GROUNDWATER RESOURCE INFORMATION PROJECT
EASTERN CAPE PROVINCE

GROUNDWATER INFORMATION SOURCE REFERENCE SHEET

SOURCE REF NR:	SR 066	Own Archive	✓	Copy attached	✓
		Sourced		Copy at source	

A: SOURCE DESCRIPTION

District Municipality:

Amatole		Chris Hani	✓	O.R Tambo	
Ukhahlamba		Cacadu		Alfred Nzo	

Local Municipality: INTSIKA YETHU LOCAL MUNICIPALITY

Institution where Information is held: SRK CONSULTING

Branch of Institution: EAST LONDON

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B: TYPE OF INFORMATION

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Report / Info Title: INTSIKA YETHU WARD 19 - GEOHYDROLOGICAL INVESTIGATION TO DETERMINE THE RISK OF GROUNDWATER CONTAMINATION FROM ON-SITE SANITATION

Report Nr: 323574/1 Date: Jul-03

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Specify Other:					

Captured by: PS. Nel Date: 18/02/2004 Signed:

C: GEOHYDROLOGICAL CATEGORIZATION

Project Type

Source development		Feasibility Study		Sanitation Study:	
Specify Other:					

Reference Co-ordinate:

Latitude	Longitude
S 31°59'06.6"	E 27°45'43.1"

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

Comments:

Reviewed by: JU du Plooy Date: 18/02/2004 Signed: [signature]

SINAKHO CONSULTING

INTSIKA YETHU WARD 19

GEOHYDROLOGICAL INVESTIGATION TO DETERMINE THE RISK OF GROUNDWATER CONTAMINATION FROM ON-SITE SANITATION

SRK Consulting
Engineers and Scientists

SINAKHO CONSULTING

INTSIKA YETHU WARD 19

GEOHYDROLOGICAL INVESTIGATION TO DETERMINE THE RISK OF GROUNDWATER CONTAMINATION FROM ON-SITE SANITATION

By:

JU du Plooy [Pr Sci Nat]

Report No. 323574/1

September 2003

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APPENDICES

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1. INTRODUCTION AND TERMS OF REFERENCE

SRK Consulting (SRK) was appointed by Sinakho Consulting (Sinakho) on the 18th of July 2003 to conduct a hydrogeological investigation to determine the contamination risk to groundwater from on-site sanitation. The investigation was based on the guidelines as given by the Department of Water Affairs and Forestry[1].

The terms of reference were as follows:

a) A desk study to determine the position of fatal flaws (Dolerite dykes, faults etc.) and boreholes in the study area;
b) Hydrocensus to determine and verify the positions of existing boreholes and groundwater usage;
c) Description of the generic soil type in the area, derived from test holes (one per village);
d) Determine the groundwater development potential (based on Intsika Yethu Hydrogeological Feasibility Study);
e) Application of the groundwater protocol document as required by DWAF;

2. LOCALITY OF PROJECT AREA

Ward 19 of the Intsika Yethu Local Municipality is situated approximately 23 kilometers east of Cofimvaba, within the boundaries of the Chris hani District Municipality.The locality map of the area is presented in Appendix 1 (Locality Map: Intsika Yethu Ward 19).

3. GROUNDWATER PROTOCOL

As background to the study, the key aspects from DWAF's Protocol document are included in Appendix 4.

[1] A protocol to manage the potential of groundwater contamination from on site sanitation. Edition 1, 1997

4. GEOHYDROLOGICAL ASSESSMENT – INTSIKA YETHU WARD 19

4.1 GROUNDWATER POTENTIAL ASSESSMENT

Regional scale: Ward 19 of the Intsika Yethu Local Municipality is classified as a Minor Aquifer System[2], i.e. "groundwater occurs mainly along structures, fractures or along geological contacts" (Aquifer Classification Map of South Africa).

Local scale: The groundwater development potential of the study area can be summarised as follows:

- **Central and Northern Parts:** The overall groundwater development potential in this area can be classified as low;
- **South-eastern:** The groundwater development potential in this area can be classified as moderate to good;
- **North-eastern:** The groundwater development potential in this area is generally low with isolated areas with a good potential for the development of groundwater sources (mainly structure orientated);
- **Western (Boundary):** This area can be classified as having a good potential for the development of groundwater sources;

(*Note: Above information was obtained from the Intsika Yethu Hydrogeologica Fasibility Study, SRK Report No. 313166/1)

The geology of the study area comprises the following:

- Brownish-red and grey mudstone and sandstone from the Burgersdorp formation(Central, western and north-eastern parts of the study area);
- Sandstone and brownish-red and grey mudstone from the Katberg formation (South-eastern part of the study area);
- Quaternary Alluvial deposits (Intersects the central part of the study area)';
- Karoo Dolerite from the Jurassic period (sill, ring structures and linear dykes);

Table 4.1 lists the villages and indicate their groundwater development potential (based on SRK report 313166/1):

