WN-1

Borehole 70: WN-1

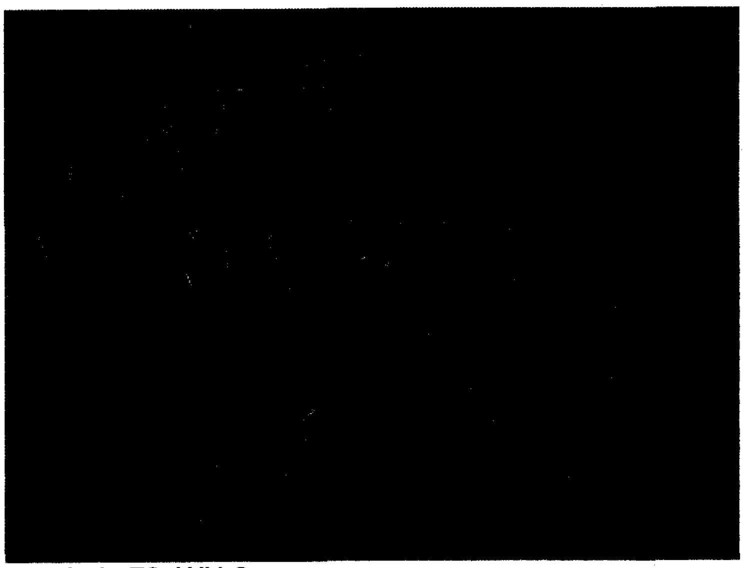
Farm:	Wolwefontein
Water level:	9.85 m
Yield:	Unknown
Use:	Domestic

WN-2

Borehole 71: WN-2

Farm:	Wolwefontein
Water level:	2.56 m
Yield:	Unknown
Use:	Domestic

WN-3



Borehole 72: WN-3

Farm:	Wolwefontein
Water level:	Not measured
Yield:	Unknown
Use:	Domestic

D.8 Gypsum Hazard Rating

DOUGLAS TAVISTOCK JOINT VENTURE

MIDDELBURG WATER RECLAMATION PROJECT

HAZARD RATING OF MODELLED IMPACTED MINE WATER AND GYPSUM WASTE

Report No.: JW119/10/B478/B

12 JANUARY 2011

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Date	Revision	Description	Issued to	Issue Format	No. Copies
24/08/10	A	Hazard Rating of Gypsum Waste	Ms L Moore	PDF	1
12/01/2011	B	Hazard Rating of Gypsum Waste	Ms L Moore	PDF	1

SYNOPSIS

BHP Billiton Energy Coal South Africa (BECSA) appointed Jones & Wagener Consulting Civil Engineers to, inter alia, hazard rate the modelled impacted mine water and gypsum waste streams that will be generated by the envisaged Middelburg Water Reclamation Plant (MWRP). The impacted mine water and the two gypsum waste streams will be disposed of in engineered waste storage/management facilities, but the hazard ratings will dictate the liner requirements for these facilities.

In terms of the Minimum Requirments, the modelled impacted mine water is classified as a Hazard Group 2 waste requiring disposal in a storage facility complying with that of a hazardous waste lagoon system.

In terms of the Minimum Requirements waste classification system, the metallic gypsum waste (Stage 1 waste) and the gypsum waste (Stage 2/3 gypsum waste), obtained from test trials conducted with Middelburg Mine Services' water at a pilot plant in 2006, both classify as general waste, which require disposal in engineered disposal facilities complying with the performance specifications of the DWAF's Minimum Requirements for G:M:B^+/G:L:B^+ landfills. It is understood, however, that the intention may be to dispose of the metallic gypsum waste in liquid form, which will then require a liner design complying with the performance requirements of a hazardous waste lagoon.

A lagoon type liner will be more expensive than a G:M:B^+/G:L:B^+ liner and it is the intention of the DEA to phase the disposal of liquid waste out over time. The current target date for phasing out the disposal of liquid waste, based on the draft waste classification and management regulations of September 2010, is 3 years from date of promulgation of the new waste regulations.

Based on the Minimum Requirements approach the monthly loading rate for the metallic gypsum is 3 018 tons/hectare/month and for the gypsum cake 3 624 tons/hectare/month. As the two waste streams will be disposed of in engineered and lined disposal facilities, the total load per hectare for the metallic gypsum is 301 800 tons/hectare. The total load for the gypsum cake is 362 400 tons per hectare.

The September 2010 edition of the new waste classification system was also used to classify the two gypsum waste streams for disposal/storage purposes. The primary objective of this was to verify the classifications obtained when using the current Minimum Requirements system and, in addition, the new waste classification and waste management regulations may be promulgated in early 2011, which could make them applicable to the MWRP project. The new system is more or less in line with that of other waste classification systems being used elsewhere in the world and therefore represents the newest thinking with regard to waste risk assessments.

Using the new draft waste classification system, the metallic gypsum waste (Stage 1 waste) is classified as a Type 3 waste, which requires disposal on a waste disposal facility of which the liner design performance is expected to be similar to that of the current G:M:G^+/G:L:B^+ system, provided the waste is dewatered. If the waste is not dewatered, a liner system typical of the current hazardous lagoons will be required.

The gypsum waste (Stage 2/3 gypsum waste), which is to be dewatered, classifies as a Type 4 or inert waste, which will require in all likelihood, disposal on a waste Type D disposal facility, with a liner design which only requires a 150 mm base preparation layer and which must drain to a leachate collection drain or sump (DWAF, 1998). However, as the magnesium in the gypsum waste is expected to be readily dissolved by seepage water, we do recommend that the storage facility be provided with a formal leachate collection layer.

For the elements analysed, the two gypsum waste streams contain no elements that is likely to cause genetic (teratogenic), mutagenic and carcinogenic impacts or effects.

Based on the findings of the waste classification performed on the two gypsum waste streams obtained from the trial run in 2006, it is recommended that:

- The metallic (Stage 1) gypsum waste be dewatered prior to disposal, as this approach will reduce the design and construction cost of the metallic gypsum waste disposal facility and will bring waste management at the MWRP in line with the current DEA thinking of phasing out the disposal of liquid waste within the next few years,
- Although the Stage 2/3 gypsum waste is classified as an inert waste for disposal in terms of the DEA's draft waste regulations, the storage facility should be provided with a formal leachate collection system, which is less stringent than that of a G:M:B^+/G:L:B^+ waste disposal facility barrier system.

M van Zyl

Project Manager

DOUGLAS TAVISTOCK JOINT VENTURE

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HAZARD RATING OF MODELLED IMPACTED MINE WATER AND GYPSUM WASTE

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1. INTRODUCTION

1.1 Background

BHP Billiton Energy Coal South Africa (BECSA) appointed Jones & Wagener Consulting Civil Engineers (J&W) to, inter alia, hazard rate the impacted mine water to be treated and gypsum waste streams that will be generated by the Middelburg Water Reclamation Plant (MWRP). The MWRP is a joint venture between BHP Billiton Energy Coal South Africa (Pty) Ltd and Tavistock Collieries (Pty) Ltd and is formally known as the Douglas Tavistock Joint Venture (DTJV). The impacted mine water will be stored prior to treatment in an engineered storage facility and the gypsum waste streams will be disposed of in engineered waste disposal facilities, but the waste classification of both will dictate the storage facility liner requirements.

The impacted water balancing dam (also termed the plant feed water dam), which will be located before the water treatment facility, will have a storage capacity of 30 000 m^3 for the Phase 1, the 15 Mℓ/day water treatment capacity plant, and 60 000 m^3 for the Phase 1 and 2, the 30 Mℓ/day water treatment capacity plant.

Two gypsum waste streams will require disposal, namely primary gypsum waste (or Stage 1 gypsum waste), also termed metallic gypsum waste and secondary cake (or Stage 2 and 3 gypsum waste), also termed gypsum cake, as the intention is to dewater this waste stream. The metallic gypsum will be generated in the Stage 1 liming process and the gypsum cake in the Stage 2 and 3 liming processes. The metallic gypsum waste may be disposed of as a slurry, based on current thinking, and as the name implies, the gypsum cake will be dewatered prior to disposal.

At a water treatment capacity of 15 Mℓ/day, approximately 21 tons of metallic gypsum waste will be generated, while approximately 75 tons of gypsum cake will be generated. When the treatment capacity is increased to 30 Mℓ/day, the waste generation rates will also double, provided the impacted mine water characteristics does not change significantly over time.

1.2 Objectives

Two objectives were identified for the waste classification, namely to:

- Hazard rate the impacted mine water and gypsum waste streams in terms of the Department of Water Affairs and Forestry's (the DWAF's) "Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste", Second Edition (DWAF, 1998), and to, based on the classification, calculate a monthly and total disposal rate, and

- Classify the gypsum waste streams in terms of the Department of Environmental Affairs' draft waste classification system for disposal regulations (DEA, 2010a and 2010b).

2. WASTE CLASSIFICATION

2.1 Characteristics of the Impacted Mine Water

The impacted mine water will be obtained from three sections of the Middelburg Mine. Each section of the mine generates an impacted mine water with a different chemical fingerprint. The modelled quality of the combined impacted water streams were used in this hazard rating report.

2.2 Analyses of gypsum waste streams

The classification presented here is based on sludge obtained from a treatment demonstration plant at Anglo Coal's Navigation Plant to test the suitability of the demonstration plant's reverse osmosis desalination technology using Middelburg Mine impacted mine water. These trails were conducted in 2006 (Golder, 2007).

The gypsum sludges generated in this trial were hazard rated in early 2007 by Golder based on the draft third edition of the Department of Water Affairs and Forestry's "Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste" (DWAF, 2004) based on a recommendation made by the Department of Environmental Affairs and Tourism (the DEAT). However, the third edition of the Minimum Requirements has never been formally approved and the Department of Environment (the DEA) is currently developing a new waste classification system, which will eventually be regulated. In the interim, the second edition of the Minimum Requirements is still in use, as well as additional instructions given by the DEA (DEA, 2008 and 2009). It has therefore been agreed with the DTJV, that the chemical analyses obtained from the gypsum waste streams produced at the pilot plant will be used to reclassify the two gypsum waste types.

The chemical analyses being used were from the South African Acid Rain Leach Procedure (ARLP) obtained for the two gypsum waste streams, namely the metallic gypsum waste (ST1-1) and gypsum waste (ST2/3-1) from the trials conducted in 2006 (Golder, 2007).

J&W based the waste classification on chemical analyses results obtained from Golder's report no 8592/9427/2/P, dated 27 April 2007, Appendix C (Golder, 2007). In addition, although no organic constituents were analysed for, these are not expected to be present within the two gypsum waste streams.

2.3 Hazard Rating in terms of the Minimum Requirements

2.3.1 Minimum Requirements Methodology

In terms of the DWAF's Minimum Requirements all industrial waste is classified as hazardous until proven otherwise (DWAF, 1998a).

The impacted mine water and the two gypsum waste streams were classified in terms of the Minimum Requirements (DWAF, 1998a), and letters from the Department of Environment and Tourism (DEAT), titled "Waste Delisting Procedure", signed by their Director General, dated 21 April 2008 (DEAT, 2008) and 12 January 2009 (DEAT, 2009) respectively. The hazard ratings in this report are therefore in compliance with the Minimum Requirements as amended by the DEAT. The gypsum waste streams were subjected to the South African Acid Rain Leach

Procedure (ARLP). The ARLP is used in cases where non-organic waste is mono-disposed or disposed with other waste not containing bio-degradable organic waste. The impacted mine water was not subjected to any leach tests as it is a liquid. In the case of the impacted mine water, the concentrations of the elements were compared directly to the respective Acceptable Risk Levels (ARLs) as listed in the Minimum Requirements of 1998.

The concentrations of the hazardous substances in the gypsum waste leach solutions were compared to the ARLs for the aquatic environment as listed in the Minimum Requirements or as identified by J&W. The ARL, expressed in parts per million (ppm) or mg/ℓ = 0.1 x LC_{50} (mg/ℓ)[1]. Where the concentration in the ARLP leach solution is > than the ARL, the mine water or gypsum waste is classified as hazardous for that particular substance. The most hazardous substance dictates the Hazard Rating of the mine water and the gypsum waste.

The waste has been hazard rated based on the most hazardous constituent of concern. Furthermore, the monthly loading rate, i.e., the amount of waste that can be disposed of in tons/hectare/month, has also been calculated, namely:

> Monthly loading rate = Allowable dose per month/Concentration in leach solution, where
>
> Allowable dose per month = ARL/0.66[2]

The allowable maximum load per hectare for lined waste disposal facilities is again calculated from the monthly dose as:

> Total load (ton/hectare) = 100 x dose (g/ha/month)/mg of most hazardous substance per kilogram of waste

or, for unlined waste disposal facilities as:

> Total load (ton/hectare) = 10 x dose (g/ha/month)/mg of most hazardous substance per kilogram of waste

A waste can be delisted to general waste in cases where the:

> Concentration in the leach solution < 0.1 x Hazard Group 1, or
>
> Concentration in the leach solution < ARL for Hazard Group 2, 3 or 4 substances, or
>
> An allowable load of [(ARL/0.66) / (Measured concentration)] is not exceeded.

2.3.2 Hazard Rating

Based on the above Minimum Requirements approach, the impacted mine water is classified as a Hazard Group 2 waste, as the concentration of manganese > than its ARL value – see Table 1. As the impacted water is a liquid, it will have to be stored in a lined facility complying with the liner performance requirements of a Hazardous Waste Lagoon (Legge, 2010). The impacted mine water quality was also compared to the SANS 241 drinking water standards. The reason for this comparison being that the groundwater in the area, where the balancing dam is to be

---

[1] ***The factor of 0.1 is calculated from a cross section of typical dose response data, with a typical slope of dose response curves. From an exposure 10 times lower than the LC50, approximately 0,00034% or one in 300 000 of a population exposed to the contaminant, is likely to die (DWAF, 1998).***

[2] **The factor 0.66 is derived from the ratio of the substance in a weight of underground body of water (DWAF, 1998)**

constructed, is still pristine and should be protected from impacts from the impacted mine water. The results show that the impacted mine water also exceeds the SANS 241 Class II standard for a number of variables – see Table 1.

The metallic gypsum waste (ST1-1) is classified as a general waste due to none of the elements analysed for in the ARLP leach solution having concentrations > their respective ARLs – see Table 1 below.

The gypsum cake (ST2/3-1) is also classified as a general waste as none of the concentrations of the elements in the ARLP leach solution are > their respective ARLs – see Table 1 below.

Although the two wastes contain a high total concentration (TC) of manganese, the manganese (and other metals) was not mobilised by the Acid Rain leach solution as the pH of the final solution was > 8.3 for the metallic gypsum waste and > 9.5 for the gypsum waste.

