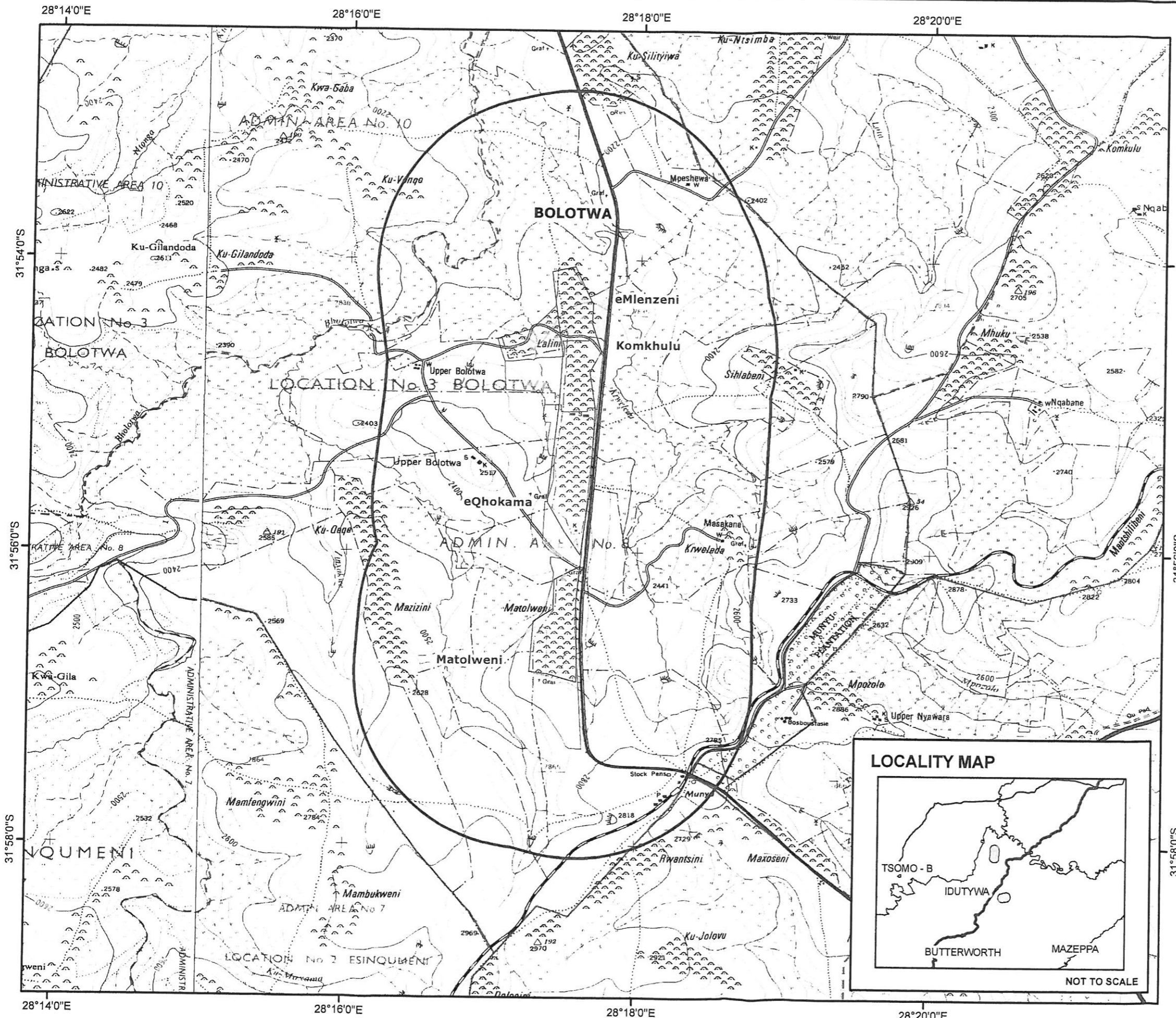
PRODUCED BY

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SANITATION PROTOCOL BOLOTWA

WARD 3 - MAP 2



COMMUNITY POPULATION

PLAN MAP 2

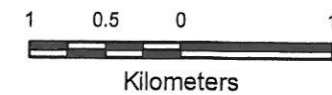
DATE 21 February 2006

LEGEND

- Project community
- Village 2km buffer zone
- Population**
- < 400
- 401 - 500
- 501 - 600
- > 600