[2] According to the Aquifer Classification Map of South Africa

Table 4.1: Village Groundwater Development Potential

Village	Near Dyke, Sill ,Fault or lineament	Groundwater Development Potential	Main Water Source
Zwelixolile	Dyke / Lineament	Good	Surface water (River) & Rainwater tanks
Bulawayo	Dyke / Lineament	Good	Surface water (Dam)
Chitheka	Dyke / Lineament	Good	Surface water (Dam)
Phikweni	Dyke / Lineament	Moderate	Surface water (Dam)
Mgxobozweni	Dyke / Lineament / Sill	Good	Groundwater (Borehole & spring)
Qhesha village	Dyke / Lineament	Good	Surface water (Dam)
Luxeni	Dyke / Lineament	Good	Surface water (Dam)
Luqolweni	Dyke / Lineament / Sill	Good	Groundwater (Borehole & spring)
Ngali	Dyke / Lineament	Good	Groundwater (Borehole)
Lower Tsojana	Dyke / Lineament	Moderate to Good	Surface water (Tsojana River)
Mdletyeni Komkhulu	Dyke / Lineament / Sill	Good	Grounwater (Springs) & Surface water (Tsojana river)
Mangubomvu	Dyke / Lineament	Good to Moderate	Groundwater (Borehole)
Mahlubini Komkhulu	Dyke / Lineament	Moderate	Groundwater (Spring)
Mzantsi Mhlahlane	Dyke / Lineament / Sill	Moderate	Groundwater (Spring)
Ndzaba	Dyke / Lineament	Moderate to Good	Groundwater (Spring)
Mdeni	Dyke / Lineament	Moderate	Groundwater (Borehole)
Mahlatini	Sill	Good	Groundwater (Spring)
Mahusheni Komkhulu	Sill	Good	Surface water (River)
Gesini	Sill	Good	Groundwater (Spring)
Mvumelwano	None	Low	Surface water (River)
Ngudle (Komkhulu)	None	Low	Surface water (Dam)
Ntlabathini -	None	Moderate to Low	Surface water (Dam)
Mome	None	Moderate	Groundwater (Spring)
Mamfengwini	None	Low	Groundwater (Spring) & Surface water (Dam)
Stemela	None	Moderate	Groundwater (Spring) & Surface water (Spring)
Ngceza Komkhulu	None	Moderate	Groundwater (Spring)

Note: The above classification of the groundwater potential is based on the position of the village relative to potential groundwater targets, such as dolerite dykes, sills and faults. Lineaments were also taken into account. A high groundwater potential would be allocated where the village falls within a 400 m of such targets. A low potential would be allocated where there are no prominent water bearing structures and where inaccessible areas exists (eg. steep valleys and/or mountainous areas)

4.2 HYDROCENSUS

The results of the hydrocensus are portrayed in Appendix 2. In summary, the following:

- Thirteen of the villages in the study area utilises groundwater (boreholes and / or springs as their main water source. The other thirteen villages utilises surface water sources (River, dam or rainwater) as their main water source;
- Only one water level could be measured during the hydrocensus, i.e Mgxobozweni village where the water level measured was 1,80 mbgl;
- In the majority of the villages pit latrines are used as a sanitation system, while in the other villages no formal sanitation systems are in place;
- The majority of the households and existing pit latrines are situated in excess of 120 metres from the water sources.

4.3 GROUNDWATER QUALITY

Water samples were taken in three (3) boreholes in the study area and submitted to a certified laboratory for analysis. Table 4.3 summarises the water quality results of the boreholes. In field measurements (pH & EC) taken of all the surface water sources indicates no signs of pollution from the current on site sanitation systems.

Table 4.3: Water Quality Results

Borehole Number (Sample ref.)	Latitude	Longitude	Electrical Conductivity (EC) (mS/m)	Nitrate (N) (mg/l)
Mdeni – J 3517	31° 56' 00.1"	27° 50' 48.9"	137	1.6
Mangubomvu	31° 59' 23.8"	27° 51' 17.4"	88	8.4
Ngali	31° 54' 47.0"	27° 44' 45.7"	69	5.4

Ideal
Good
Marginal
Poor
Unacceptable

*Note: Classification as per *"Quality of Domestic of Domestic Water Supplies, Volume 1: Assessment Guide, Second Edition, 1998"* document

The results summarised in Table 4.3 indicates no signs of pollution in the boreholes from informal on site sanitation.

4.4 ASSESSMENT OF FLAG CONDITIONS & RISK EVALUATION

The risk of contaminating groundwater from on-site sanitation basically hinges around the following aspects:

- Pollution load;
- Flag conditions, especially the depth to groundwater and nature of the unsaturated zone (i.e. the zone between the base of the pit and the groundwater level) - ;
- Presence of existing boreholes and/or springs close to the latrines (they can act as conduits);
- Presence of geological structures or features where economical quantities of groundwater can be expected (including dolerite dykes, sill contacts and faults).

Pollution load: According to information as received from Sinakho Consulting, the average number of households per hectare is less than 10. The pollution load is therefore **low.**
Flag conditions: As part of the risk evaluation, an assessment is made of whether flag conditions exist at any of the villages. The general flag conditions are listed in Table 4.4a and are referenced as such in Table 4.4b.

Table 4.4a: Flag Conditions

Flag Condition
1. Is the groundwater less than 3 m from the base of the pit?
2. Is the base of the pit in or on fractured bedrock?
3. Is the source of water down-gradient of latrine sites?
4. Is the water source within 50 m of latrine sites?
5. Is the water source within 75 m of high volume latrines?
6. Is the groundwater already contaminated by activities in the village or town?

Table 4.4b: Evaluation of risk

Village	Nature of bedrock	Dykes, sills or faults within 400m	Pollution load (h/ha)	Depth to bedrock (m)	Depth to WL (m)	Water use	Existing boreholes / springs	Flag conditions (refer to Table 4.4)	Risk of contamination to groundwater
Zwelixolile	Fractured	Dyke	< 10	1.9		Surface water	None	2	Low
Bulawayo	Fractured	Dyke	< 10	1.5		Surface water	None	2 , 3	Low
Chitheka	Fractured	Dyke	< 10	1.2		Surface water	None	2	Low
Phikweni	Fractured	Dyke	< 10	1.7		Surface water	None	2	Low
Mgxobozweni	Weathered dolerite & Fractured	Dyke & Sill	< 10		1.8	Groundwater	Borehole & spring	1 , 2 , 3	Possible
Qhesha village	Fractured	Dyke	< 10	1.7		Surface water	None	2	Low
Luxeni	Fractured	Dyke	< 10	0.8		Surface water	None	2 , 3	Low
Luqolweni	Weathered dolerite & Fractured	Dyke & Sill	< 10	1.1		Groundwater	Borehole & spring	2 , 3	Possible
Ngali	Fractured	Dyke	< 10	1.2		Groundwater	Borehole	2 , 3	Possible
Lower Tsojana	Fractured	Dyke	< 10	0.8		Surface water	None	2 , 3	Low
Mdletyeni Komkhulu	Weathered dolerite & Fractured	Dyke & Sill	< 10	1.3		Ground & surface water	Spring	2 , 3	Possible
Mangubomvu	Fractured	Dyke	< 10	1.4		Groundwater	Borehole	2 , 3	Possible
Mahlubini Komkhulu	Fractured	Dyke	< 10	0.4		Groundwater	Spring	2 , 3	Low to Possible
Mzantsi Mhlahlane	Weathered dolerite & Fractured	Dyke & Sill	< 10	1.3		Groundwater	Spring	2 , 3	Low to Possible
Ndzaba	Fractured	Dyke	< 10	0.6		Groundwater	Spring	2 , 3	Possible
Mdeni	Fractured	Dyke	< 10			Groundwater	Borehole	2 , 3	Possible
Mahlatini	Weathered dolerite	Sill	< 10	1.3		Groundwater	Spring	3	Low
Mahusheni Komkhulu	Weathered dolerite	Sill	< 10	1.3		Surface water	None	3	Low
Gesini	Weathered dolerite	Sill	< 10	1.3		Groundwater	Spring	3	Low