The results indicate that both the metallic gypsum waste (Stage 1 waste) and gypsum waste (Stage 2 and 3 waste) may be disposed of on a waste disposal facility that complies with the design requirements of a G:L:B^+/G:M:B^+ landfill site if dewatered. However, as the intention may be to dispose of the metallic gypsum as a liquid waste, the design has to comply with the performance requirements of a hazardous waste lagoon liner system.

Table 1: Modelled mine water concentrations & gypsum waste ARLP leach concentrations of inorganic elements compared with their respective ARLs and SANS 241 Drinking Water Standards

Chemical Substance	Modelled Impacted Mine Water	Metallic Gypsum Waste ST1-1	Gypsum Waste ST2/3-1	Detection Limit	ARL (ppm)	Hazard Group	SANS 241 Drinking Water: Class I	SANS 241 Drinking Water: Class II
Ammonia as N	1.17	NA	NA	Not given	10.9	4	< 1	1 - 2
Aluminium (Al)	[redacted]	0.050	0.050	0.010	10	4	< 0.3	0.300 – 0.500
Arsenic (As)	Not given	bdl	bdl	0.10	0.43	2		
Boron (B)	Not given	0.200	0.200	Not given	7.8	4		
Barium (Ba)	Not given	0.020	0.020	0.010	7.8	3		
Beryllium (Be)	Not given	bdl	bdl	0.010	1.2	3		
Calcium (Ca)	288.32	435	451	0.010	_	_	< 150	150 – 300
Cadmium (Cd)	Not given	bdl	bdl	0.010	0.031	1		
Cobalt (Co)	Not given	bdl	bdl	0.010	6.9	2		
Chromium (Cr) (total)	Not given	bdl	bdl	0.010	4.7	3		
Copper (Cu)	Not given	0.020	0.020	0.010	0.10	2		
Fluoride	0.47	NA	NA	Not given	1.0	3	< 1	1.0 – 1.5
Iron (Fe)	[redacted]	0.10	0.10	0.10	9.0	3	< 0.20	0.20 – 2.0
Potassium (K)	17.69	17	6.7	0.010	_	_	< 50	50 – 100
Lead (Pb)	Not given	bdl	bdl	0.10	0.10	2		
Lithium (Li)	Not given	0.037	0.034	Not given	0.14	1		
Magnesium (Mg)	[redacted]	417	335	0.010	_	_	< 70	70 – 100
Manganese (Mn)	10.71	0.023	0.013	0.010	0.30	2	< 0.10	0.10 – 1.00
Molybdenum (Mo)	Not given	0.067	0.003	0.010	3.7	4		
Sodium (Na)	19.92	17.5	7.7	0.010	_	_	< 200	200 – 400
Nickel (Ni)	Not given	0.050	0.050	0.010	0.62	2		
Phosphorous (P)	Not given	NA	NA	0.010	10	4		
Selenium (Se)	Not given	bdl	bdl	0.10	0.26	2		
Silver (Ag)	Not given	bdl	bdl	0.010	2.0	3		
Strontium (Sr)	Not given	0.502	0.418	0.10	1.0	3		
Titanium (Ti)	Not given	bdl	bdl	Not given	0.73	2		
Vanadium (V)	Not given	bdl	bdl	0.010	1.3	3		

Chemical Substance	Modelled Impacted Mine Water	Metallic Gypsum Waste ST1-1	Gypsum Waste ST2/3-1	Detection Limit	ARL (ppm)	Hazard Group	SANS 241 Drinking Water: Class I	SANS 241 Drinking Water: Class II
Zinc (Zn)	Not given	0.30	0.30	0.010	0.70	2		
Sulphate		-	-	-	-	-	< 400	400 – 600
Final pH	7.05	8.3	9.5		<5 - >12	*	5.0 – 9.5	4.0 – 10.0
	Concentration > ARL							
	Exceeds SANS 241 Drinking water standard Class I							
	Exceeds SANS 241 Drinking water standard Class II							

All values in mg/ℓ, except pH
ARLP: Acid Rain Leach Procedure
ARL: Acceptable Risk Level
Bdl: Below detection limit
NA: Not analysed
*: Waste not allowed to be disposed if pH <5 and >12

2.3.3 *Carcinogenetic, mutagenetic and teratogenetic characteristics of the impacted mine water and gypsum waste streams*

Ammonia is a listed teratogen, and although the ammonia concentration in the impacted mine water exceeds the Class I standard marginally, it still complies with the Class II requirement. The ammonia concentration falls within the Class II standard for ammonia and no time limit has been set for using water with an ammonia concentration between 1 and 2 mg/ℓ in the Class II range. The setting of the standards would have taken the teratogenetic effects of ammonia into account; so that the impacted mine water is not classified as a teratogen.

Although nickel was detected in the leach solutions of the gypsum waste, it does not constitute a carcinogen or mutagen in the case of the two gypsum waste streams. From the literature search it was concluded that inhalable nickel oxide (NiO) and nickel sub-sulphide (Ni_3S_2) at high temperatures and concentrations (≥ 10 mg/m^3 Ni) causes cancer of the respiratory system (Nickel Institute, 2002). There is also evidence that inhaled copper-nickel oxides could be causing cancer, again in the smelter environment. However, in the case of the two gypsum waste streams, the nickel is water soluble elemental nickel, which is then precipitated as nickel hydroxide after the addition of lime. No evidence could be found that it is likely to cause cancer or mutagens when inhaled or by oral intake in the precipitated state.

Based on the analyses conducted and the elements analysed for, the two gypsum waste streams contain no elements that is likely to cause genetic (teratogenic), mutagenic and carcinogenic impacts or effects.

2.3.4 *Loading Rates based on Minimum Requirements*

The determination of loading rates is not applicable to liquids or effluents, such as the impacted mine water.

Although the two gypsum waste streams delist to general waste based on the fact that for the elements analysed, none of the concentrations in the leach solutions were > their respective ARLs, the one substance that was closest to its ARL was strontium (Sr) followed by manganese (Mn) - see Table 1. If this approach is used, the monthly loading rate for the metallic gypsum waste is 3018 tons/hectare/month and for the gypsum waste it is 3 624 tons/hectare/month.

As the two waste streams will be disposed of in engineered and lined disposal facilities, the total load per hectare for the metallic gypsum waste is 100 x 3 018 tons/hectare/month, which equals 301 800 tons/hectare. The total load for the gypsum cake is 100 x 3 624 tons/hectare/month, which equals 362 400 tons/hectare – see Appendix A.

2.4 Classification based on draft New Waste Classification System

2.4.1 *New Waste Classifications System Methodology*

The new classification system, currently being developed by DEA, is not applicable to liquid waste. A liquid waste, whether hazardous or not, must be disposed of in a disposal or storage facility complying with that of a hazardous waste lagoon system (DEA, 2010a).

The two gypsum waste streams were also classified using the new waste classification system for disposal on landfill currently being developed by the Department of Environmental Affairs (the DEA, 2010b). The objective of this was to support the findings of the classification done based on the currently applicable Minimum Requirements and in anticipation of the new classification system, which should come into effect in early 2011.

The proposed new classification system is based on the Australian State of Victoria's waste classification system, which uses the Australian Standard Leaching Procedure (ASLP) to determine the leachable concentrations of pollutants. For the ASLP a number of leach solutions can be used, namely:

- For waste to be disposed of with putrescible matter, an acetic acid leach solution is used. This leach solution is very similar to the TCLP leach solution, except that the pH is 5.0, instead of pH 4.98.

- In cases where non-organic waste is to be co-disposed with other non-putrescible waste, a basic 0.1 M sodium tetraborate decahydrate solution of pH 9.2 ± 0.1 will be used in addition to the TCLP leach solution. The objective of this test is to identify contaminants that are leached at high pH values.

- For non-putrescible waste that is to be mono-disposed, Reagent Water must be used as a leach agent. As the intention is to mono-dispose the two gypsum waste streams, the reagent water leach should be conducted on the two gypsum waste streams (DEA, 2010b).

In addition to the above, the total concentrations (TCs) of the constituents of concern must also be determined. The proposed inorganic constituents of concern are listed in Table 3 and 4. The number of potentially hazardous substances has been significantly reduced and brought in line with the potentially hazardous substances being used in other parts of the world to classify waste.

Once the results are known, the waste is classified in line with the approach summarised in Table 2 below. Table 2 also provides information regarding the ultimate allowed fate of each waste type.

The DEA has indicated that, for an interim period, the TCLP test results can be used for a year to classify waste under the new system once the new system comes into effect, which is expected to occur in early 2011. In this case the ARLP test results were used, which has an initial pH of 3.6 to 3.8, and is therefore could therefore be more aggressive than the ASLP's TCLP solution, which has a pH of 5.0. However, a Reagent Water Leach should have been used, as the two gypsum waste streams will be mono-disposed. The classification is therefore conservative, as it is based on the leach results of the ARLP test.

Table 2: Description of Waste Types.

Criteria	Risk Level	Description of Risk associated with Disposal to Landfill
LC > LCT2, or TC > TCT2	**Type 0: Very High Risk**	Considered very high risk waste with a very high potential for contaminant release. Requires very high level of control and ongoing management to protect health and the environment.
LCT1 < LC ≤ LCT2, or TCT1 < TC ≤ TCT2	**Type 1: High Risk**	Considered high risk waste with high potential for contaminant release. Requires high level of control and ongoing management to protect health and the environment.
TC ≤ TCT1 and LCT0 < LC ≤ LCT1	**Type 2: Moderate Risk**	Considered moderate risk waste with some potential for contaminant release. Requires proper control and ongoing management to protect health and the environment.
TC < 20 x LCT0, or LCTi < LC ≤ LCT0 and TCTi < TC ≤ TCT0	**Type 3: Low Risk**	Low risk waste with low potential for contaminant release. Requires some level of control and ongoing management to protect health and the environment.
TC < 20 x LCTi, or LC ≤ LCTi, or TC ≤ TCTi	**Type 4: Very Low Risk – Inert Waste**	Very low risk waste that– (a) does not undergo any significant physical, chemical or biological transformation; (b) does not burn, react physically or chemically or otherwise affect any other matter with which it may come into contact; and (c) does not impact negatively on the environment because of its very low pollutant content and because the toxicity of its leachate is insignificant. Only basic control and management required.

(Source: DEA, 2010b)

2.4.2 Classification of Gypsum Waste Streams using the draft New Waste Classification System

In line with the approach explained above, the metallic gypsum waste and the gypsum waste were classified using the proposed new system even though a Reagent Water Leach was not conducted[3]. The ARLP results were used instead and therefore the classification should be regarded as conservative. The values of the elements against which the total constituent and LCT leach values are compared are listed in Tables 3 and 4 - see LCTi, LCT0, LCT1 and LCT2.

The first step in classifying the two gypsum waste streams was by multiplying the TCs of the constituent analysis values by 20 and then comparing these with that of the various TCTs – see Table 3 and 4. Based on the analyses carried out and applying the approach illustrated in Figure 1, the metallic gypsum and gypsum cake cannot be classified as a Type 4 or inert waste based on the results of the 20 x TC analyses alone, as in both cases the 20 x TC values for most elements are > the TCTi.

The next step entails comparing the LC of the two gypsum waste streams with that of the LCTi, LCT0, LCT1 and LCT2 values. As can be seen from Table 3 and 4, the ARLP values for both waste streams are < the TCTi values for all the inorganics tested for. Based on the ARLP results, the two gypsum wastes can therefore be classified as inert waste or Type 4 wastes. Although the 20 x TC values are > the TCTi values, the ARLP results proove that the elements do not leach readily. This is due to the finals pHs of the leach solutions being 8.3 and 9.5 respectively for the metallic gypsum waste stream and Stage 2/3 gypsum cake (Golder, 2007).

[3] In terms of the draft DEA waste classification for waste disposal regulations, in cases were a non-putrescible waste is mono-disposed, only a Reagent Water Leach test needs to be conducted in order to determine the waste's risk profile for disposal purposes.

In addition, for the Stage 2/3 gypsum waste, the only TC constituents at a higher concentration than their listed TCTi values are copper and manganese - see Table 4. Total copper concentration in the earth's soil ranges from 20 – 30 mg/kg (Alloway, 1995). The copper in the gypsum is 18.3 mg/kg, while the TCTi value is 16 mg/kg. As the copper is lower than the average range in the soils, we recommend that the gypsum be classified as an inert waste for copper. A literature review of typical soils also indicated that manganese can range from 80 to 7000 mg/kg. Dolerite derived soils, which are also found in the Middelburg Mines area, can have manganese concentrations between 2500 and 3000 mg/kg (McBride, 1993). The natural range of manganese in the soils is very similar to that of the Stage 2/3 gypsum cake. Based on this we motivate that the Stage 2/3 gypsum waste be classified as an inert waste. Although the waste can be classified as an inert waste, it contains a high concentration of leachable magnesium (see Table 1), which may have an impact on the groundwater quality if leachate from the disposal facility is able to escape. It is therefore recommended that the disposal facility for the Stage 2/3 gypsum waste be provided with a leachate collection system.

For the metallic gypsum, the TC value for manganese (Mn) is > than the TCT0 and TCT1 values. Based on the TC value, the waste is classified as a Type 1 or High Risk Waste. Type 1 waste has a high potential for contaminant release and requires a high level of control and ongoing management to protect health and the environment. However, as has been proved by the ARLP results, the final leach solution has a pH of 8.3, which indicates that the waste has some buffering capacity. It is therefore unlikely that heavy metals will be mobilised from the waste when subject to rainfall. It is therefore recommended that the waste be classified as a Type 3 waste (as most of the TC values > TCTi), which requires disposal on a landfill with a landfill barrier similar to that of a G:L:B$^+$ waste management facility (see Figure 1).

The proposed landfill barrier systems for Type 3 and Type 4 waste management facilities are given in Figures 1 and 2. If the metallic gypsum waste is disposed as a liquid, the more stringent landfill barrier system, namely that for hazardous lagoons must be adhered to (DEA, 2010a). **It is the DEA's intention to phase the disposal of liquid waste out within 3 years of the promulgation of the new waste classification and management regulations (DEA, 2010a). It is therefore recommended that consideration be given to dewater the metallic sludge from commencement of the operation of the MWRP.**

In the case of the Stage 2/3 gypsum cake, we do recommend that the barrier system for the gypsum material be provided with a leachate collection system due to the solubility and hence leachability of the magnesium. The barrier system should therefore be more conservative than the one presented in Figure 2.