SCALE

1:50,000

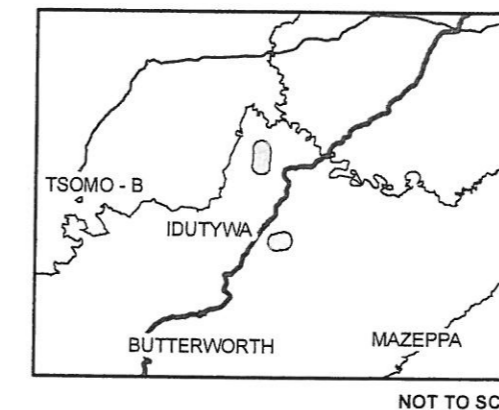


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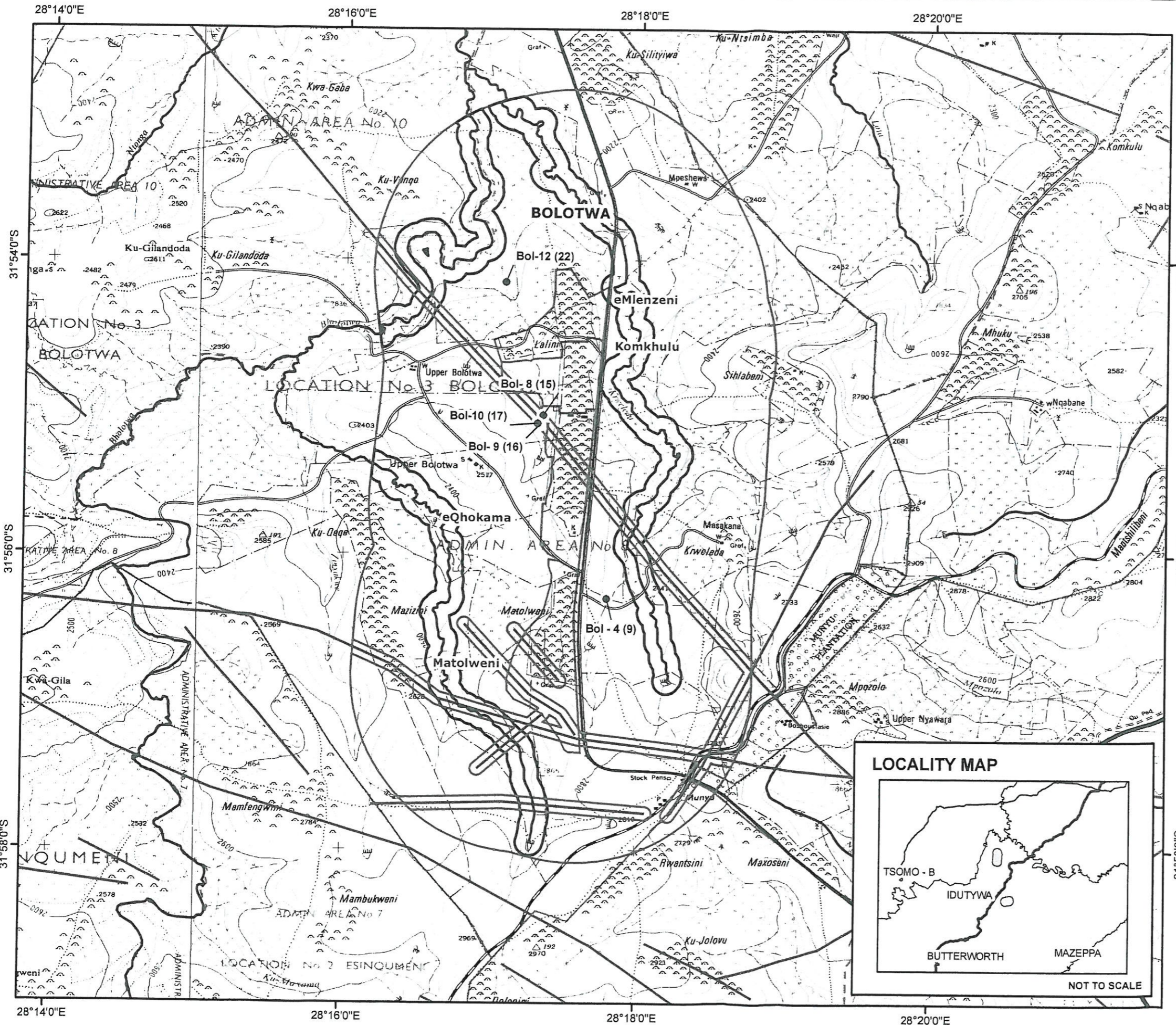
LOCALITY MAP