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Mvumelwano	Fractured	None	< 10	>1.3		Surface water	None	2 , 3	Low
Ngudle (Komkhulu)	Fractured	None	< 10	0.8		Surface water	None	2 , 3	Low
Ntlabathini	Fractured	None	< 10	1.7		Surface water	None	2 , 3	Low
Mome	Fractured	None	< 10	1.0		Groundwater	Spring	2 , 3	Low
Mamfengwini	Fractured	None	< 10	1.0		Ground & surface water	Spring	2 , 3	Low
Stemela	Fractured	None	< 10	1.1		Ground & surface water	Spring	2 , 3	Low
Ngceza Komkhulu	Fractured	None	< 10	0.7		Groundwater	Spring	2	Low

Notes:

- Possible risk: The risk is seen as possible due to fractured nature of the bedrock and where existing borehole is closer than 50 m from an existing pit latrine or household.
- The classification of the pollution load was done in accordance with Table 1, Appendix 4.
- The depth to bedrock was taken from the test holes dug by community members - see Appendix 3.

4.5 SOIL PROFILE

The results of the test pits are given in Appendix 3. They indicate the following:

- The average depth to bedrock is 1.2 m, the shallowest being 0.40 m and the deepest 1.90m;
- The test pit profile is typically sandy silt (top), sandy clay and a silty sand (middle) to fractured shale/sandstone (bottom), weathered dolerite (sabunga) is also found in some areas;
- The permeability of fractured rock, in general, can be seen as high (refer to the Groundwater Protocol, section 1.3.3, where it is stated "Under fractured conditions flow can be exceptionally rapid. Lewis et al. (1980) measured rates of flow as high as 3 m in 25 minutes"), with the permeability in the areas with weathered dolerite as medium to low.

4.6 CONCLUSIONS

Based on the local geology, the villages can be grouped into those situated on fractured bedrock and those situated on weathered dolerite.

Weathered dolerite: The soil in the areas underlain by a dolerite sill can expected to consist of weathered clay, a residue of the dolerite. Permeability will be low and fluids will tend to remain in situ, rather than seep away. The villages partially situated on dolerite include Mgxobozweni, Luqolweni, Mdletyeni Komkhulu, Mzantsi Mhlahlane, Mahlatini, Mahusheni Komkhulu and Gesini villages. The rest of the project villages are situated on fractured rock.

Fractured rock: The fractured rock consists of fractured sandstone and/or shale, with the most upper layers weathered to sandy clay. Permeability is high and fluids will migrate through the fractures in the rock.

Based on the available information, the following are concluded:

- The pollution load is low;
- The bedrock comprises fractured rock and weathered dolerite;
- The depth to bedrock ranges from 0.4 m to 1.9 m (in the fractured rock);
- Groundwater is currently used in 15 of the villages (boreholes and springs) for drinking purposes;
- The depth to groundwater will vary due to the varying topography, but was measured as 1.8m in Mgxobozweni village.
- Flag conditions exist, mainly due to the fractured nature of the bedrock and the positions of existing boreholes and springs (mainly situated down-gradient from village) relative to the pit latrines.
- No information could be obtained on the existing boreholes regarding their yield, but water samples analysed from the three boreholes suggests that the sources have not been contaminated by existing on site sanitation systems.

4.7 RECOMMENDATIONS

The protection of groundwater (boreholes and springs) sources is important, especially where existing boreholes are close to existing or future pit latrines (they can act as conduit for contamination to reach the water table).

In accordance with the Groundwater Protocol (see Table 2 and 3, Appendix 4), the following are recommended:

- Where existing boreholes are within 200m of existing or new latrines, the existing unused equipment must be recovered from the boreholes to allow for water level and water quality monitoring. The monitoring should be done on a yearly basis.
- Existing boreholes should not necessarily be closed or sealed since their yield potential is not known and they might be used in future. Before a borehole is closed or sealed, it must be yield tested to determine its value in terms of future use.

- Where existing or planned latrine sites are situated within 100 m of important groundwater bearing structures care must be taken in the design of the pit latrines (Refer to Figure 2 – Appendix 1);
- In the villages where the risk of groundwater pollution is classified as possible, alternative measures to protect the groundwater (existing and future) sources must be discussed between the sanitation engineer and the project hydrogeologist (Refer to Table 4.4b)