Table 3: Total constituent and ARLP results for Metallic Gypsum (ST1-1) compared to new SASLP and SASTC values

	Metallic Gypsum (ST1-1)													
Chemical Species	Total Concentration (TC)	ARLP analyses in mg/l	20 x TC in mg/kg	Detection limit	LCTi	TCTi	LCT0	TCT0	LCT1	TCT1	LCT2	TCT2
	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
As	<4	bdl	[illegible]	0.1	0.01	5.8	0.5	500	1	500	4	2 000
B	<40	0.200	[illegible]	Not given	0.5	150	25	15 000	50	15 000	200	60 000
Ba	29.0	0.020	[illegible]	0.010	0.7	62.5	35	6 250	70	6 250	280	25 000
Cd	2.105	bdl	[illegible]	0.010	0.005	7.5	0.25	260	0.5	260	2	1 040
Co	426.2	bdl	[illegible]	0.010	0.5	50	25	5 000	50	5 000	200	20 000
Cr	20.6	bdl	412	0.010	0.1	46 000	5	800 000	10	800 000	40	N/A
Cr(VI)	NA	NA	NA		0.05	6.5	2.5	500	5	500	20	2 000
Cu	31.1	0.020	[illegible]	0.010	1.0	16	50	19 500	100	19 500	400	78 000
Hg	NA	NA	NA		0.001	0.93	0.05	160	0.1	160	0.4	640
Mn	34 206	0.023	[illegible]	0.010	0.4	1 000	20	25 000	40	25 000	160	100 000
Mo	2.370	0.067	[illegible]	0.010	0.07	40	3.5	1 000	7	1000	28	4 000
Ni	300.6	0.050	[illegible]	0.010	0.07	91	3.5	10 600	7	10 600	28	42 400
Pb	8.637	bdl	[illegible]	0.10	0.01	20	0.5	1 900	1	1 900	4	7 600
Sb	NA	NA	NA		0.01	10	0.5	75	1	75	4	300
Se	1.050	bdl	[illegible]	0.10	0.01	10	0.5	50	1	50	4	200
V	11.60	bdl	[illegible]	0.010	0.1	150	5	2 680	10	2 680	40	10720
Zn	416.2	0.300	[illegible]	0.010	3.0	240	160	160 000	320	160 000	1200	640 000
TDS	NA	NA	NA	-	250	N/A	2500	N/A	5000	N/A	20000	N/A
Chloride	NA	NA	NA	-	100	N/A	5000	N/A	10000	N/A	40000	N/A
Sulphate as SO_4	NA	NA	NA	-	200	N/A	10000	N/A	20 000	N/A	80 000	N/A
NO_3 as N	NA	NA	NA	-	6.0	N/A	300	N/A	600	N/A	2 400	N/A
Fluoride	NA	NA	NA	-	1.0	N/A	50	10 000	100	10 000	400	40 000

NA	Not analysed
N/A	Not available
	TC > TCi
	TC > TCT0/TCT1
	20 x TC > TCTi

Table 3: Total constituent and ARLP results for Gypsum Cake (ST2/3-1) compared to new SASLP and SASTC values

	Gypsum Cake (ST2/3-1)											
Chemical Species	Total Concentration (TC)	ARLP analyses in mg/l	20 x TC in mg/kg	Detection limit	LCTi	TCTi	SASLP0	SASTC0	SASLP1	SASTC1	SASLP2	SASTC2
	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg	mg/ℓ	mg/kg
As	5.020	bdl	[illegible]	0.10	0.01	5.8	0.5	500	1	500	4	2 000
B	<40	0.200	[illegible]	Not given	0.5	150	25	15 000	50	15 000	200	60 000
Ba	12.3	0.020	[illegible]	0.010	0.7	62.5	35	6 250	70	6 250	280	25 000
Cd	0.418	bdl	[illegible]	0.010	0.005	7.5	0.25	260	0.5	260	2	1 040
Co	0.672	bdl	[illegible]	0.010	0.5	50	25	5 000	50	5 000	200	20 000
Cr	4.3	bdl	86	0.010	0.1	46 000	5	800 000	10	800 000	40	N/A
Cr(VI)	NA	NA	NA		0.05	6.5	2.5	500	5	500	20	2 000
Cu	18.3	0.020	[illegible]	0.010	1.0	16	50	19 500	100	19 500	400	78 000
Hg	NA	NA	NA		0.001	0.93	0.05	160	0.1	160	0.4	640
Mn	2 224	0.013	[illegible]	0.010	0.4	1 000	20	25 000	40	25 000	160	100 000
Mo	1.498	0.003	29.96	0.010	0.07	40	3.5	1 000	7	1000	28	4 000
Ni	10.9	0.050	[illegible]	0.010	0.07	91	3.5	10 600	7	10 600	28	42 400
Pb	<6	bdl	[illegible]	0.10	0.01	20	0.5	1 900	1	1 900	4	7 600
Sb	NA	NA	NA		0.01	10	0.5	75	1	75	4	300
Se	0.554	bdl	NA	0.10	0.01	10	0.5	50	1	50	4	200
V	10.37	bdl	[illegible]	0.010	0.1	150	5	2 680	10	2 680	40	10720
Zn	<60	0.300	[illegible]	0.010	3.0	240	160	160 000	320	160 000	1280	640 000
TDS	NA	NA	NA	-	250	N/A	2500	N/A	5000	N/A	20000	N/A
Chloride	NA	NA	NA		250	N/A	5000	N/A	10000	N/A	40000	N/A
Sulphate as SO_4	NA	NA	NA		100	N/A	10000	N/A	20 000	N/A	80 000	N/A
NO_3 as N	NA	NA	NA		200	N/A	300	N/A	600	N/A	2 400	N/A
Fluoride	NA	NA	NA		6.0	N/A	50	10 000	100	10 000	400	40 000

NA	Not analysed
N/A	Not available
(light shading)	TC > TCi
(medium shading)	TC > TC0/TC1
(dark shading)	20 x TC > TCTi

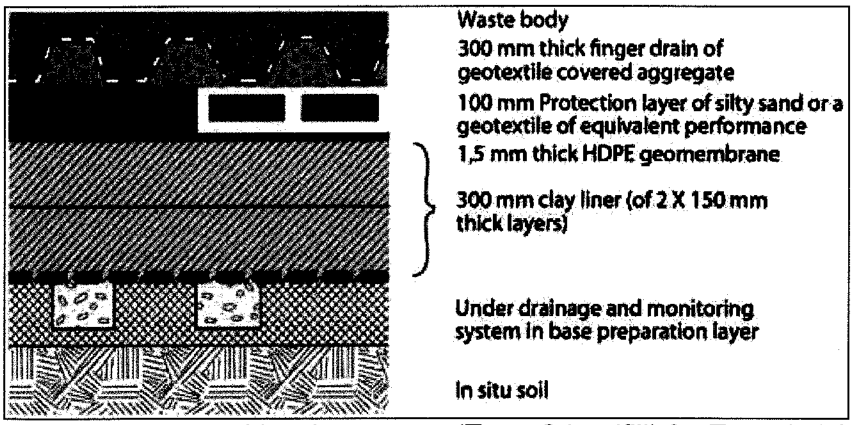

Figure 1: Proposed barrier system (Type C landfill) for Type 3 risk wastes (DEA, 2010a)

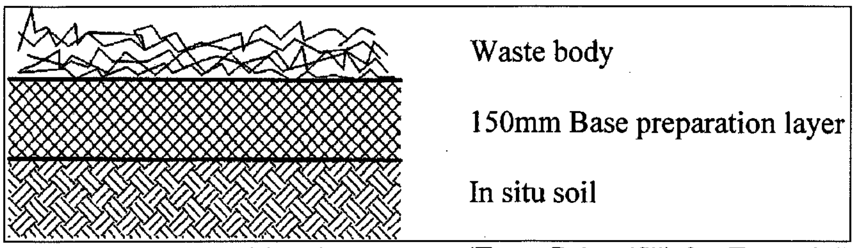

Figure 2: Proposed barrier system (Type D landfill) for Type 4 (Inert Waste) risk wastes (DEA, 2010a)

3. SUMMARY AND CONCLUSIONS

Based on the objectives and in terms of the Minimum Requirements waste classification system:

- Based on the modelled water quality of the combined impacted mine water streams, the modelled impacted mine water is classified as a Hazard Group 2 waste requiring storage in a hazardous waste lagoon management facility;
- The metallic gypsum waste (Stage 1 waste) and the gypsum waste (Stage 2/3 waste), obtained from test trials conducted with Middelburg Mines' water at a pilot plant in 2006, both classifies as general waste, which require disposal in engineered disposal facilities complying with the performance specifications of the DWAF's Minimum Requirements for G:M:B+/G:L:B+ landfills.
- If the metallic gypsum waste is disposed of as a liquid, a waste management facility complying with the performance requirements of a hazardous waste lagoon is required.
- The monthly loading rate for the metallic gypsum is 3 018 tons/hectare/month and for the gypsum cake 3 624 tons/hectare/month. As the two waste streams will be disposed of in engineered and lined disposal facilities, the total load per hectare for the metallic gypsum is 301 800 tons/hectare. The total load for the gypsum cake is 362 400 tons per hectare.
- The impacted mine water and the two gypsum waste streams contain no elements that are likely to cause genetic (teratogenic), mutagenic and carcinogenic impacts or effects.

As lagoon type liners will be more expensive than a G:M:B$^+$/G:L:B$^+$ liner and, as it is the intention of the DEA to phase the disposal of liquid waste out over time, it is recommended that consideration be given to dewatering the metallic gypsum waste prior to disposal. The current target date for phasing out the disposal of liquid waste, based on the draft waste classification and management regulations of September 2010, is 3 years from date of promulgation of the new waste regulations (DEA, 2010a).

The September 2010 edition of new waste classification system for waste disposal was also used to classify the two gypsum waste streams. The primary objective of this was to verify the classifications obtained when using the current Minimum Requirements system and, in addition, the new waste classification and waste management regulations may be promulgated in early 2011, which could make them applicable to the MWRP project. This new system is more or less in line with that of other waste classification systems being used elsewhere in the world and therefore represents the newest thinking with regard to risks posed by waste.

In the case of the new regulations, liquid waste, such as the impacted mine water, need to be disposed of in a waste management facility with a hazardous waste lagoon barrier system (DEA, 2010a).

Using the new draft waste classification system:

- The metallic gypsum waste (Stage 1 waste) is classified as a Type 3 waste, which requires disposal on a waste disposal facility of which the liner design performance is expected to be similar to the current G:M:G$^+$/G:L:B$^+$ system, provided the waste is dewatered. If the waste is not dewatered, a liner system typical of the current hazardous lagoons will be required, and in addition, the disposal of liquid waste may well be phased out over the next few years.
- The gypsum waste (Stage 2/3 gypsum waste), which is to be dewatered, classifies as a Type 4 or inert waste, which will require in all likelihood, disposal on a waste Type D disposal facility, with a liner design which only requires a 150 mm base preparation layer and which must drain to a leachate collection drain or sump (DWAF, 1998). However, as the magnesium in the gypsum waste is expected to be readily dissolved by seepage water, we do recommend that the storage facility be provided with a formal leachate collection layer.

4. RECOMMENDATIONS

Based on the findings of the waste classification performed on the modelled impacted water, and the two gypsum waste streams obtained from the trial run in 2006, it is recommended that:

- The metallic (Stage 1) gypsum waste be dewatered prior to disposal, as this approach will reduce the design and construction cost of the metallic gypsum waste disposal facility and will bring waste management at the MWRP in line with the current DEA thinking of phasing out the disposal of liquid waste within the next few years,
- Although the Stage 2/3 gypsum waste is classified as an inert waste for disposal in terms of the DEA's draft waste regulations, the storage facility should be provided with a formal leachate collection system, which is less stringent than that of a G:M:B$^+$/G:L:B$^+$ waste disposal facility barrier system.

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Project Manager

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7 January 2011

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APPENDIX A

MONTHLY LOADING RATE CALCULATION

MONTHLY LOADING RATE CALCULATIONS FOR MWRP GYPSUM WASTE STREAMS

MWRP: METALLIC GYPSUM (ST1-1)

MONTHLY LOADING RATE: ARLP RESULTS

		Manganese	Strontium
	Concentration of element (ppm) in leach solution	0.023	0.502
	Load for element in g/ha/month from Min Req.	454	1515
	Load in kg/ha/month	19739130	3017928
	Load in tons/ha/month for H:H	**19739**	**3018**

The monthly disposal rate is calculated by dividing the ARL by 0.66, which gives the load for the element in g/ha/month. The monthly load of the waste is then calculated by dividing the load (in g/ha/month) with the concentration of the component in the leach solution (ppb).

MWRP: GYPSUM CAKE (ST2/3-1)

MONTHLY LOADING RATE: ARLP RESULTS

		Manganese	Strontium
	Concentration of element (ppm) in leach solution	0.013	0.418
	Load for element in g/ha/month from Min. Req.	454	1515
	Load in kg/ha/month	34923077	3624402
	Load in tons/ha/month for H:H	**34923**	**3624**

The monthly disposal rate is calculated by dividing the ARL by 0.66, which gives the load for the element in g/ha/month. The monthly load of the waste is then calculated by dividing the load (in g/ha/month) with the concentration of the component in the leach solution (ppb).

D.9 Heritage Impact Assessment

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PROJECT 2010/45

SPECIALIST STUDY: HERITAGE IMPACT ASSESSMENT REVISION 2 IN CONNECTION WITH AMENDMENTS TO THE MIDDELBURG WATER RECLAMATION PROJECT, STEVE TSHWETE LOCAL MUNICIPALITY, MPUMALANGA

PREPARED FOR

Marius van Zyl
Jones & Wagener Consulting Civil Engineers

DATE: 1 February 2011

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EXECUTIVE SUMMARY

This report contains a heritage impact assessment investigation (heritage specialist study) in accordance with the provisions of Sections 38(1) and 38(3) of the *National Heritage Resources Act* (NHRA) (25/1999) for purposes of assessing impacts on heritage features that may be affected by the proposed Middelburg Water Reclamation Project (MWRP) and its amendments. This investigation forms part of the process of conducting the required EIA that will inform the environmental feasibility with regard to the proposed project and its amendments.

The investigation was carried out by an independent generalist heritage practitioner, Dr RC de Jong (Cultmatrix cc).

The water treatment facility will treat all excess mine water produced by Middelburg Mine's North – and Klipfontein Sections to catchment standards for release into the catchment. As part of the study, it is necessary to determine the environmental impacts associated with this project to ultimately determine the feasibility thereof. This will entail doing a detailed Environmental Impact Assessment (EIA) of the proposed project, developing project specific Environmental Management Programme's (EMP), undertaking a water permit application process, developing an Integrated Water and Waste Management Plan (IWWMP) for the scheme, undertaking Water Use Licence Application's (WULA) for the scheme, updating the Integrated Water Use Licences, and obtaining the necessary environmental authorisations in terms of other legislation.