NOT TO SCALE

SANITATION PROTOCOL BOLOTWA

WARD 3 - MAP 4



VULNERABLE AREAS

PLAN MAP 4

DATE 21 February 2006

LEGEND

- Project community
- Perennial river
- Census 2001-boundary data
- Alluvium
- Dyke
- Village 2km buffer zone
- 150m Buffer zone from perennial river
- 75m Buffer zone from dyke

Aquifer Protection Zones

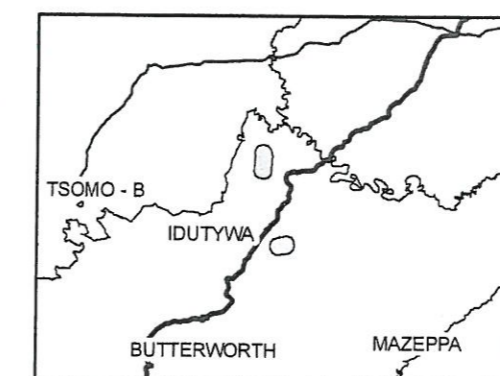
- No pit latrines to be located on prominent fissure belts related to dykes and faults
- 150m from the centre of rivers and prominent surface drainage systems
- 75m metres from dykes and faults
- 50m from water supply source (spring or borehole)
- No high loading (schools, clinic etc.) sanitation system should be installed within 75m of a groundwater supply source