JOHAN DU PLOOY Pr Sci Nat

Hydrogeologist

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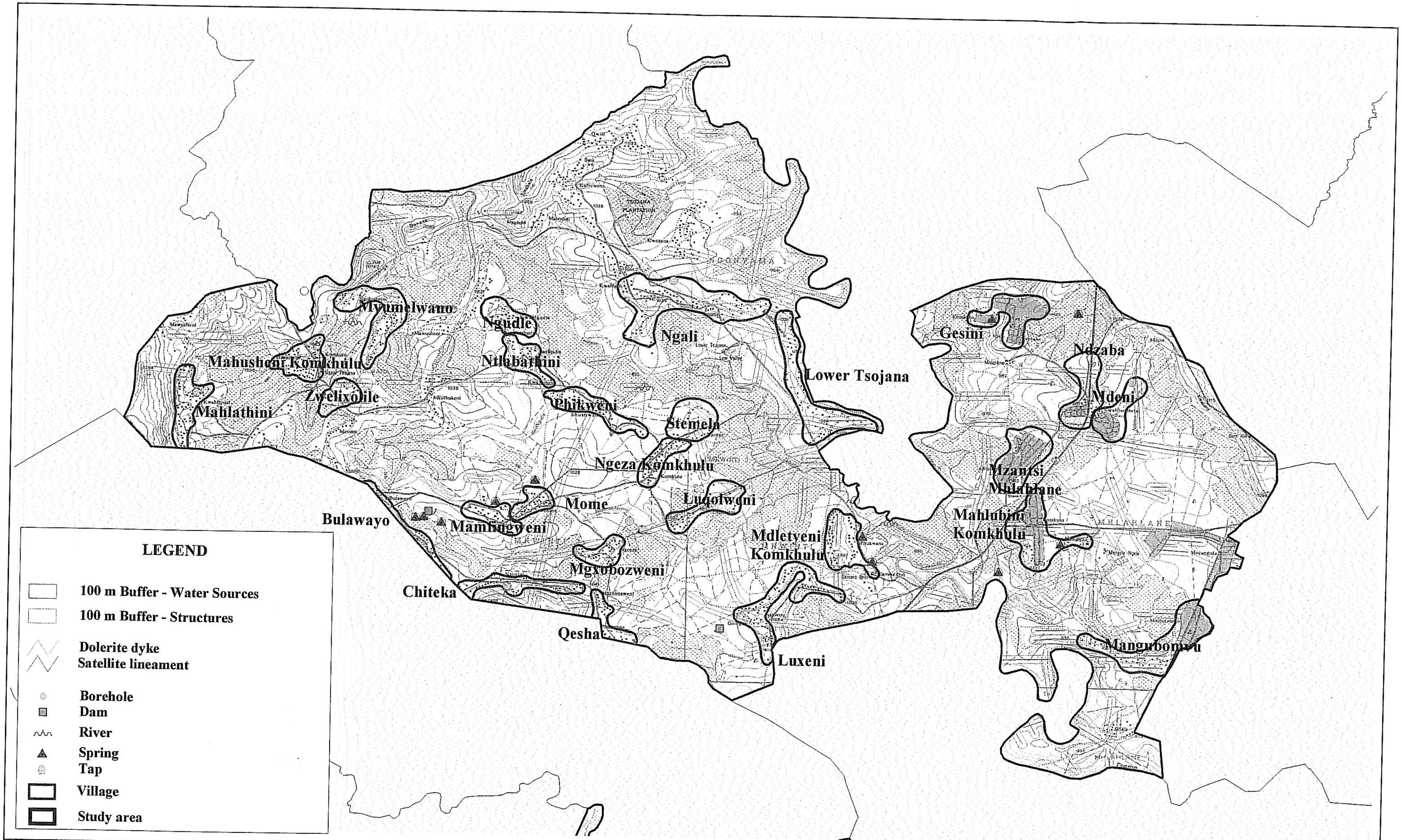
APPENDIX 1

Fig 1: Locality Map

Fig 2: Hydrogeology

SRK Consulting
Engineers and Scientists



JOB NO.	INTSIKA YETHU WARD 19 - SANITATION INVESTIGATION	FIG NO.
323574	Hydrogeology	002
		September 2003

APPENDIX 2:

Hydrocensus Information

Table 1: Groundwater Protocol – Intsika Yethu Ward 19 - Hydrocensus

SRK Consulting
Engineers and Scientists

Village Name:	Borehole/Spring/ School/Sample	Bhole Number	Latitude	Longitude	Water level (mbgl)	Equipment	Yield (l/s) (Info on NGDB)	EC ms/m	PH	TDS mgk	Sanitation Type	No of existing latrines at schools	Contact Person	Comments
Luxeni			31° 59' 06.6"	27° 45' 43.1"										
	Dam		31° 59' 18.8"	27° 45' 27.6"				19.00	7.50				Mr. M Nkomana	Human & Animal consumption, reported to run throughout the year. Dam is ±750m down gradient of village.
Mdletyeni Komkhulu			31° 58' 05.3"	27° 46' 53.9"										
(Mdletyeni)	Spring -1		31° 58' 05.1"	27° 47' 18.1"				103.00					Mr. M Nkomana	Small spring, supply water to the village. Algae growth
(Komkhulu)	Spring - 2		31° 58' 24.4"	27° 47' 26.2"				69.00	6.60				Mr. M Nkomana	Reported to be Brackish, supply Gwadela, Majova, Gwadela Komkhulu & part of Luxeni. Algae growth
	Tsojana River		31° 57' 36.8"	27° 47' 11.9"				27.00	7.90				Mr. M Nkomana	Supplies part of Mdletyeni, is ± 200m below village.
Mdeni														
	Borehole	J3517	31° 56' 00.1"	27° 50' 48.9"				(GOOD 137) 141.00	7.80		No Sanitation - Dongas/ Long Drops		Mr. Mbhono	The only source of water to the village. It is located at 300m down the village
Mahlubini Komkhulu			31° 57' 57.7"	27° 49' 35.3"										
	Dam/Spring		31° 58' 08.1"	27° 49' 54.7"									Mr. Mbhono	Supply the entire village, reported to never run dry. This dam is ± 450m below the village.
Mangubomvu														
	Wind pump		31° 59' 23.8"	27° 51' 17.4"		Wind pump		92.00	7.30				Mr. Mbhono	Village used this wind pump bur their main supply is borehole from adjacent village which feeds to the taps in this village.
Gesini			31° 55' 16.2"	27° 48' 56.5"										
(Gesini)	Spring		31° 55' 12.7"	27° 48' 56.6"				30.00	7.10		No Sanitation facilties		Mrs. Peter	Slow flowing. Long wait for water. Dark Brown. Human & Animal consumption, not protected.
Ndzaba			31° 56' 01.7"	27° 50' 10.3"										
(Ndzaba)	Spring		31° 55' 07.5"	27° 50' 05.0"				19.00	7.30				Mr. Ntutheta	Reported to run throughout the year, supply Ndzaba Village.
Mzantsi Mhlahlane			31° 57' 00.9"	27° 49' 27.6"										
(Mzantsi)	Spring		31° 58' 30.5"	27° 49' 06.2"				79.00	6.50		Part of the village uses dry system toilets, not in good conditions		Mrs. Peter	Supply the entire village, reported to run throughout the year. Strong flow ± 0.3l/s.
Mamfengwini			31° 57' 54.4"	27° 42' 35.1"										
	Dam		31° 57' 51.2"	27° 41' 36.2"							Pit System	Some of the households using pit toilets, others uses bushes and dongas. Depth to rock is ± 1m depending on the spot.	Makhayakude Ntlemeza (Board)	Get water from the dam and the spring. Distance from the dam to the village is ± 300m. Dam is below the village. Village is on a valley.
([illegible])	Spring		31° 57' 42.2"	27° 42' 28.7"									Makhayakude Ntlemeza (Board)	Spring is below the village. Distance from spring to the nearest house is 120m.
✓ Bulawayo			31° 57' 54.6"	27° 41' 07.6"										
	Dam		31° 57' 51.2"	27° 41' 36.2"							Pit System	Some of the households using pit toilets, others uses bushes and dongas. Depth to rock is ± 1.5m	Thembile Kabayi (0722360186)	Get water from the dam. Dam is below the village. Distance from the dam to the village is 400m. The village is on top of the hill.