The original intention was to collect and treat excess mine water at a treatment plant site located east of the R 575 (the road between Vandyksdrift and Kriel) in the north-western corner of the farm Hartbeestfontein 339 JS. This plant would discharge the water to the Spookspruit via a pipeline (Klipfontein pipeline) that would connect with the mine's Klipfontein Section to the east, branching off to the north via another pipeline (Alternative 2) that would run along a mine haul road traversing Goedehoop farm past the Mavela Mine, connecting with the Goedehoop Dam. In April 2009 Cultmatrix prepared and submitted a Heritage Impact Assessment report in connection with the proposed pipelines and treatment plant.

Because of issues related to the location of this pipeline, an alternative pipeline (Alternative 1) was proposed later, situated further to the west and located on farm land (cultivated and grazing) on the farms Rietfontein 314 JS and Goedehoop 315 JS, thereby avoiding the mine property that would be traversed by Alternative 2. In addition, it was proposed to enlarge the treatment plant site by extending it to the south in order to locate the plant itself, its holding dam and its waste disposal site further away from a sensitive natural pan, situated immediately north of the original treatment plant site, closer to less sensitive old mining land characterised by slimes dams and other features.

This HIA report assesses the amendments mentioned above and at the same time evaluates and compares the original eastern pipeline (Alternative 2) with the proposed western pipeline (Alternative 1). The report also evaluates the Klipfontein pipeline sections (no alternative alignments are possible), as well as a proposed discharge point located east of the treatment plant site near the Niekerk Spruit.

It includes information from the April 2009 HIA report and also incorporates information from another HIA report (May 2006), submitted to Jones & Wagener in connection with proposed mining activities on the South, Hartbeestfontein and Goedehoop sections of Middelburg Mine. The May 2006 report included the results of an Archaeological Impact Assessment (AIA), conducted by JA van Schalkwyk. These results have been, where appropriate, incorporated into this report (as well as in the April 2009 HIA report) and therefore no new and separate AIA was considered necessary.

According to Roger Price, Council for Geoscience, there are lots of fossils and trace fossils. A lot of studies have been done in the past by mining companies but most of the studies have probably been sedimentological rather than palaeontological, with comments on palaeontology as an afterthought. It is impossible to predict where fossils and trace fossils might occur and the only way to find out is to randomly check for any occurrences during site preparation work.

The **Alternative 1 pipeline** begins at the Goedehoop Dam, runs north-west past a homestead ruin (MM 10) and the turns west to cross the Spookspruit, where it turns south-west to cross farm land (crops and grazing areas) to a point north of a natural pan, where it turns south and runs through the remains of a eucalyptus plantation, ending at the treatment plant site.

The **Klipfontein pipeline** starts at the Rondeboschje Dam and traverses in a westerly direction through existing and former cultivated farm land, old grazing land and wetlands alongside farm roads and tracks, ending at the treatment plant site.

The **Alternative 2 pipeline** begins at the Goedehoop Dam and turns south, bypassing the Mavela Colliery and traversing existing and former cultivated and grazing land along a former mine service or haul road to a point where it meets the Klipfontein pipeline, where turns west to end at the treatment plant site.

The **Niekerk Spruit Discharge Point** (25°54'53.16"S 29°24'46.35"E) is located on the no rthern boundary of the Hartbeesfontein Section at a point between an old slimes dam and an old farm dam in the Spruit. This discharge point is fed by a separate pipeline.

As a cultural landscape this environment can be classified as a combination of a historic farming landscape and relic farming landscape, displaying the following typical features:

- Tracks and fences
- Gravel roads
- Grazing areas (existing and former)
- Cultivated land (existing and former)
- Power lines
- Farmsteads and homesteads
- Farm cemeteries
- Dams, wind pumps and boreholes
- Exotic vegetation
- Vacant abandoned land (grazing, old cultivated land, ruins, etc)

The co-ordinates of the Alternative 1 pipeline route are:[1]

TP PG001 25°52'15.10"S 29°25'45.10"E (Goedehoop Dam)
TP PG2 01 25°52'12.80"S 29°25'36.10"E
TP PG2 02 25°52'13.20"S 29°25'29.00"E
TP PG2 03 25°52'14.80"S 29°25'22.00"E
TP PG2 04 25°52'14.80"S 29°25'14.70"E
TP PG2 05 25°52'15.50"S 29°25'7.60"E
TP PG2 10 25°52'41.80"S 29°24'50.70"E
TP PG2 15 25°53'12.90"S 29°24'40.30"E
TP PG2 20 25°53'36.40"S 29°24'27.50"E
TP PG2 25 25°53'49.10"S 29°23'59.40"E
TP PG2 29 25°54'13.00"S 29°24'1.10"E (Treatment Pla nt)

The co-ordinates of the Alternative 2 pipeline route are:[2]

TP PG001 25°52'15.10"S 29°25'45.10"E (Goedehoop Dam)
TP PG1 01 25°52'10.40"S 29°25'50.30"E
TP PG1 05 25°52'12.40"S 29°26'30.20"E
TP PG1 10 25°52'26.70"S 29°27'2.40"E
TP PG1 15 25°52'53.40"S 29°26'54.80"E
TP PG1 20 25°53'22.70"S 29°26'38.60"E
TP PG1 30 25°54'11.60"S 29°26'18.90"E
TP PG1 35 25°54'43.60"S 29°26'10.80"E
TP PG1 40 25°55'12.90"S 29°26'9.20"E
Junction with Klipfontein pipeline 25°55'18.90"S 29 °26'8.39"E

[1] Provided by Jones & Wagener
[2] Provided by Jones & Wagener

The co-ordinates of the Klipfontein pipeline are:[3]

TP PK 01 25°55'53.22"S 29°30'39.16"E (Klipfontein S ection)
TP PK 10 25°55'9.62"S 29°30'10.26"E
TP PK 15 25°54'55.96"S 29°29'42.96"E
TP PK 30 25°55'6.33"S 29°27'55.75"E
TP PK 40 25°55'13.18"S 29°26'53.09"E
TP PK 45 25°55'23.92"S 29°26'28.75"E
TP PK 48 25°55'20.68"S 29°26'13.58"E
TP PK 50 25°55'17.17"S 29°26'5.14"E
TP PK 60 25°54'57.49"S 29°25'4.11"E
TP PK 65 25°54'49.42"S 29°24'33.12"E
TP PK end 25°54'44.15"S 29°24'11.34"E (Treatment Pl ant)

The co-ordinates of the treatment plant site are:[4]

WWTP 1 25°54'15.47"S 29°23'46.21"E
WWTP 2 25°54'16.99"S 29°24'22.98"E
WWTP 3 25°54'47.54"S 29°24'15.09"E
WWTP 4 25°54'55.61"S 29°24'42.94"E
WWTP 5 25°55'10.14"S 29°24'35.81"E
WWTP 6 25°55'8.30"S 29°24'6.30"E
WWTP 7 25°55'1.50"S 29°24'5.57"E
WWTP 8 25°54'57.95"S 29°23'17.89"E

The intended development comprises the installation of a water pipeline and the construction of a water treatment plant and this provided the following "triggers" for an HIA:

- Linear development longer than 300 meters (6 km water pipeline)
- Development affecting a site larger than 5000 sq m (treatment plant)
- The broader area consists of historic and relic farm land where heritage resources such as farmsteads and cemeteries are known to exist

The general aim of any heritage impact assessment investigation and report is to ensure that the needs of socio-economic development are balanced by the needs to preserve significant heritage resources.

The purpose of this report is to identify and assess features of heritage significance, identify possible impacts and propose measures to manage possible negative impacts. This information must enable the relevant heritage authority to authorise the proposed development as required in terms of Section 38 of the NHRA.

The investigation was conducted as follows:

- Desktop study, including a search of archaeological reports for other projects (no studies for other projects in the same area exist), completed heritage impact assessment reports, historic maps, historic aerial images, cadastral diagrams and general publications about the broader area
- Field survey in November 2010

Heritage impacts are categorised as:

- Neutral (no impact)
- Direct or physical impacts, implying alteration or destruction of heritage features within the project boundaries
- Indirect impacts, e.g. restriction of access or visual intrusion concerning the broader environment
- Cumulative impacts that are combinations of the above

The predicted heritage impacts by the proposed development are neutral since no visible features of heritage significance will be directly and adversely affected.

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[3] Provided by Jones & Wagener
[4] Created by the author

Visual impacts are of less importance because the general environment has already been visually transformed by development (mining, power generation and transmission, farming), implying that the proposed development will not imply a visual intrusion into the cultural landscape.

Heritage impacts (both direct and indirect) can be managed through one or a combination of the following measures:

- Mitigation (minimising adverse impacts through further documentation and research before a place is altered or destroyed)
- Avoidance
- Compensation (balancing of making good the destruction of one heritage feature by the preservation of another one)
- Enhancement (positive impacts on heritage features)
- Rehabilitation (re-use of preserved heritage features)
- Interpretation (providing information on heritage features)
- Memorialisation (retaining the memory of important heritage features that have been destroyed)
- No action
- Relocation (historic equipment, graves)
- Alternatives

Of the above measures, "no action", avoidance and mitigation apply in the case of this project, depending on the type of heritage feature that may and could be affected.

This report complies as follows with the provisions of Section 38 (3) of the *National Heritage Resources Act* (Act 25 of 1999):

(a) Identification and mapping of heritage resources
(b) Cultural significance
(c) Predicted impacts
(f) Impact management measures

See Table 1 (below).

TABLE 1: Identification of heritage features, impacts and mitigation measures

S 3(2) NHRA heritage resource	(a) Identification		(b) Significance	(c) Impact		(d) Recommended impact management
	Site	**GPS**		**Study area**	**Impact type, certainty and significance**	
Buildings, structures, places and equipment of cultural significance	MM 5[5]	25°54'28.70"S 29°23'55.80"E	Low local	WWTP site	Neutral (outside pipeline alignment and plant site)	Ruin. No action.
	MM 6	25°54'22.30"S 29°24'9.10"E	Low local	WWTP site	Probably neutral, depending on final pipeline alignment	Homestead ruin with old rubbish dump and car wrecks. Sample (excavate) dump and document ruin before destruction should it be negatively affected by the Alternative 1 pipeline alignment, otherwise no action.
	MM 9	25°54'51.90"S 29°23'48.14"E	Low local	WWTP	Probably neutral (just outside waste site)	Old borrow pit. No action.

[5] Includes sites identified in the April 2009 HIA report

S 3(2) NHRA heritage resource	(a) Identification		(b) Significance	(c) Impact		(d) Recommended impact management
	Site	GPS		Study area	Impact type, certainty and significance	
	MM 10	25°52'11.54"S 29°25'44.29"E	Low local	Alternative 1 Pipeline	Probably neutral (outside alignment)	Remains of Goedehoop farmstead. Some parts could be 60 years and older. Document before destruction if unavoidable.
Areas to which oral traditions are attached or which are associated with intangible heritage	None	-	-	-	-	-
Historical settlements and landscapes	None	-	-	-	-	-
Landscapes and natural features of cultural significance	Natural pan	25°53'57.78"S 29°24'12.54"E	Unknown	Alternative 1 Pipeline and WWTP site	Neutral	Although no artefacts were found, natural pans often contain scattered deposits of Stone Age artefacts. The pan is a sensitive natural feature and falls outside the development areas.
Geological sites of scientific or cultural importance	None	-	-	-	-	-
Archaeological and palaeontological sites	Chance finds	Unknown	Low local?	WWTP and all pipelines	Unknown (WWTP site and pipeline corridor are already transformed land)	Mitigation: Report and evaluate any graves or archaeological features and artefacts when found during site preparation work
Graves and burial sites	MM 8	25°52'37.00"S 29°26'2.00"E	Medium local	Goedehoop Dam	Neutral	Large farm cemetery, well outside both pipeline corridors. No action.
Features associated with labour history	None	-	-	-	-	
Movable objects	None	-	-	-	-	

(d) Social and economic benefits

The development will have no direct benefits related to the conservation of heritage resources (structures) since none of significance that will be directly affected has been identified. However, if important archaeological features are exposed during site preparation activities, this may present an opportunity to conduct a Phase 2 (archaeological) investigation that may generate new information, before such features could be destroyed.

The project is part of a scheme to alleviate the critical shortage of water in the Middelburg area by collecting and treating excess mine water, an activity that in the long term will minimise pollution.

(e) Public consultation

This is part of the environmental impact assessment process.

(g) Mitigation during pipeline installation and construction work

Except for monitoring of any chance finds (graves, archaeological features) during site preparation and construction work, no mitigation measures apply.

Findings and recommendations

The proposed water pipelines and treatment plant are located in a cultural landscape classified primarily as a combination of relic farm land and a historic farm land landscape. This type of landscape is of low heritage sensitivity because it is able to absorb new development with few adverse effects on heritage.

- The proposed original pipeline (Alternative 2) will traverse old farm land and run past a colliery and along an existing farm road. This pipeline will have no effect on any heritage features since these areas represent transformed land that would have destroyed any heritage features; hence, none were identified.
- The proposed alternative pipeline (Alternative 1) will traverse cultivated land (maize) and grazing areas, which represent transformed land that would have destroyed any heritage features, with the exception of the remains of the old Goedehoop farmstead (MM 10) and a ruin on the treatment plant site (MM 6), even though these features are of low cultural significance. Alternative 1 may affect these two heritage features.
- The Klipfontein pipeline will traverse former and existing farm land (cultivated and grazing) and will run past farm roads and mining land. All this represents transformed land that would have destroyed any heritage features; hence, none were identified.
- The proposed treatment plant will be located on environmentally degraded land, characterised by heritage features such as ruins (MM 5), old cultivated and grazing land, an old borrow pit (MM 9) and the remains of eucalyptus plantations. These features are of low cultural significance and any direct impacts will therefore be very low.

Visual impacts are of less importance because the general environment has already been visually transformed by development (mining, power generation and transmission, farming), implying that the proposed development will not imply a visual intrusion into the cultural landscape. Noise, dust, pollution and restrictions of access patterns as indirect impacts are also not issues, except during installation work.

From a historic built environment perspective no features of real heritage significance were identified and those features that are extant (bordering on the western pipeline corridor) are of fairly recent origin and of low cultural significance.

From an archaeological perspective no finds or artefacts of significance were identified.

The nature and significance of what has been found in terms of heritage is not of such importance that the proposed treatment plan location and Klipfontein pipeline alignment should be changed and that alternative sites should be considered.