SCALE

1:50,000



LOCALITY MAP



NOT TO SCALE

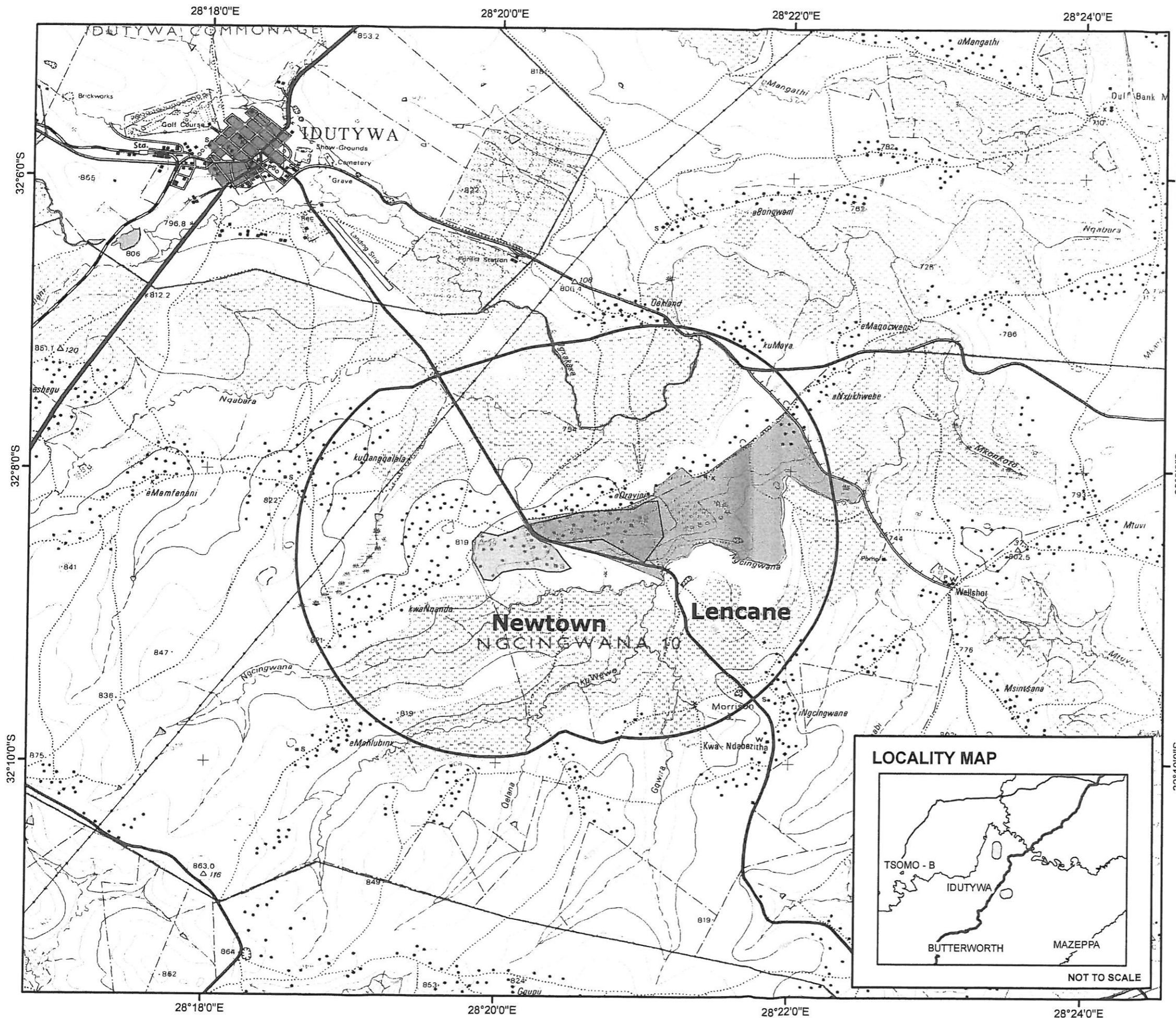
PRODUCED BY

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SANITATION PROTOCOL LENCANE & NEWTOWN

WARD 6 - MAP 2



COMMUNITY POPULATION

PLAN MAP 2

DATE 21 February 2006

LEGEND

- Project Community