Bulawayo	Spring - 1		31° 57' 55.1"	27° 41' 32.5"									Thembile Kabayi (0722360186)	Spring is below the village. Distance from spring to the village is ± 280m.
	Spring - 2		31° 57' 55.7"	27° 41' 26.1"									Thembile Kabayi (0722360186)	
Lubuayo	Spring - 3		31° 57' 59.1"	27° 41' 46.4"									Thembile Kabayi (0722360186)	
Momo			31° 57' 43.6"	27° 43' 00.4"										
Nome	Spring		31° 57' 25.2"	27° 42' 59.2"							Pit System	There are a few pit latrines in the village. The rest is using bushes and dongas. Depth to rock is ± 1m depending on the spot.	Mzonke Gcaza (Board)	Get water from the spring, sometimes get dry and wait.
														Spring is below the village. Distance from spring to the village is ± 600m
														The village is on a valley down to the stream.
Ngudle (Komkhulu)			31° 55' 28.0"	27° 42' 41.4"							Pit Systems	Some households have pit system toilets & some villagers use dongas.	Mr Mavumengwana	Water comes from the same dam as Chitheka Village to the taps at the village.
Ntlabathini			31° 55' 45.6"	27° 42' 50.7"							Pit Systems	Pit system toilets & Dongas to some villagers.	Mr. Mavumengwana	Water to the village comes from the same dam as Chitheka village.
														It is pumped to taps at the village.
Phikweni			31° 56' 29.7"	27° 43' 33.7"							Pit Systems	Pit system toilets & Dongas to some villagers.	Mr. Mavumengwana	Water is fetched from taps at the village.
Qhesha Village			31° 59' 09.4"	27° 43' 55.5"								Make use of dongas & some have long drops toilets	Mrs. Ngandela	Get water from the same dam as Luxeni village.
Chitheka														
	Tap		31° 58' 48.2"	27° 42' 38.7"				12.00	7.50				Mrs. Ngandela	Water comes from the dam to the taps at the village.
														Not reliable source as it doesn't run all the time.
Mgxobozweni			31° 58' 16.1"	27° 44' 00.6"										
	Borehole	3361	31° 57' 56.1"	27° 44' 14.7"		Wind pump							Mrs. Ngandela	Faulty, water level is 1.60m.
														Uses the same spring as Luqolweni.
Luqolweni			31° 57' 53.3"	27° 44' 45.3"										
Lugalwa	Spring		31° 58' 02.6"	27° 44' 24.6"		n/a		97.00	7.00	500.00	No Sanitation	Make use of Dongas	Mr. Pukwana	Spring is located at ± 300m below village. Also supplies Mgxobhozweni village.
	Hand pump	T33575	31° 58' 03.1"	27° 44' 25.4"				n/a						Reported to run throughout the year.
													Mr. Pukwana	Borehole not in use.
Ngceza Komkhulu			31° 56' 53.3"	27° 44' 55.2"									Mr. Pukwana	For water Supply refer to Stemele & Luquweni Pages.
Stemela			31° 56' 48.8"	27° 44' 54.4"										
	River		31° 56' 11.2"	27° 44' 24.6"				21.00	7.50		Pit System	Pit system in few households & Dongas	Mr. Pukwana	Supply Stemele & part of Ngceza.
														It is situated ± 400m down gradient of the village and next to the cattle dip.
Ngali Village														
Ngali	Borehole		31° 54' 47.0"	27° 44' 45.7"		Hand Pump		IDEAL 69			Pit System	Pit system in few households & Dongas	Mr. Mgombothi	Supply mission & Ngali Villages. The borehole is ± 150m below village.
Mission			31° 55' 00.8"	27° 44' 58.8"							Pit System	Also pit system & dongas	Mr. Mgombothi	Uses same borehole as Ngali Village
Lower Tsolana			31° 56' 46.9"	27° 46' 40.2"										
	River		31° 57' 53.8"	27° 47' 38.6"				19.00	7.50				Mr. Mgombothi	Appr. 750m below the village.
Mahlathini			31° 56' 25.2"	27° 38' 31.1"										
	Tap		31° 56' 20.9"	27° 38' 32.0"				11.00	6.6		Pit system	Pit System toilets to most households & dongas to some villagers	Mrs. Tsotsi	The supply is reported to be relaible & runs throughout the year.