Comparing the western (Alternative 1) and eastern (Alternative 2) pipelines connecting the treatment plant with the Spookspruit, the eastern pipeline (Alternative 2) is preferred since it will affect no heritage features in contrast to Alternative 1 that may affect two heritage features where mitigation could be required (namely the Goedehoop farmstead MM 10 and a homestead ruin MM 6).

Cultmatrix states that there are no compelling reasons not to approve either of the proposed alternative pipelines (although preference is given to Alternative 2), the Klipfontein pipeline, the Niekerk Spruit Discharge Point and the treatment plant and that the project can continue provided that the following mitigation measures are adopted in order to minimise adverse impacts:

1. Should any hidden human remains be disturbed, exposed or uncovered during site clearing and excavations, these should immediately be reported to an archaeologist. Burial remains should not be disturbed or removed until inspected by an archaeologist.
2. Site preparation activities must also be monitored for the occurrence of any hidden archaeological material (Stone Age tools, potsherds) and similar chance finds (such as historic middens and foundations) and if any are exposed, this should be reported to an archaeologist so that an investigation and evaluation of the finds can be made.
3. Should Alternative 1 be selected, the homestead ruin and rubbish dump (MM 6) should be documented and sampled (excavated) in case they will be affected and should therefore be destroyed.

4. Should Alternative 2 be selected, the remains of the Goedehoop farmstead should be documented in case it will be affected and therefore will be destroyed.

RC DE JONG
Public Officer and Principal Investigator

Date: 1 February 2011

1. REPORT CONTEXT

1.1 General notes

1. The structure of this report is based on the following generally accepted standards for heritage scoping and impact assessment investigations:

    - SOUTH AFRICAN HERITAGE RESOURCES AGENCY, Heritage Impact Assessment: Notification of intent to develop (form)
    - DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND DEVELOPMENT PLANNING, PROVINCIAL GOVERNMENT OF THE WESTERN CAPE, 2005, Guideline for involving heritage specialists in EIA processes (document)
    - DEPARTMENT OF ENVIRONMENT AFFAIRS AND TOURISM, Integrated Environmental Management Guidelines
    - SOUTH AFRICAN HERITAGE RESOURCES AGENCY, 2006, *Minimum standards: Archaeological and palaeontological components of impact assessment reports* (unpublished).
    - PROVINCIAL HERITAGE RESOURCES AUTHORITY GAUTENG, 2010, *Report requirements for HIA reports* (unpublished).
    - WORLD BANK, *Environmental Assessment Sourcebook Update No 8, September 1994: Cultural Heritage in Environmental Assessment.*
    - Best-practice HIA reports submitted by Cultmatrix and other heritage consultants

2. This report is informed by the *National Heritage Resources Act* (25/1999) (NHRA) and is consistent with the various ICOMOS charters for places of cultural significance.

3. Recommendations contained in this application do not exempt the applicant from complying with any national, provincial and municipal legislation or other regulatory requirements, including any protection or management or general provision in terms of the NHRA.

4. Rights and responsibilities that arise from this report are those of the applicant and not that of Cultmatrix cc. Cultmatrix cc assumes no responsibility for compliance with conditions that may be required by SAHRA in terms of this report.

5. Cultmatrix assumes no responsibility whatsoever for any loss or damages that may be suffered as a direct or indirect result of information contained in this application. Any claim that may however arise is limited to the amount paid to Cultmatrix for services rendered to compile this report.

6. Although all possible care is taken to identify all sites of cultural importance during the survey of study areas, the nature of archaeological and historical sites are as such that it always is possible that hidden or subterranean sites could be overlooked during the study. Cultmatrix and its subcontractors will not be held liable for such oversights or for costs incurred as a result thereof.

1.2 Purpose of the report

The purpose of this report is to identify and assess features of heritage significance, identify possible impacts from two alternative pipeline routes (between the treatment plant and the Goedehoop Dam) and from another pipeline and a discharge point, evaluate and compare the two alternative water pipeline routes between the treatment plant and the Goedehoop Dam area and propose management measures to mitigate negative impacts that could be associated with the treatment plant, the pipelines and the discharge point. This information must enable the relevant heritage authority to authorise the proposed development as required in terms of Section 38 of the NHRA.

The below table lists and describes the three general categories of heritage impact assessment studies and reports, which offices are involved (i.e. to which offices reports should be submitted) and which type of response is required from these offices.

TABLE 2: Applicable category of heritage impact assessment study and report

Type of study and report	Aim	Office involved	Requested response
Screening: Not this report	The aim of the screening investigation is to provide an informed heritage-related opinion about the proposed development by an appropriate heritage specialist. The objectives of this investigation are to screen potential heritage issues through a site inspection, to develop a broad understanding of heritage policy-related context, to review any existing data on the history and heritage significance of the site, to check if the site has any formal heritage status, to discuss the proposed development with heritage contacts and to scan the development proposals. The result of this investigation is a brief statement indicating potential heritage impacts/issues and the need for further investigation.	-	-
		-	-
		-	-
Scoping (basic assessment): Not this report	The aim of the scoping investigation is to analyse heritage issues and how to manage them within the context of the proposed development. The objectives are to assess heritage significance (involving site inspections and basic desktop and archival research); to identify the need for further detailed inputs by heritage specialists, to consult with local heritage groups and experts, to review the general compatibility of the development proposals with heritage policy and to assess the acceptability of the proposed development from a heritage perspective. The result of this investigation is a heritage scoping report indicating the presence/absence of heritage resources and how to manage them in the context of the proposed development.	-	-
		-	-
		-	-
Full HIA: This report	The aim of the full HIA investigation is to analyse and recommend heritage management mitigation measures and monitoring programmes. The objectives are to analyse heritage issues, to research the chronology of the site and its role in the broader context, to undertake a comprehensive assessment of heritage significance, to analyse the nature and scale of the proposed development, to consult with local heritage groups and experts as part of the broader EIA stakeholder engagement process, to establish the compatibility of the proposed development with heritage and other statutory frameworks and to assess alternatives in order to promote heritage conservation issues.	Mpumalanga Heritage Resources Authority	Comments and authorisation
		SAHRA Archaeology, Palaeontology and Meteorites Unit	Comments
		SAHRA Built Environment Unit	Comments

1.3 Terms of reference

- To survey the three proposed pipeline corridors, the discharge point and the treatment plant site as well as the surrounding environment
- To identify and map heritage resources that may be affected directly
- To assess the cultural significance of these heritage resources
- To assess the impact of the development on these heritage resources
- To assess the benefits of conserving these heritage resources in relationship to the socio-economic benefits of the development
- To provide the public with an opportunity to comment on the heritage aspects of the proposed development
- To consider alternatives if heritage resources will be affected in a negative manner
- To determine methods to mitigate negative impacts before, during and after construction activities
- To evaluate and compare the two alternative pipeline routes between the treatment plant and the Goedehoop Da and to recommend the best possible alternative that would have the least impact on any heritage features

1.4 History of the report

This report has been preceded by:

- The May 2006 HIA Cultmatrix report for the Middelburg Mine

- The HIA report (April 2009) in connection with the Alternative 1 pipeline alignment and treatment plant site
- The first draft (12 December 2010) of this report
- The second draft (14 December 2010) of this report, known as Revision 1

1.5 Legal context of the report

ACT	COMPONENT	IMPLICATION	RELEVANCE	COMPLIANCE
NHRA	S 34	Impacts on buildings and structures older than 60 years	Possibly homestead ruin (MM 6)	Document before destruction
	S 35	Impacts on archaeological and palaeontological heritage resources	Old rubbish dump (MM 6)	Sample (excavate) before destruction, monitor exposure of hidden features and artefacts during site preparation work
	S 36	Impacts on graves	None	-
	S 37	Impacts on public monuments	None present	-
	S 38	Developments requiring an HIA	Development is listed activity	Heritage impact assessment
NEMA	EIA Regulations	Activities requiring an EIA	Development is subject to an EIA	HIA is part of EIA
Other	-	-	-	-

1.6 Strategic planning context of the project

The key enablers behind this project include the need to alleviate the critical shortage of water in the Middelburg area by collecting and treating excess mine water, an activity that in the long term will also minimise pollution.

1.7 Development criteria in terms of Section 38 of the NHRA

1.7	Development criteria in terms of Section 38(1)	Yes/No details
1.7.1	Construction of road, wall, power line, pipeline, canal or other linear form of development or barrier exceeding 300m in length	Yes
1.7.2	Construction of bridge or similar structure exceeding 50m in length	No
1.7.3	Development exceeding 5000 sq m	Yes
1.7.4	Development involving three or more existing erven or subdivisions	No
1.7.5	Development involving three or more erven or divisions that have been consolidated within past five years	No
1.7.6	Rezoning of site exceeding 10 000 sq m	No
1.7.7	Any other development category, public open space, squares, parks, recreation grounds	No

1.8 Property details

1.8	Property details	
1.8.1	Name and location of property	Middelburg Water Reclamation Project
1.8.2	Erf or farm numbers	Hartbeestfontein 339 JS, Goedehoop 315 JS, Rietfontein 314 JS
1.8.3	Magisterial district	Middelburg
1.8.4	Closest town	Middelburg
1.8.5	Local authority	Steve Tshwete
1.8.5	Current use	Vacant, grazing, residential, mining
1.8.5	Current zoning	Agricultural, mining
1.8.5	Predominant land use of surrounding properties	Agricultural, residential, commercial, vacant
1.8.9	Total extent of property	6 km pipeline, 27860 sq m treatment plant, 55469 sq m holding dam, 177364 sq m waste disposal area

1.9 Property ownership

1.9	Property owners	
1.9.1	Farms	Hartbeestfontein 339 JS, Goedehoop 315 JS, Rietfontein 314 JS
1.9.2	Name and contract address	BHP Billiton Coal South Africa
1.9.3	Telephone number	-
1.9.4	Fax number	-
1.9.5	E-mail	-

1.10 Developer

1.10	Developer	
1.10.1	Name and contact address	Douglas Tavistock Joint Venture
1.10.2	Telephone number	
1.10.3	Fax	
1.10.4	E-mail	

1.11 Environmental practitioner

1.11	Environmental Specialist	
1.11.1	Name and contact address	Beth Candy, Jones & Wagener Consulting Civil Engineers, PO Box 1434, Rivonia 2128
1.11.2	Telephone number	(011) 519-0200
1.11.3	Fax	(011) 519-0201
1.11.4	E-mail	candy@jaws.co.za

1.12 Heritage assessment practitioner

1.12	Specialist (1)	
1.12.1	Name and contact address	Dr RC de Jong (Principal Member: Cultmatrix cc), PO Box 12013, Queenswood 0121, Pretoria
1.12.2	Qualifications and field of expertise	PhD (Cultural History) UP (1990), Post-Graduate Museology Diploma UP (1979), generalist heritage management specialist with experience in museums and heritage since 1983
1.12.3	Relevant experience in study area	Heritage survey of Modjadjiskloof (2007), assistance to Tsonga Kraal Open-Air Museum near Letsetele
1.12.4	Telephone number	(082) 577-4741
1.12.5	Fax number	(086) 612-7383
1.12.6	E-mail	cultmat@iafrica.com

2. DEVELOPMENT CONTEXT

2.1 Development site/area location and boundaries

The proposed water treatment plant site is located east of the R 575 (the road between Vandyksdrift and Kriel) in the north-western corner of the farm Hartbeestfontein 339 JS, and the pipeline is located on the farms Goedehoop 315 JS and Rietfontein 314 JS. Access to the sites is from the R 575.

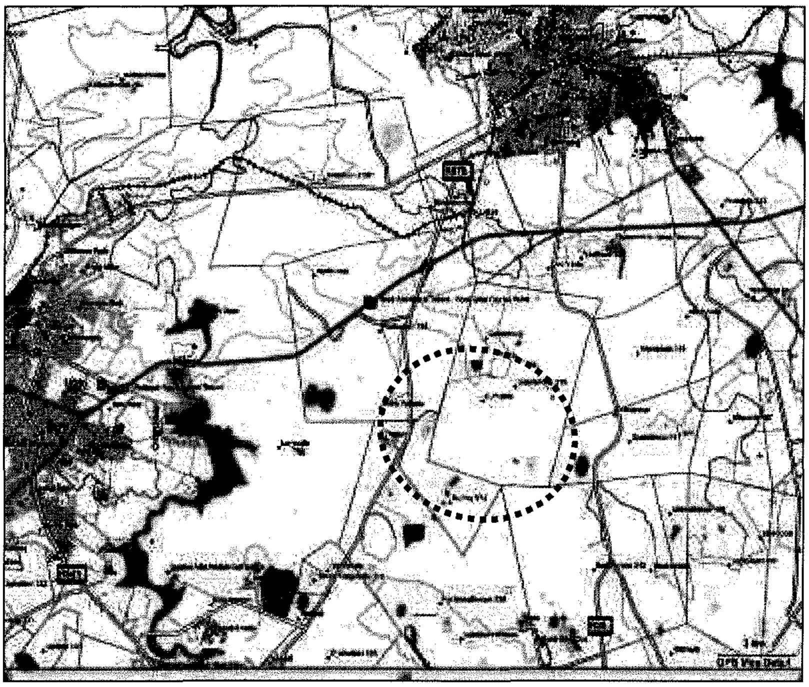


FIGURE 1: General location of the study area – Middelburg is at the top

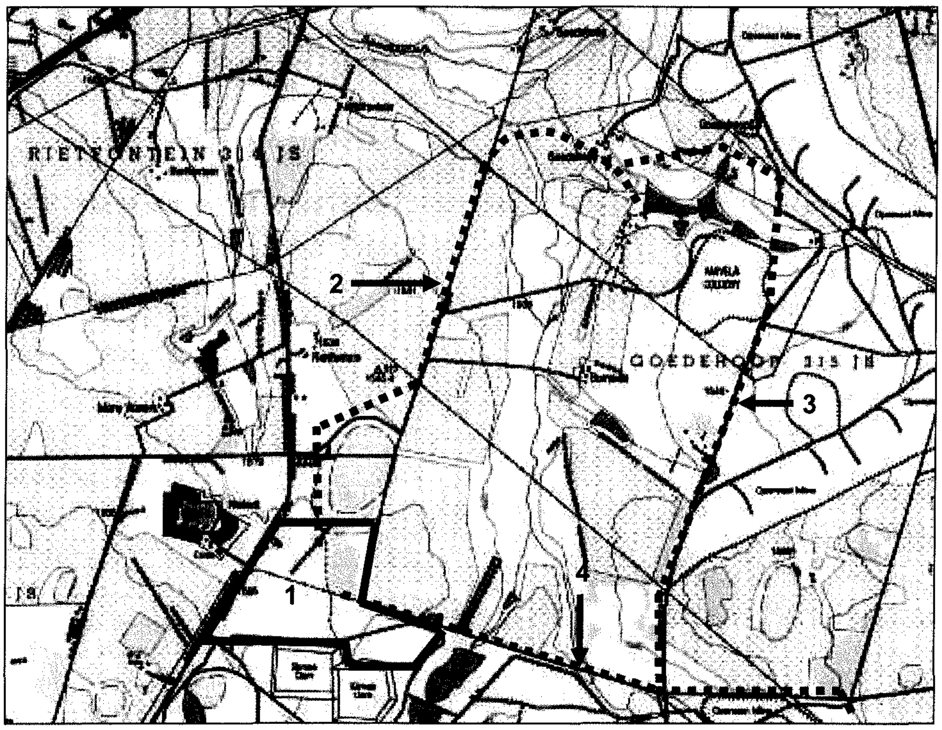


FIGURE 2: Section of 2529 CD Middelburg (1996) indicating the treatment plant site (1), the Alternative 1 pipeline (2), the Alternative 2 pipeline (3) and the Klipfontein pipeline (4)