- Village 2km buffer zone
- Population**
- < 550
- > 550

SCALE

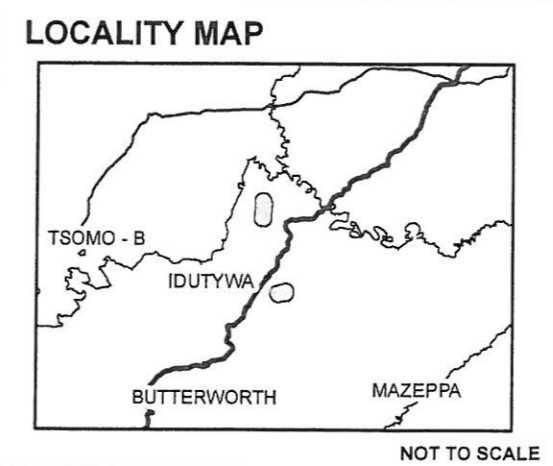
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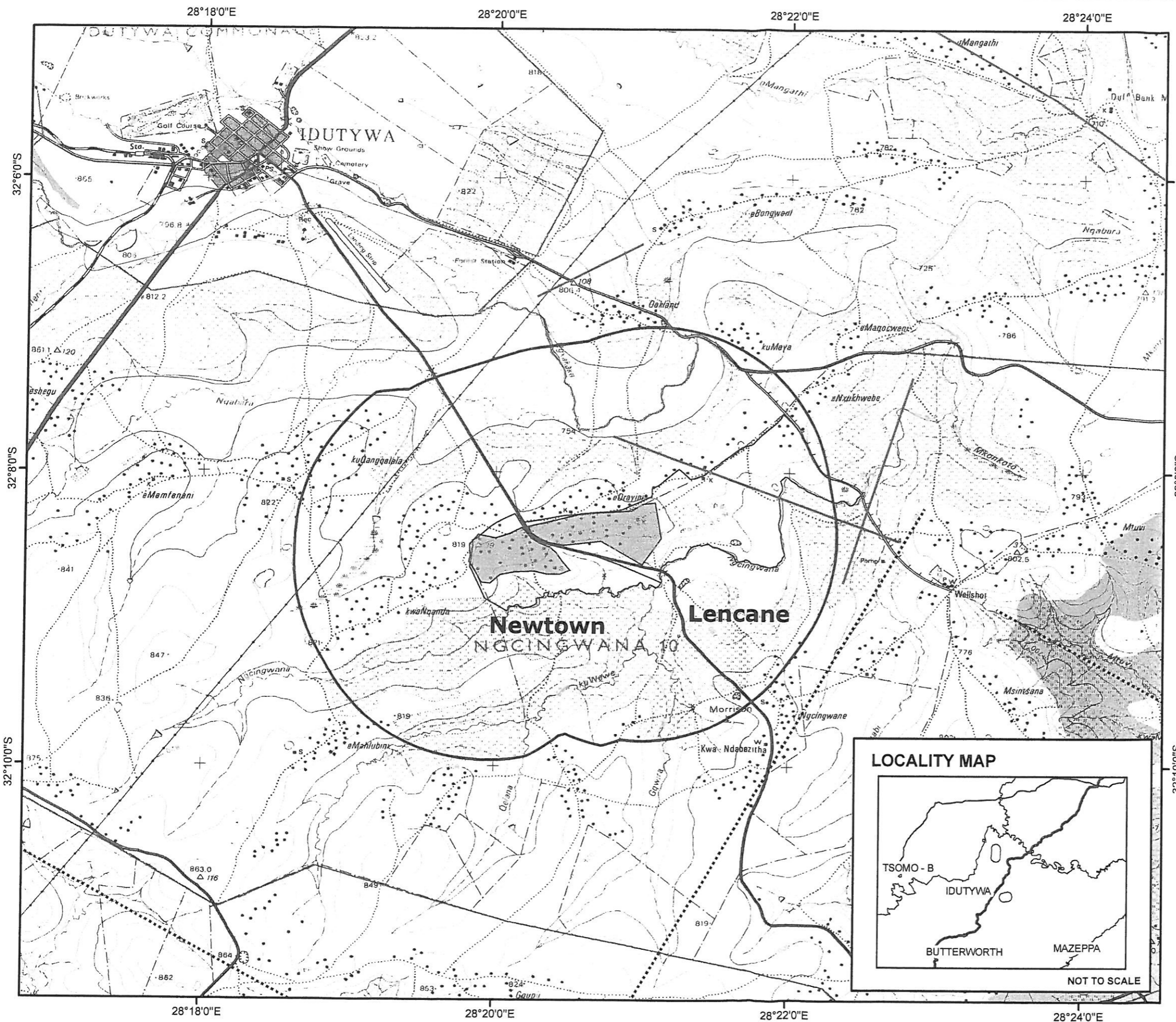
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SANITATION PROTOCOL LENCANE & NEWTOWN