Mahusheni Komkhulu			31° 55' 59.2"	27° 39' 46.1"										
	Tap		31° 55' 00.9"	27° 39' 54.8"				12.00	7.00		Pit System	Pit system toilets to few villagers & dongas to the rest	Mrs. N Mnani	Pumped from the river to the taps at the village. Also feeds Zwelixolile Village.
Zwelixolile			31° 56' 27.1"	27° 40' 14.8"							Pit Systems			Get water from the taps and from rainwater tanks.
Mvumelwano			31° 55' 34.2"	27° 40' 51.9"										
	River		31° 55' 24.2"	27° 40' 34.0"							Pit System	Pit system toilets to few villagers & dongas to the rest	Mrs. N Mlotya	Reported to run throughout the year. ±500m from the village.

APPENDIX 3:

Test Holes – Soil Profiles

Table 2: Groundwater Protocol – Intsika Yethu Ward 19 - Soil Profiles

SRK Consulting
Engineers and Scientists

Village Name:	Latitude	Longitude	Depth	Soil Profile Description
Luxeni	31° 59' 06.6"	27° 45' 43.1"	0.0 - 0.5m	Slightly moist to Dry, medium brown, fine grained very dense sand.
			0.5 - 0.8m	Slightly moist to Dry, fine grained soft to hard weathered sandstone.
Majona			0.0 - 0.5m	Slightly moist, medium brown fine grained very dense sand.
			0.5 - 0.7m	Moist orange brown, motted coarse grained fairly hard conglomerate.
Mdletyeni Komkhulu	31° 58' 05.3"	27° 46' 53.9"	0.0 - 0.8m	Moist, dark brown, medium grained, very dense, slightly clayey sand.
			0.8 - 1.30m	Slightly moist, greyish white, gine grained soft to hard siltstone.
Gwadela			0.0 - 0.7m	Very moist to damp, medium brown, fine grained sand with roots.
			0.7 - 1.45m	Very moist to damp, dark brown, orange, medium grained clayey sand.
Mdeni	31° 56' 00.1"	27° 50' 48.9"		
Mahlubini Komkhulu	31° 57' 57.7"	27° 49' 35.3"	0.0 - 0.2m	Slightly moist, medium brown, fine grained, very dense sand with some gravel.
			0.2 - 0.4m	Dry, grey, white, fine grained soft to hard sandstone.
Mangubomvu	31° 59' 23.8"	27° 51' 17.4"	0.0 - 0.6m	Slightly moist, dark brown, medium grained very dense sand.
			0.6 - 1.4m	Slightly moist, medium brown, fine to mesium grained very dense slightly silty
				sand with scattered calcrete modules.
Gesini	31° 55' 16.2"	27° 48' 56.5"	0.0 - 0.7m	Slightly moist to dry dark brown, medium grained, very dense sand with occasional
				conglomerate & fine roots.
			0.7 - 1.30m	Dry dral brown, reddish, medium grained very dense, slightly clayey sand with
				scattered sub-rounded boulder.
Ndzaba	31° 56' 01.7"	27° 50' 10.3"	0.0 - 0.3m	Slightly moist to dry dark brown, fine to medium grained dense sand.

			0.3 - 0.6m	Dry , reddish/brown, fine grained soft to hard mudstone.
Mzantsi Mhlahlane	31° 57' 00.9"	27° 49' 27.6"	0.0 - 1.0m	Dry dark brown, fine to medium grained very dense sand.
			1.0 - 1.3m	Slightly moist, dark brown, medium grained very dense sand with some gravel (conglomerate).
Mamfengwini	31° 57' 54.4"	27° 42' 35.1"		Brown top soil with sandstone on the surface.
Bulawayo	31° 57' 54.6"	27° 41' 07.6"		Brown top soil with no rock.
Mome	31° 57' 43.8"	27° 43' 00.4"		Brown top soil and sandstone on the surface.
Ngudle (Komkhulu)	31° 55' 28.0"	27° 42' 41.4"	0.0 - 0.5m	Slightly moist to dry, fine grained, very dense sand.
			0.5 - 0.8m	Fairly dry, reddish brown, fine grained highly weathered sandstone.
				Refusal @ 0.8m
Ntlabathini	31° 55' 45.8"	27° 42' 50.7"	0.0 - 0.9m	Slightly moist, dark brown, fine grained very dense sand.
			0.9 - 1.7m	Very moist , orange brown, medium grained very stiff clay.
Phikweni	31° 56' 29.7"	27° 43' 33.7"	0.0 - 0.6m	Moist, dark brown, fine, to medium grained, very dense sand.
			0.6 - 1.2m	Very moist, purple brown, medium grained, very stiff clay.
			1.2 - 1.7m	Moist, orange/ brown, medium grained very stiff clay.
Qhesha Village	31° 59' 09.4"	27° 43' 55.5"	0.0 - 0.7m	Very moist, dark brown, fine grained, very dense sand.

			0.7 - 1.3m	Very moist to damp, orange/yellow, medium grained very stiff clay.
			1.3 - 1.7m	Moist, purple, fine to medium grained very stiff clay.
Chitheka	31° 58' 48.2"	27° 42' 38.7"	0.0 - 0.4m	Very moist, fine.grained, dark brown, very dense sand (top soil)
			0.4 - 1.2m	Very moist, reddish brown fine grained, very dense slightly silty sand
				with some conglomerate.
Mgxobozweni	31° 58' 16.1"	27° 44' 00.8"		
Luqolweni	31° 57' 53.3"	27° 44' 45.3"	0.0 - 0.3m	Slightly moist, fine to medium grained, very dense sand.
			0.3 - 1.1m	Slightly moist reddish brown, fine to medium grained slightly silty sand.
Ngceza Komkhulu	31° 56' 53.3"	27° 44' 55.2"	0.0 - 0.4m	Slightly moist dark brown, fine grained, very dense sand.
			0.4 - 0.7m	Moist, reddish brown, fine to medium grained very dense slightly silty sand.
				Note: Refusal @ 0.7m (conglomerate)
Stemela	31° 56' 48.8"	27° 44' 54.4"	0.0 - 0.6m	Slightly moist, dark brown, fine grained very dense sand (top soil)
			0.6 - 1.1m	Moist, reddish brown, fine to medium grained slightly silty sand.
Ngali Village	31° 54' 47.0"	27° 44' 45.7"	0.0 - 0.4m	Slightly moist, dark brown, fine grained, very dense gravely sand with fine roots
			0.4 - 0.8m	Moist, Reddish brown, medium grained very dense slightly silty sand with
				conglomerate.
Mission	31° 55' 00.8"	27° 44' 58.8"	0.0 - 0.6m	Moist dark brown fine grained very dense sand.
			0.6 - 1.3m	Moist reddish brown, medium to coarse grained slightly silty sand with some gravel
				conglomerate.
Lower Tsojana	31° 56' 46.9"	27° 46' 40.2"	0.0 - 0.6m	Dry darkbrown, fine grained very dense sand.
			0.6 - 0.8m	Dry khaki olive, fine grained soft to hard sandstone.