FIGURE 3: Google Earth image (2009) of the general development area indicating the treatment plant site (yellow), the plant/dam and waste disposal sites (white), the Alternative 1pipeline alignment (black), the Alternative 2 pipeline alignment (blue)and the Klipfontein pipeline alignment (green)

2.2 Description of distinguishing regional features

2.2.1 Environmental features

TABLE 3: Environmental features

COMPONENT	DESCRIPTION
Acocks veld type	Bankenveld
Geological and mining	Coal and borrow pits
Geology	Arenite, tillite, rhyolite
Hydrology	Spookspruit and drainage lines, natural pans
Land cover	Grass land and cultivated land
Land use	Mixed farming
Vegetation	Moist sandy Highveld grass land
Slope	0-9%
Terrain morphology	Slightly irregular undulating plains
Wetlands	Along rivers, pans

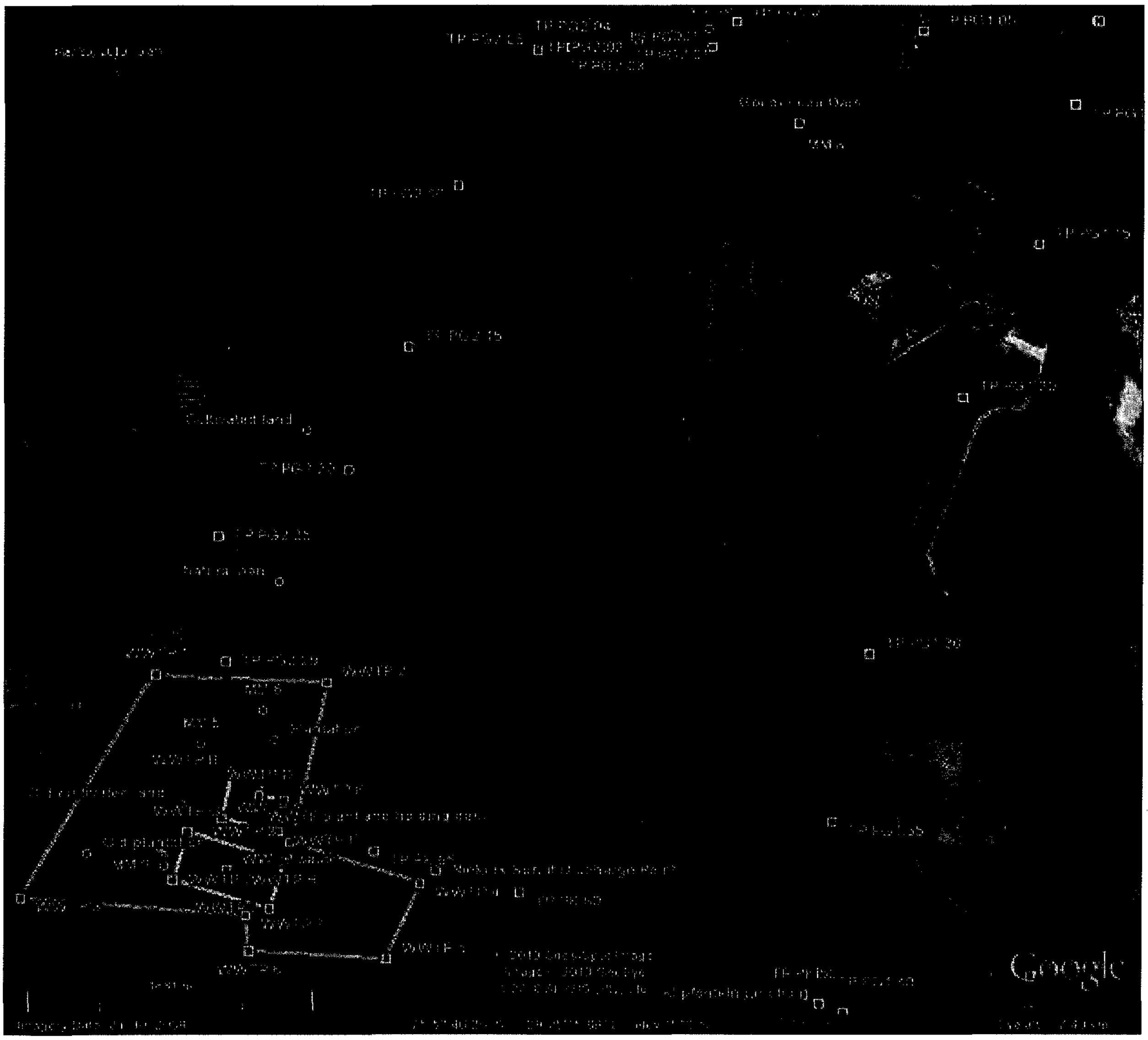


FIGURE 4: Google Earth image (2009) indicating the treatment plant site and the two alternative pipelines, a section of the Klipfontein pipeline and the location of the Niekerk Spruit Discharge Point

2.2.2 Heritage features

TABLE 4: Heritage features

S 3(2) NHRA heritage resource	DESCRIPTION
Buildings, structures, places and equipment of cultural significance	Tracks, fences, roads, dams, farmsteads, homesteads, cemeteries, power lines, wind pumps, cultivated land, car wrecks
Areas to which oral traditions are attached or which are associated with intangible heritage	None
Historical settlements and landscapes	Naledi Village (west of R 575)
Landscapes and natural features of cultural significance	Streams and pans
Geological sites of scientific or cultural importance	None

S 3(2) NHRA heritage resource	DESCRIPTION
Archaeological and palaeontological sites	Broader area is known for Stone Age artefacts and Iron Age finds and sites
Graves and burial grounds	Cemetery
Areas of significance related to labour history	None
Movable objects	None

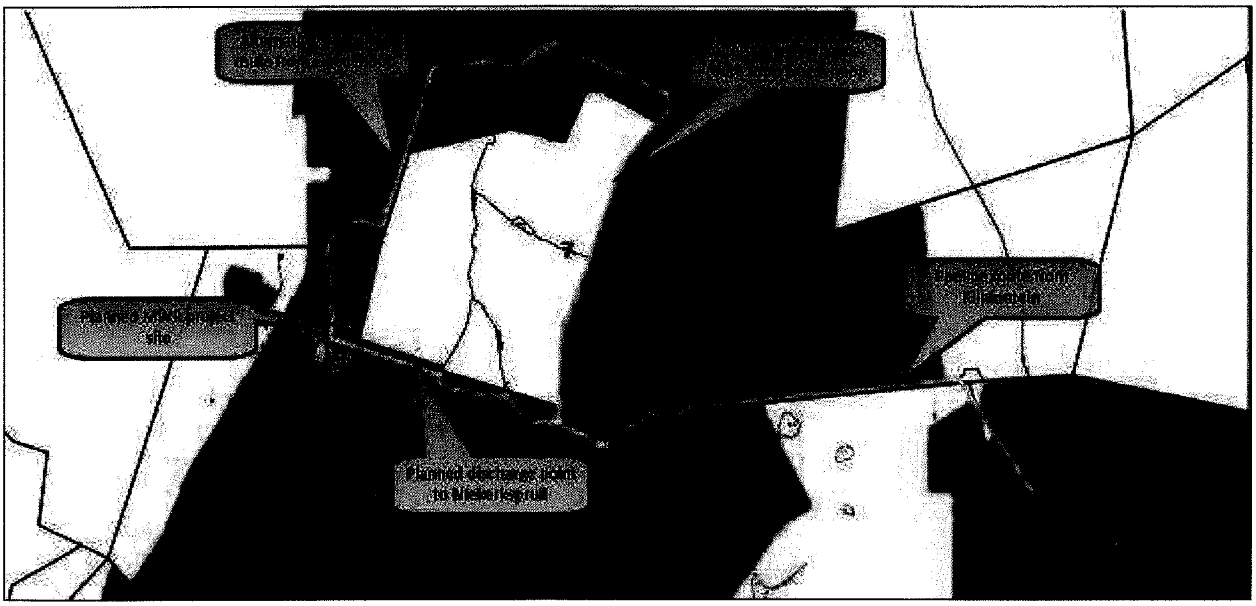


FIGURE 5: Schematic map indicating the various pipelines and the MWRP treatment plant as well as the discharge point

2.2.3 Description of development site

The **Alternative 1 pipeline** begins at the Goedehoop Dam, runs north-west past a homestead ruin (MM 10) and the turns west to cross the Spookspruit, where it turns south-west to cross farm land (crops and grazing areas) to a point north of a natural pan, where it turns south and runs through the remains of a eucalyptus plantation, ending at the treatment plant site.

The **Klipfontein pipeline** starts at the Rondeboschje Dam and traverses in a westerly direction through existing and former cultivated farm land, old grazing land and wetlands alongside farm roads and tracks, ending at the treatment plant site.

The **Alternative 2 pipeline** begins at the Goedehoop Dam and turns south, bypassing the Mavela Colliery and traversing existing and former cultivated and grazing land along a former mine service or haul road to a point where it meets the Klipfontein pipeline, where turns west to end at the treatment plant site.

The **Niekerk Spruit Discharge Point** (25°54'53.16"S 29°24'46.35"E) is located on the no rthern boundary of the Hartbeesfontein Section at a point between an old slimes dam and an old farm dam in the Spruit. This discharge point is fed by a separate pipeline.

As a cultural landscape this environment can be classified as a combination of a historic farming landscape and relic farming landscape, displaying the following typical features:

- Tracks and fences
- Gravel roads
- Grazing areas (existing and former)
- Cultivated land (existing and former)
- Power lines

- Farmsteads and homesteads
- Farm cemeteries
- Dams, wind pumps and boreholes
- Exotic vegetation
- Vacant abandoned land (grazing, old cultivated land, ruins, etc)

The co-ordinates of the Alternative 1 pipeline route are:[6]

TP PG001 25°52'15.10"S 29°25'45.10"E (Goedehoop Dam)
TP PG2 01 25°52'12.80"S 29°25'36.10"E
TP PG2 02 25°52'13.20"S 29°25'29.00"E
TP PG2 03 25°52'14.80"S 29°25'22.00"E
TP PG2 04 25°52'14.80"S 29°25'14.70"E
TP PG2 05 25°52'15.50"S 29°25'7.60"E
TP PG2 10 25°52'41.80"S 29°24'50.70"E
TP PG2 15 25°53'12.90"S 29°24'40.30"E
TP PG2 20 25°53'36.40"S 29°24'27.50"E
TP PG2 25 25°53'49.10"S 29°23'59.40"E
TP PG2 29 25°54'13.00"S 29°24'1.10"E (Treatment Pla nt)

The co-ordinates of the Alternative 2 pipeline route are:[7]

TP PG001 25°52'15.10"S 29°25'45.10"E (Goedehoop Dam)
TP PG1 01 25°52'10.40"S 29°25'50.30"E
TP PG1 05 25°52'12.40"S 29°26'30.20"E
TP PG1 10 25°52'26.70"S 29°27'2.40"E
TP PG1 15 25°52'53.40"S 29°26'54.80"E
TP PG1 20 25°53'22.70"S 29°26'38.60"E
TP PG1 30 25°54'11.60"S 29°26'18.90"E
TP PG1 35 25°54'43.60"S 29°26'10.80"E
TP PG1 40 25°55'12.90"S 29°26'9.20"E
Junction with Klipfontein pipeline 25°55'18.90"S 29 °26'8.39"E

The co-ordinates of the Klipfontein pipeline are:[8]

TP PK 01 25°55'53.22"S 29°30'39.16"E (Klipfontein S ection)
TP PK 10 25°55'9.62"S 29°30'10.26"E
TP PK 15 25°54'55.96"S 29°29'42.96"E
TP PK 30 25°55'6.33"S 29°27'55.75"E
TP PK 40 25°55'13.18"S 29°26'53.09"E
TP PK 45 25°55'23.92"S 29°26'28.75"E
TP PK 48 25°55'20.68"S 29°26'13.58"E
TP PK 50 25°55'17.17"S 29°26'5.14"E
TP PK 60 25°54'57.49"S 29°25'4.11"E
TP PK 65 25°54'49.42"S 29°24'33.12"E
TP PK end 25°54'44.15"S 29°24'11.34"E (Treatment Pl ant)

The co-ordinates of the treatment plant site are:[9]

WWTP 1 25°54'15.47"S 29°23'46.21"E
WWTP 2 25°54'16.99"S 29°24'22.98"E
WWTP 3 25°54'47.54"S 29°24'15.09"E
WWTP 4 25°54'55.61"S 29°24'42.94"E
WWTP 5 25°55'10.14"S 29°24'35.81"E
WWTP 6 25°55'8.30"S 29°24'6.30"E
WWTP 7 25°55'1.50"S 29°24'5.57"E
WWTP 8 25°54'57.95"S 29°23'17.89"E

[6] Provided by Jones & Wagener
[7] Provided by Jones & Wagener
[8] Provided by Jones & Wagener
[9] Created by the author

2.2.4 Surrounding environment

AREA	DESCRIPTION
East	Farm land and collieries
North	Farm land
West	R 575 road
South	Farm land and Middelburg Mine

2.3 Development description

2.3	Development description	
2.3.1	Nature of proposed development	See below
2.3.2	Predicted impacts on heritage value of site and contents	None, except possibly for impacts on hidden (buried) heritage features and Site MM 6
2.3.3	Structures older than 60 years affected by proposed development	Site MM 6 (possible)
2.3.4	Rezoning or change of land use	No
2.3.5	Construction work	Yes
2.3.6	Total floor area of proposed development	-
2.3.7	Extent of land coverage of development	6 km pipeline, 27860 sq m treatment plant, 55469 sq m holding dam, 177364 sq m waste disposal area
2.3.8	Earth moving and excavation	Yes
2.3.9	Number of storeys	Immaterial
2.3.10	Maximum height above ground level	Immaterial
2.3.11	Monetary value development	Not available
2.3.12	Time frames	Urgent

The water treatment facility will treat all excess mine water produced by Middelburg Mine's North – and Klipfontein Sections to catchment standards for release into the catchment. As part of the study, it is necessary to determine the environmental impacts associated with this project to ultimately determine the feasibility thereof. This will entail doing a detailed Environmental Impact Assessment (EIA) of the proposed project, developing project specific Environmental Management Programme's (EMP), undertaking a water permit application process, developing an Integrated Water and Waste Management Plan (IWWMP) for the scheme, undertaking Water Use Licence Application's (WULA) for the scheme, updating the Integrated Water Use Licences, and obtaining the necessary environmental authorisations in terms of other legislation.