WARD 6 - MAP 3



GEOLOGY MAP

PLAN MAP 3

DATE 21 February 2006

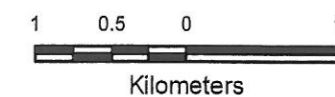
LEGEND

- Project Community
- Census 2001 - boundary data
- Geology**
- Jd: Dolerite
- Pa: Adelaide Subgroup - Grey and brownish-red mudstone, sandstone
- TRK: Katberg formation - Sandstone, brownish-red and grey mudstone
- Alluvium
- Dyke
- Lineament

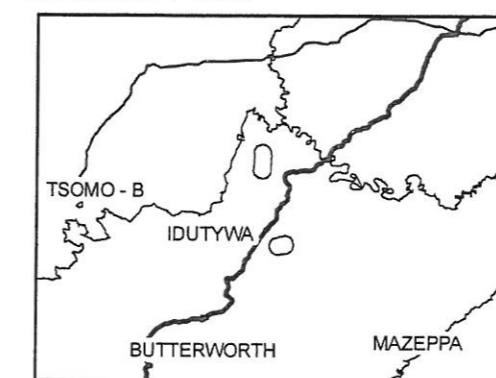
No geological outcrop points surveyed

SCALE

1:50,000



LOCALITY MAP



NOT TO SCALE

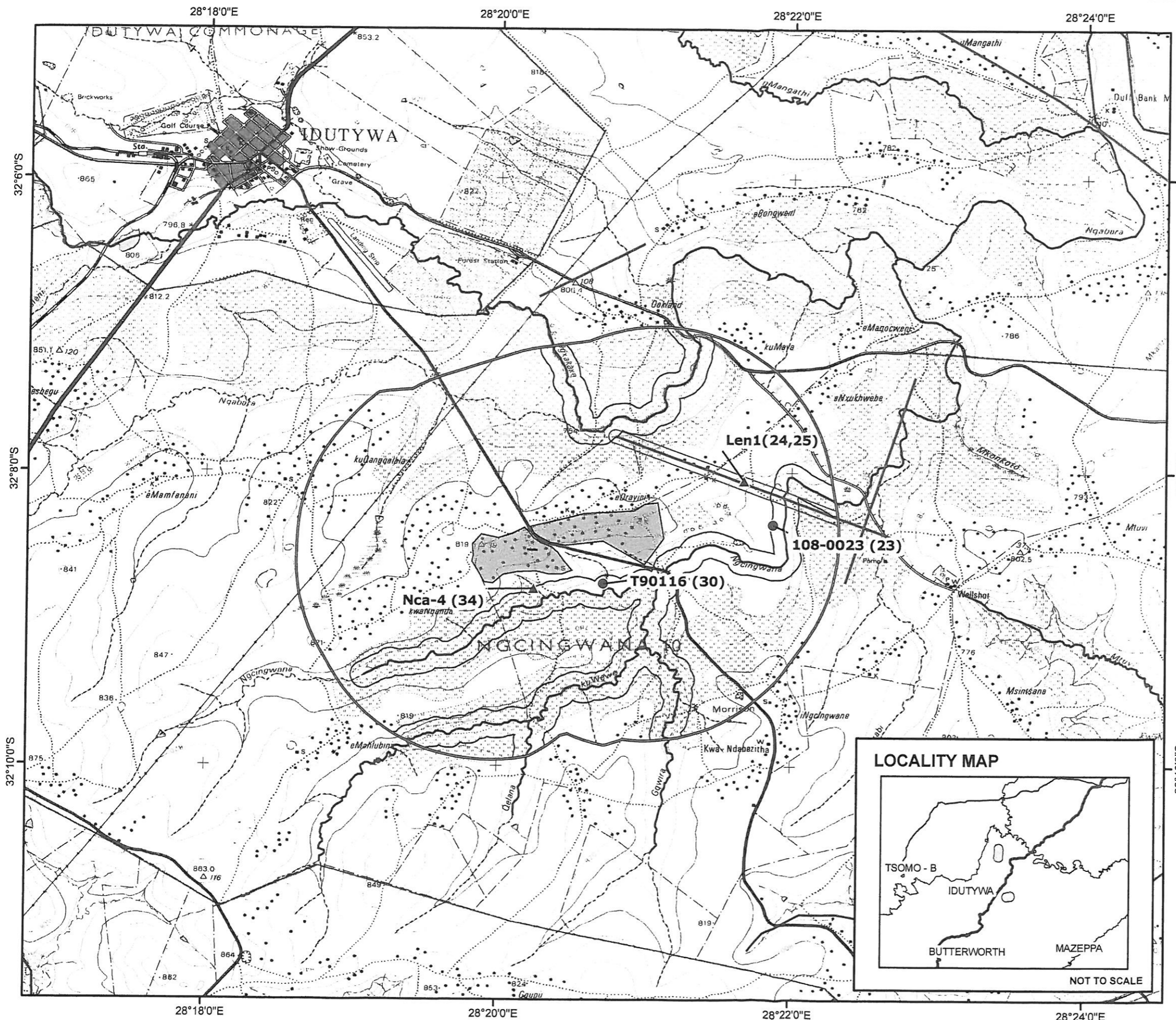
PRODUCED BY

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SANITATION PROTOCOL LENCANE & NEWTOWN

WARD 6 - MAP 4



VULNERABLE AREAS

PLAN MAP 4

DATE 21 February 2006

LEGEND

- Project Community
- Perennial river
- Non-perennial river
- Borehole - Labelled with nr and (photo nr)
- Spring - Labelled with nr and (photo nr)
- Village 2km buffer zone
- 150m Buffer zone from perennial river
- 75m Buffer zone from dyke
- Alluvium
- Dyke

Aquifer Protection Zones

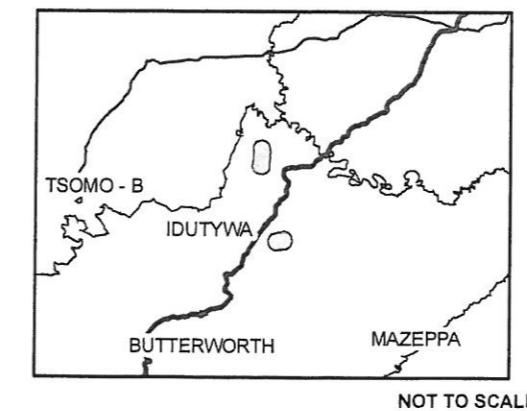
- No pit latrines to be located on prominent fissure belts related to dykes and faults
- 150m from the centre of rivers and prominent surface drainage systems
- 75m metres from dykes and faults
- 50m from water supply source (spring or borehole)
- No high loading (schools, clinic etc.) sanitation system should be installed within 75m of a groundwater supply source

SCALE

1:50,000



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