Mahlathini	31° 56' 25.2"	27° 38' 31.1"	0.0 - 0.4m	Slightly moist, fine grained very dense dark brown sand.
			0.4 - 0.8m	Slightly moist, purple fine grained very stiff clay.
			0.8 - 1.3m	Slightly moist, orange/yellow, medium to coarse grained weathered dolerite
				(Sabunga)
Mahusheni Komkhulu	31° 55' 59.2"	27° 39' 46.1"	0.0 - 1.1m	Moist, red-brown, medium grained very dense sand.
			1.1 - 1.3m	Slightly moist orange/yellow medium grained weathered dolerite.
				(Sabunga)
Zwelixolile	31° 56' 27.1"	27° 40' 14.8"	0.0 - 0.3m	Slightly moist, dark brown, fine grained very dense sand with fine roots.
			0.3 - 0.9m	Slightly moist to dry, brown/orange medium to coarse grained very dense sandy grave
				(conglomerate)
			0.9 - 1.5m	Moist, reddish orange, fine medium grained very stiff clay.
			1.5 - 1.9m	Dry/khaki/orange, fine grained soft to hard sandstone.
Mvumelwano	31° 55' 34.2"	27° 40' 51.9"	0.0 - 1.3m	Slightly moist, brown/maroon, fine grained very dense gravelly sand.
				Bedrock deeper then 1.3m

APPENDIX 4:

DWAF GROUNDWATER PROTOCOL

Due to the risk of on-site sanitation systems to groundwater, the National Sanitation Co-ordinating Office (NaSCo) and the Directorate of Geohydrology of the Department of Water Affairs and Forestry initiated the development of a protocol. The aim of the protocol is to ensure that reasonable measures are taken to guard against contamination of valuable groundwater resources by inappropriately located or designed sanitation systems. The risks of groundwater contamination are related to a number of factors, but ultimately risk depends on aquifer vulnerability and the magnitude of the pollutant threat.

To assess the risk, three aspects need to be investigated:

- *Pollution load;*
- *Geological conditions (saturated and unsaturated flow);*
- *Hydrogeological conditions*
- *Surface Runoff*

Pollution load

The loading in a specific area depends on the density of latrines per hectare and the number of people utilising each pit. Muller (1989) defined population densities as follows:

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

Geological conditions

Geological conditions play a major role in attenuating pollutants entering the subsurface system. As a basic principle, the longer it takes the contaminants to reach the groundwater, the lower the impact on water quality. Adequate thickness for the unsaturated zone does, however, depend on the prevailing permeability's.

Problems associated with unsaturated zone travel time in South Africa are thin soil cover and the fractured nature of the bedrock. Under fractured conditions flow can be exceptionally rapid. Lewis et al. (1980) measured rates of flow as high as 3 m in 25 minutes.

If the unsaturated zone consists of permeable sands or fractured bedrock, attenuation of the pollution would be limited and the risk of groundwater pollution would be high.

Hydrogeological conditions

To assess the threat and impacts of contamination the prevailing water usage and hydrogeological conditions have to be assessed. A hydrocensus should therefore be undertaken and data collected regarding the groundwater environment. If the aquifer has an important role in supplying water, contamination has to be limited, either by altering the sanitation system or by moving the source of water. The contamination of the groundwater sources will have a major economic impact and could prevent the goals of the RDP being met.

Surface water runoff

Surface water run-off entering the pits **increases** the risk of groundwater contamination. Further, surface run-off can transport contaminants from overflowing or poorly managed pits to adjacent surface streams. *Every effort must therefore be made to manage both the surface runoff and the pit latrines correctly.* For example, a small drainage ditch can be installed around the latrine or the latrine can be raised slightly.

To **summarise**, the protocol consists of a number of steps, simplified in the Contamination Risk Assessment Flow Sheet. Each step consists of a separate task:

(a) Assessment of groundwater potential.
(b) Evaluation of groundwater use.
(c) Assessment of sensitive "flag" situations.
(d) Evaluation of pollution risk to the groundwater resource.
(e) Evaluation of measures to reduce the risk.
(f) Implementation of risk reduction measures.

Groundwater Potential:
Two levels of geohydrological assessment are necessary - an assessment of the regional strategic value of the aquifer and an assessment of the local value of the aquifer. For the regional scale assessment, the Aquifer Classification Map of South Africa is used.

Groundwater use:
Reliance on groundwater and other water supplies, position of boreholes/springs used and borehole details

Flag conditions:
Circumstances exist where conditions are less suitable for on-site sanitation systems (flag conditions)

Risk to groundwater:
The threat posed by the sanitation system and the potential of the unsaturated zone to attenuate contaminants before reaching the groundwater.

Measures to reduce risk:
If **possible risk** exists; the sanitation engineer should investigate risk reduction options. If **likely risk** exists, the sanitation engineer and a hydrogeologist will have to investigate risk reduction options and their recommendations should be discussed with DWAF officials."