The original intention was to collect and treat excess mine water at a treatment plant site located east of the R 575 (the road between Vandyksdrift and Kriel) in the north-western corner of the farm Hartbeestfontein 339 JS. This plant would discharge the water to the Spookspruit via a pipeline (Klipfontein pipeline) that would connect with the mine's Klipfontein Section to the east, branching off to the north via another pipeline (Alternative 2) that would run along a farm road traversing Goedehoop farm past the Mavela Mine, connecting with the Spookspruit near Goedehoop Dam. In April 2009 Cultmatrix prepared and submitted a Heritage Impact Assessment report in connection with the proposed pipelines and treatment plant.

Because of issues related to the location of this pipeline, an alternative and shorter pipeline (Alternative 1) was proposed later, situated further to the west and located on farm land (cultivated and grazing) on the farms Rietfontein 314 JS and Goedehoop 315 JS, thereby avoiding the mine property that would be traversed by Alternative 2. In addition, it was proposed to enlarge the treatment plant site by extending it to the south in order to locate the plant itself, its holding dam and its waste disposal site further away from a sensitive natural pan, situated immediately north of the original treatment plant site, closer to less sensitive old mining land characterised by slimes dams and other features.

FIGURE 6: General impression of the landscape to be traversed by the pipelines

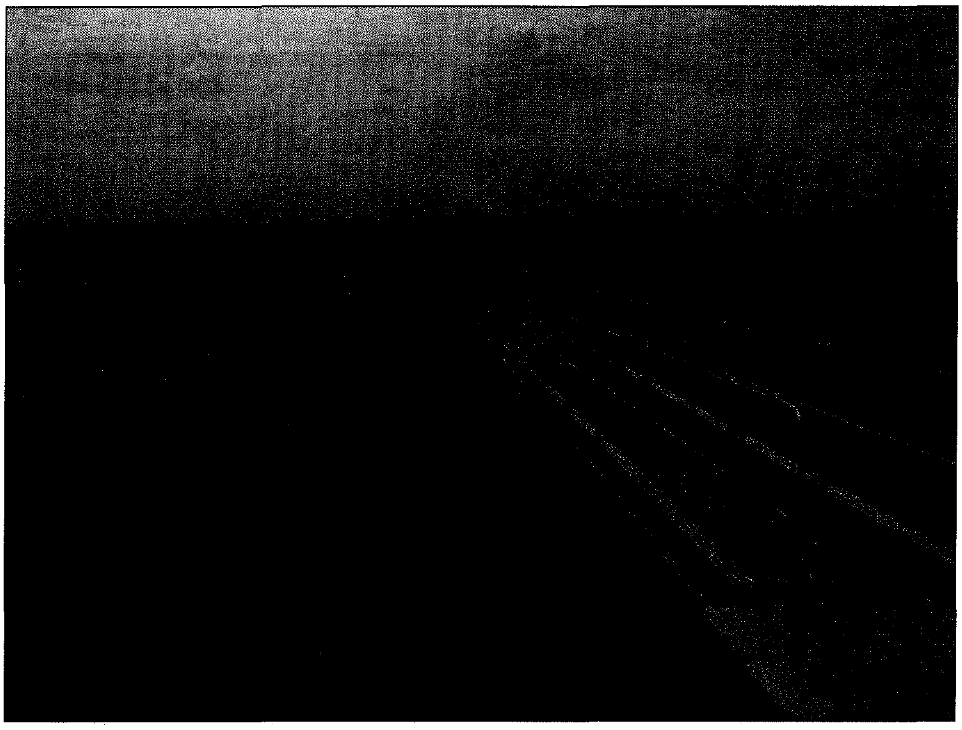


FIGURE 7: Goedehoop Dam

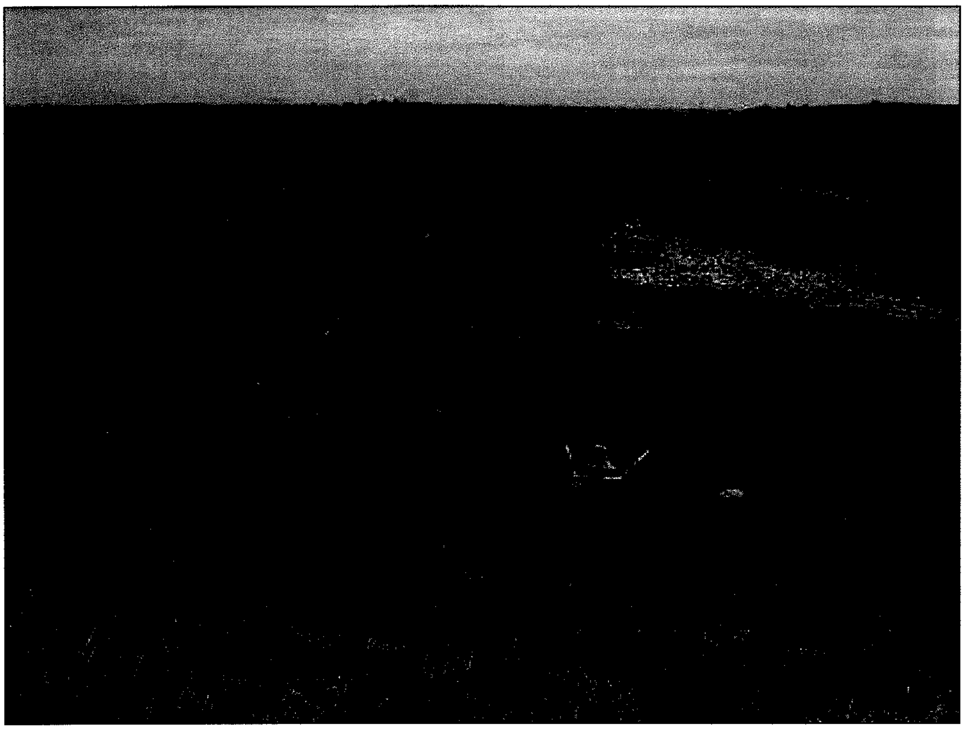


FIGURE 8: Degraded area west of Goedehoop Dam

FIGURE 9: General impression of the treatment plant site

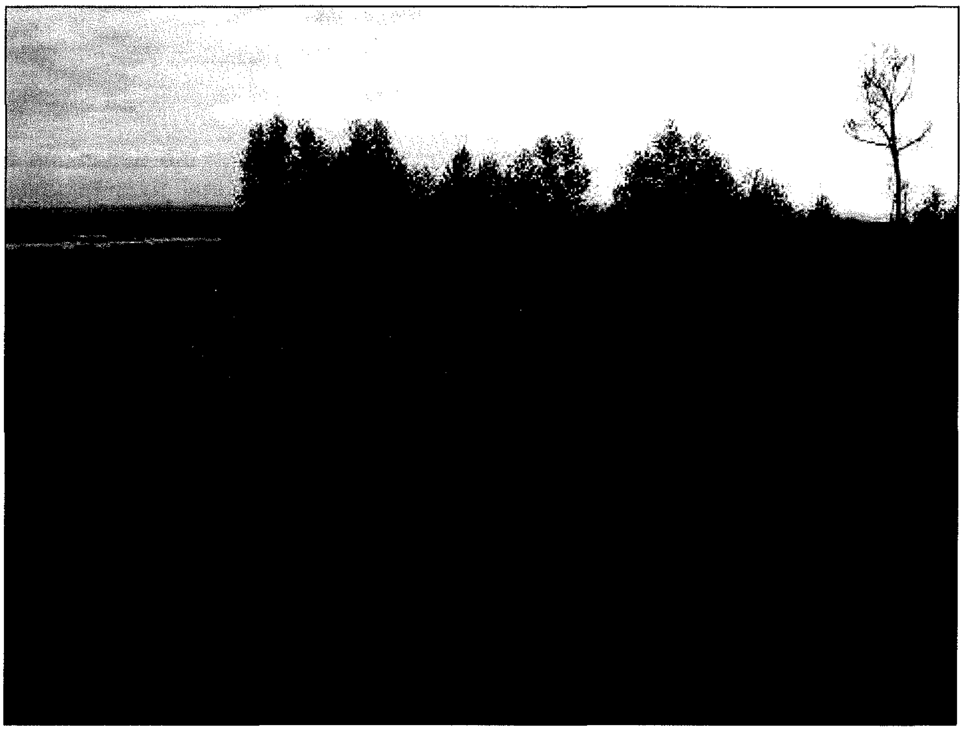


FIGURE 10: General impression of the treatment plant site with one of the many car wrecks that litter the areas and the pan in the left distance

3. HERITAGE IMPACT CONTEXT

3.1 Cultural landscape evidence

The concept of cultural landscapes is of more recent origin and, although the definitions of the National Heritage Resources Act bear reference, is primarily grounded in international doctrinal texts in the form of Charters and Recommendations produced by ICOMOS and UNESCO. The most recent and authoritative text is the World Heritage Cultural Landscapes handbook, published by the World Heritage Centre (2009).

The term "cultural landscape" embraces a diversity of manifestations of the interaction between humankind and its natural environment. Cultural landscapes often reflect specific techniques of sustainable *land-use*, considering the characteristics and limits of the natural environment they are established in, and a specific spiritual relation to nature. Cultural landscapes are illustrative of the evolution of human society and settlement over time, under the influence of the physical constraints and/or opportunities presented by their natural environment and of successive social, economic and cultural forces, both external and internal. They are categorized on the basis both of their value and of their representativity in terms of a clearly defined geo-cultural *region* and also for their capacity to illustrate the essential and distinct cultural elements of such regions. The term "cultural landscape" embraces a diversity of manifestations of the interaction between humankind and its natural environment.

The World Heritage Committee distinguishes between three categories of cultural landscapes:

- Clearly defined landscapes, designed and created intentionally by people, such as parkland and urban areas
- Organically evolved landscapes that has developed over time, including relic landscapes (where a certain activity has ceased to exist) and continuing landscapes (which retain an active social role and where the evolutionary process is still in progress)
- Associative landscapes, which are essentially natural landscapes with significant human associations in the realm of the intangible heritage

All three categories exist in the study area. However, they are too broad in terms of the practical mapping and assessment of heritage elements; hence, the following criteria for classifying the type of cultural landscape have been used:

TABLE 5: Cultural landscape classification

HERITAGE LANDSCAPE CONTEXT	ELEMENTS	EVIDENCE
A. PALAEONTOLOGICAL LANDSCAPE CONTEXT	Fossil remains. Such resources are typically found in specific geographical areas, e.g. the Karoo and are embedded in ancient rock and limestone/calcrete formations.	None
B. ARCHAEOLOGICAL LANDSCAPE CONTEXT	Archaeological remains dating to the following periods: • Early Stone Age • Middle Stone Age • Late Stone Age • Early Iron Age • Late Iron Age • Historical	None
C. HISTORICAL BUILT URBAN LANDSCAPE CONTEXT	• Historical townscapes/streetscapes • Historical structures; i.e. older than 60 years • Formal public spaces • Formally declared urban conservation areas • Places associated with social identity/displacement	None

HERITAGE LANDSCAPE CONTEXT	ELEMENTS	EVIDENCE
[redacted]		
E. HISTORICAL RURAL TOWN CONTEXT	• Historical mission settlements • Historical townscapes	None
F. PRISTINE/NATURAL LANDSCAPE CONTEXT	• Historical patterns of access to a natural amenity • Formally proclaimed nature reserves • Evidence of pre-colonial occupation • Scenic resources, e.g. view corridors, viewing sites, visual edges, visual linkages • Historical structures/settlements older than 60 years • Pre-colonial or historical burial sites • Geological sites of cultural significance.	None
[redacted]		
H. BURIAL GROUND & GRAVE SITE CONTEXT	• Pre-colonial burials (marked or unmarked, known or unknown) • Historical graves (marked or unmarked, known or unknown) • Human remains (older than 100 years) • Associated burial goods (older than 100 years) • Burial architecture (older than 60 years)	None
I. ASSOCIATED LANDSCAPE CONTEXT	• Sites associated with living heritage e.g. initiation sites, harvesting of natural resources for traditional medicinal purposes • Sites associated with displacement & contestation • Sites of political conflict/struggle • Sites associated with an historic event/person • Sites associated with public memory	None
J. HISTORICAL FARM WERF CONTEXT	• Setting of werf and its context • Composition of structures • Historical/architectural value of individual structures • Tree alignments • Views to and from • Axial relationships • System of enclosure, e.g. werf walls • Systems of water reticulation and irrigation, e.g. furrows • Sites associated with slavery and farm labour • Colonial period archaeology	None
K. HISTORICAL INSTITUTIONAL LANDSCAPE CONTEXT	• Historical prisons • Hospital sites • Historical school/reformatory sites • Military bases	None
L. SCENIC/VISUAL	• Scenic routes	None

HERITAGE LANDSCAPE CONTEXT	ELEMENTS	EVIDENCE
K. AMENITY LANDSCAPE CONTEXT	• View sheds • View points • Views to and from • Gateway conditions • Distinctive representative landscape conditions • Scenic corridors	

3.2 Determining levels of sensitivity and potential impacts

Sensitivity is the ability of a cultural landscape (or heritage resource) to absorb changes or adapt to changes whilst maintaining an acceptable degree of cultural significance.

Within the context of this study, levels of sensitivity can generally be associated with certain classes or categories of cultural landscapes as tabulated below.