CONTAMINANT RISK ASSESSMENT FLOW SHEET (From Protocol Document)

1. Is the village or town located on a major aquifer system? See aquifer classification map.

Yes → Consult hydrogeologist in DWAF Regional Office → Ascertain aquifer protection requirements and minimum design specifications

No ↓

2. Is groundwater used or likely to be used to supply the village or town with water for domestic or stock-watering purposes?

No → Project to proceed with no further action required

Yes ↓

3. Do any of the following flag items prevail at or near the village or town?

Is the groundwater less than 3 m from the base of the pit?
Is the base of the pit in or on fractured bedrock?
Is the source of water down-gradient of latrine sites?
Is the water source within 50 m of latrine sites?
Is the water source within 75 m of high volume latrines?
Is the groundwater already contaminated by activities in the village or town?

Yes → Project engineer and geohydrologist to identify appropriate remedial actions (Table 2) and to liaise with hydrogeologist in DWAF regional office if necessary → See Table 3 for possible remedial

No ↓

4. Assess the risk posed by the sanitation systems over the long-term

Consult Table 1 to define risk

Likely risk
Possible risk

Project engineer and geohydrologist to identify appropriate remedial actions (Table 2) and to liaise with hydrogeologist in DWAF regional office if necessary

See Table 3 for possible remedial measures

Low risk

Project to proceed with no further action required

TABLE 2: RECOMMENDED STEPS TO DECIDE ON WHAT RISK REDUCTION MEASURES SHOULD BE IMPLEMENTED	
LEVEL OF RISK	ACTION
Flag situations	Meeting between sanitation engineer, qualified hydrogeologist and community representative to decide on most suitable option available and on protection requirements.
Low risk	No action required, other than monitoring to check that pollution is not taking place.
Possible risk	Sanitation engineer to investigate alternatives to reduce the threat posed by the sanitation system (see Table 3). If it is impossible to alter the sanitation system and the aquifer is still possibly at risk, a qualified hydrogeologist will have to be called in to assess changes to the supply system (see Table 3).
Likely risk	Investigation of alternative water supply options by a qualified hydrogeologist and the investigation of alternative sanitation systems by a qualified sanitation engineer. A meeting between the sanitation engineer and a qualified hydrogeologist must be organised to decide on most suitable options available (see Table 3). The hydrogeologist must make certain that the staff in the Directorate of Geohydrology in the regional office of DWAF are satisfied with the options proposed.

TABLE 3: RECOMMENDED STEPS TO DECIDE ON WHAT RISK REDUCTION MEASURES SHOULD BE IMPLEMENTED	
Alterations to on-site systems (short terms measures)	- move sanitation system as far away as possible from existing boreholes (at least 50 m in unfractured rocks and 200 m in fractured rocks) - excavate larger, shallower pits - use composting type systems - raise pits above ground level to increase unsaturated zone - seal fractures in pits excavated to a fractured bedrock with a clay/slurry mixture - introduce clay into natural permeable soils - line the pits with cemented blocks and seal all the joints - bio-augmentation of pits to increase breakdown - addition of glucose or other carbon sources to the pit - improve maintenance in poorly run systems - if economically possible, consider water-borne systems with off-site

	treatment and disposal
Alterations to existing borehole supplies	- re-equip boreholes, ensuring that surface sanitary seal exists - make certain that the holes are screened at the greatest depth possible - treat contaminated water - pump at lower rates to reduce the cone of depression and thus the capture zone - modify the size of the wellhead protection zone around the borehole
Alteration to aquifer supply system (long term measures)	If feasible, and after exhausting all other alternatives, new sources of groundwater can be investigated. The existing water supply system can be abandoned (if polluted) and new boreholes can be sited upgradient from any sources of pollution. These new supplies would have to be confirmed before any existing supplies were abandoned. Abandoned boreholes are to be effectively sealed.

TABLE 1: ASSESSMENT OF RISK

UNSATURATED ZONE* CONDITIONS	POLLUTION LOAD											
	SETTLEMENT SIZE < 500 inhabitants			SETTLEMENT SIZE 500 - 1000 inhabitants			SETTLEMENT SIZE 1000 - 5000 inhabitants			SETTLEMENT SIZE > 5000 inhabitants		
	< 10 houses/ ha**	10 - 50 houses/ ha	> 50 houses/ ha	< 10 houses/ ha	10 - 50 houses/ ha	> 50 houses/ ha	< 10 houses/ ha	10 - 50 houses/ ha	> 50 houses/ ha	< 10 houses/ ha	10 - 50 houses/ ha	> 50 houses/ ha
Clay	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Possible
Massive Shale's	Low	Low	Low	Low	Low	Low	Low	Low	Possible	Low	Possible	Possible
Solid granites	Low	Low	Low	Low	Low	Low	Low	Possible	Possible	Low	Possible	Possible
Silt	Low	Low	Low	Low	Low	Possible	Low	Possible	Possible	Possible	Possible	Likely
Sandy loam	Low	Low	Possible	Low	Possible	Possible	Possible	Possible	Likely	Possible	Likely	Likely
Bedded shale's	Low	Low	Possible	Low	Possible	Possible	Possible	Possible	Likely	Possible	Likely	Likely
Weathered or fractured granites	Low	Low	Possible	Low	Possible	Likely	Possible	Likely	Likely	Likely	Likely	Likely
Fractured/weathered sandstone's	Low	Possible	Likely	Possible	Likely	Likely	Likely	Likely	Likely	Likely	Likely	Likely
Cavernous limestone's/calcretes	Low	Possible	Likely	Possible	Likely	Likely	Likely	Likely	Likely	Likely	Likely	Likely
Sand and Gravel	Possible	Likely	Likely	Likely	Likely	Likely	Likely	Likely	Likely	Likely	Likely	Likely

* The unsaturated zone is the distance between the base of the latrine to the groundwater level.

** Houses/ha, calculated by dividing the number of houses in the village by the total area, without subtracting the roads, parks, etc

Steffen, Robertson and Kirsten (South Africa) (Pty) Ltd

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