TABLE 6: Relationship between cultural landscape classes and levels of sensitivity

Sensitivity level	Implication	Landscape class	Evidence
[redacted]			
C	Ability to absorb with some adverse effects and some mitigation	Historical farm werfs Institutional landscapes	Of medium to low intrinsic, associational or contextual heritage value within a national, provincial and local context
B	Ability to absorb with considerable adverse effects and intensive mitigation	Burial grounds and graves Palaeontological and archaeological landscapes Associated landscapes	Of moderate to high intrinsic, associational and contextual value within a local context
A	No or very little ability to absorb	Historical built environments Natural landscapes Amenity/Visual/Scenic landscapes	Of high intrinsic, associational and contextual heritage value within a national, provincial and local context

3.3 Determining potential impacts

TABLE 7: Categories of development types

CATEGORY	DESCRIPTION	EVIDENCE
A: Minimal intensity development	• No rezoning involved; within existing use rights • No subdivision involved • Upgrading of existing infrastructure within existing envelopes • Minor internal changes to existing structures • New building footprints limited to less than 1000m2	No
B: Low-intensity development	• Spot rezoning with no change to overall zoning of a site • Linear development less than 100m • Building footprints between 1000m2-2000m2 • Minor changes to external envelop of existing structures (less than 25%) • Minor changes in relation to bulk and height of immediately adjacent structures (less than 25%).	No
[redacted]		

CATEGORY	DESCRIPTION	EVIDENCE
D: High intensity development	• Rezoning of a site in excess of 10 000m2 • Linear development in excess of 300m • Any development changing the character of a site exceeding 5000m2 or involving the subdivision of a site into three or more erven • Substantial increase in bulk and height in relation to immediately adjacent buildings (more than 100%)	None

3.4 Expected impact significance

TABLE 8: Expected impact significance matrix

HERITAGE CONTEXT	TYPE OF DEVELOPMENT			
	CATEGORY A	CATEGORY B	CATEGORY C	CATEGORY D
A: High heritage value	Moderate heritage impact expected	High heritage impact expected	Very high heritage impact expected	Very high heritage impact expected
B: Medium to high heritage value	Minimal heritage impact expected	Moderate heritage impact expected	High heritage impact expected	Very high heritage impact expected
C: Medium to low heritage value	Little or no heritage impact expected	Minimal heritage impact expected	Moderate heritage impact expected	High heritage impact expected
D: Low heritage value	Little or no heritage impact expected	Little or no heritage impact expected	[redacted]	Moderate heritage impact expected

4. HERITAGE IMPACT ASSESSMENT

4.1 Approach

4.1.1 Definitions and assumptions

The following aspects have a direct bearing on the investigation and the resulting report:

- *Cultural (heritage) resources* are all non-physical and physical human-made occurrences, as well as natural occurrences that are associated with human activity. These include all sites, structures and artefacts of importance, either individually or in groups, in the history, architecture and archaeology of human (cultural) development.

- The *cultural significance* of sites and artefacts is determined by means of their historical, social, aesthetic, technological and scientific value in relation to their uniqueness, condition of preservation and research potential. It must be kept in mind that the various aspects are not mutually exclusive, and that the evaluation of any site is done with reference to any number of these.

- The *value* is related to concepts such as *worth*, *merit*, *attraction* or *appeal*, concepts that are associated with the (current) usefulness and condition of a place or an object. Hence, in the development area, there are instances where elements of the place have a high level of significance but a lower level of value.

- It must be kept in mind that significance and value are not mutually exclusive, and that the evaluation of any feature is based on a combination or balance between the two.

- Isolated occurrences: findings of artefacts or other remains located apart from archaeological sites. Although these are noted and samples are collected, it is not used in impact assessment and therefore do not feature in the report.

- Traditional cultural use: resources which are culturally important to people.

- All archaeological remains, artificial features and structures older than 100 years and historic structures older than 60 years are protected by the relevant legislation, in this case the National Heritage Resources Act (NHRA) (Act No. 25 of 1999). No archaeological artefact, assemblage or settlement (site) and no historical building or structure older than 60 years may be altered, moved or destroyed without the necessary authorisation from the South African Heritage Resources Agency (SAHRA) or a provincial heritage resources authority. Full cognisance is taken of this Act in making recommendations in this report.

- The guidelines as provided by the NHRA (Act No. 25 of 1999) in Section 3, with special reference to subsection 3, and the Australian ICOMOS Charter (also known as the Burra Charter) are used when determining the cultural significance or other special value of archaeological or historical sites.

- It should be kept in mind that archaeological deposits usually occur below ground level. Should artefacts or skeletal material be revealed at the site during construction, such activities should be halted, and it would be required that the heritage consultants would be required to be notified in order for an investigation and evaluation of the find(s) to take place (*cf.* NHRA (Act No. 25 of 1999), Section 36 (6)).

4.1.2 Limiting/Restricting factors

The investigation has been influenced by the following factors related to the overall HIA:

- Unpredictability of buried archaeological remains (absence of evidence does not mean evidence of absence)

4.1.3 Field work

This was done through foot and vehicle investigations of the study area in November 2010. During the site inspection the respective properties were examined in some detail, in particular the pipeline corridor and the plant, holding dam and waste disposal areas. Certain parts of the landscape were found generally to exhibit low archaeological visibility and were checked at random intervals, while features in the respective landscapes that were more likely to have been foci for past human activity (e.g drainage lines, clumps of trees) were assessed more systematically. The archaeological visibility varied from good (grazing areas) to poor (dense grass cover on treatment plant area).

4.1.4 Desktop study

- Published literature
- Unpublished reports
- Aerial images (contemporary and historical)
- Maps (historical and contemporary)
- Internet sources

4.1.5 Verbal information

- Mr Christo Maree, Middelburg Mine

4.2 General issues of site and context

4.2.1 Context		
	(check box of all relevant categories)	*Brief description/explanation*
	Urban environmental context	• Roads • Fences • Tracks • Power lines • Farmsteads
x	Rural environmental context	
	Natural environmental context	
Formal protection (NHRA)		
	Is the property part of a protected area (S. 28)?	No
	Is the property part of a heritage area (S. 31)?	No
Other		
	Is the property near to or visible from any protected heritage sites?	No
	Is the property part of a conservation area or special area in terms of the Zoning Scheme?	No
	Does the site form part of a historical settlement or townscape?	No
x	Does the site form part of a rural cultural landscape?	Farm land
	Does the site form part of a natural landscape of cultural significance?	No
	Is the site within or adjacent to a scenic route?	No
x	Is the property within or adjacent to any other area which has special environmental or heritage protection?	Spookspruit and natural pans
	Does the general context or any adjoining properties have cultural significance?	No

4.2.2 Property features and characteristics		
	(check box if YES)	*Brief description*
x	Have there been any previous development impacts on the property	Yes: Roads, tracks, grazing land, pastures, fences, power lines, farmsteads, etc.
	Are there any significant landscape features on the property?	No
	Are there any sites or features of geological significance on the property?	No
	Does the property have any rocky outcrops on it?	No
x	Does the property have any fresh water sources (springs, streams, rivers) on or alongside it?	Spookspruit and drainage lines, natural pan, wetlands, dams
	Does the property have any sea frontage?	No
	Does the property form part of a coastal dune system?	No
	Are there any marine shell heaps or scatters on the property?	No
	Is the property or part thereof on land reclaimed from the sea?	No

4.2.3 Heritage resources on the property		
	(check box if present on the property)	*Name / List / Brief description*
Formal protections (NHRA)		
	National heritage site (S. 27)	No
	Provincial heritage site (S. 27)	No
	Provisional protection (s.29)	No
	Place listed in heritage register (S. 30)	No
General protections (NHRA)		
x	structures older than 60 years (S. 34)	Possible (Site MM 6)
x	archaeological site or material (S. 35)	Possible (chance finds)
	palaeontological site or material (S. 35)	No
x	graves or burial grounds (S. 36)	GY 1
	public monuments or memorials (S. 37)	No
Other		
	Any heritage resource identified in a heritage survey (state author and date of survey and survey grading/s)	No
	Any other heritage resources (describe)	No

4.2.4 Property history and associations		
	(check box if YES)	*Brief description/explanation*
x	Provide a brief history of the property (e.g. when granted, previous owners and uses).	See Appendix 1
	Is the property associated with any important persons or groups?	No
	Is the property associated with any important events, activities or public memory?	Yes: SPE Trichardt (farm Goedehoop), prominent farmer in Middelburg district and commanding officer of ZAR State Artillery

4.2.4 Property history and associations		
	Does the property have any direct association with the history of slavery?	No
	Is the property associated with or used for living heritage?	No
	Are there any oral traditions attached to the property?	No

4.3 Summarised identification and significance assessment of heritage resources

See Appendix 3 for significance assessment criteria

TABLE 9: Identification and significance assessment of heritage features

S 3(2) NHRA heritage resource category	ELEMENTS	INDICATORS OF HERITAGE SIGNIFICANCE										CUMULATIVE SIGNIFICANCE RATING (TOTAL 30) 1-9 = Low 10-19 = Medium 20-30 = High
		HISTORICAL	RARE	SCIENTIFIC	TYPICAL	AESTHETIC	TECHNOLOGICAL	PERSON COMMUNITY	LANDMARK	MATERIAL CONDITION	SUSTAINABILITY	
Buildings, structures, places and equipment of cultural significance	Sites MM 5, 6, 9	1	0	0	1	0	0	3	0	1	0	6 = Low local
Areas to which oral traditions are attached or which are associated with intangible heritage	None	-	-	-	-	-	-	-	-	-	-	-
Historical settlements and landscapes	None	-	-	-	-	-	-	-	-	-	-	-
Landscapes and natural features of cultural significance	Pan	1	0	1	2	1	0	0	1	1	1	8 = Low local
Geological sites of scientific or cultural importance	None	-	-	-	-	-	-	-	-	-	-	-
Archaeological and palaeontological sites	Chance finds	-	-	-	-	-	-	-	-	-	-	Unknown (Early Iron Age burial pits that may be discovered would be of high regional significance)
Graves and burial grounds	MM 8	2	1	0	1	0	0	3	1	1	1	10 = Medium local
Areas of significance related to labour history	None	-	-	-	-	-	-	-	-	-	-	-
Movable objects	None	-	-	-	-	-	-	-	-	-	-	-

4.4 Impact assessment

4.4.1 Sites MM 5, 6, 9

S 3(2) NHRA heritage resource	(a) Identification		(b) Significance	(c) Impact		(d) Recommended impact management
	Site	GPS		Study area	Impact type, certainty and significance	
Buildings, structures, places and equipment of cultural significance	MM 5[10]	25°54'28.70"S 29°23'55.80"E	Low local	WWTP site	Neutral (outside pipeline alignment and plant site)	Ruin. No action.
	MM 6	25°54'22.30"S 29°24'9.10"E	Low local	WWTP site	Probably neutral, depending on final pipeline alignment	Homestead ruin with old rubbish dump and car wrecks. Sample (excavate) dump and document ruin before destruction should it be negatively affected by the Alternative 1 pipeline alignment, otherwise no action.
	MM 9	25°54'51.90"S 29°23'48.14"E	Low local	WWTP	Probably neutral (just outside waste site)	Old borrow pit. No action.

[10] Includes sites identified in the April 2009 HIA report

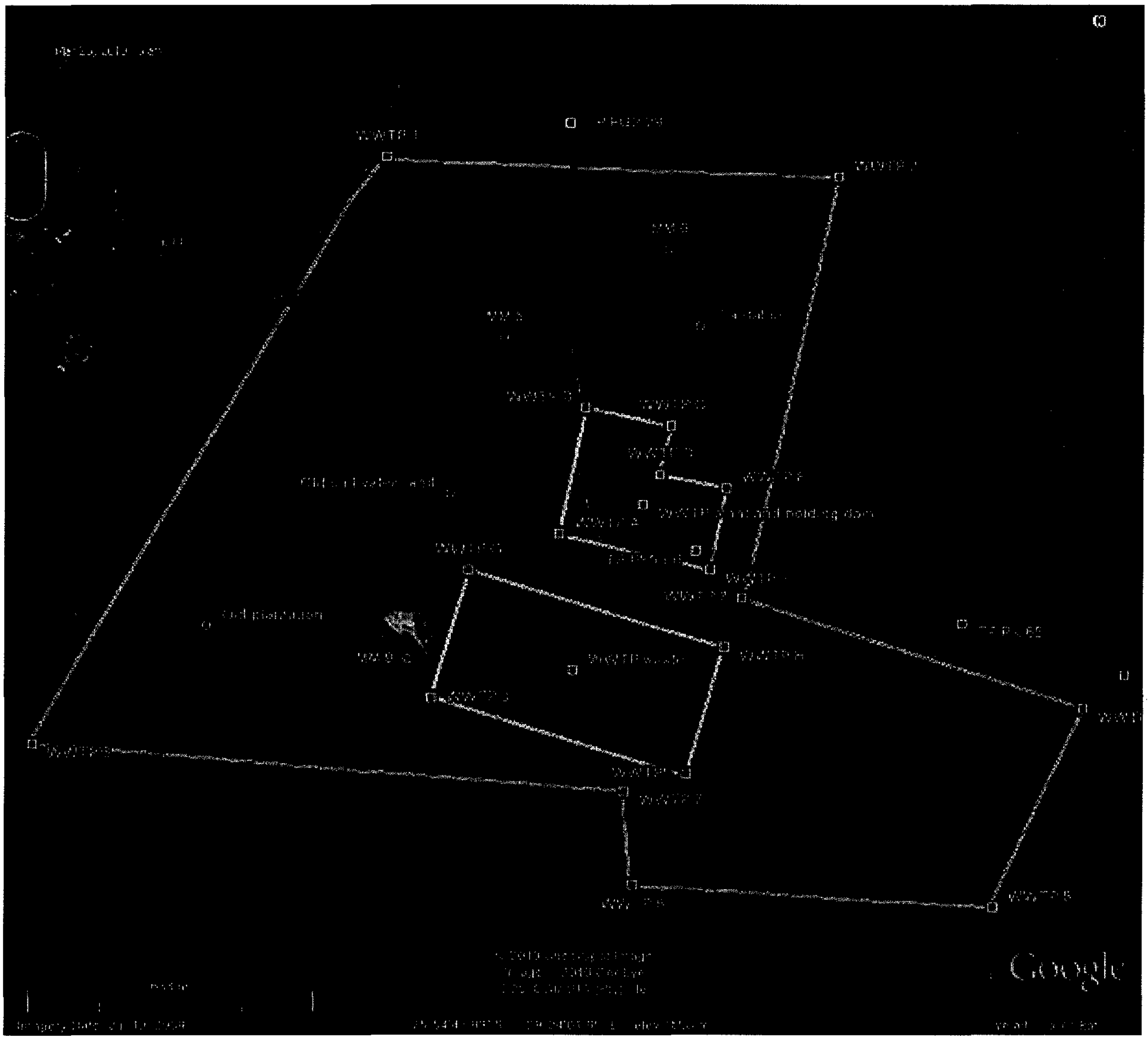


FIGURE 11: Google Earth image (2009) of the treatment plant area indicating the locations of MM 5, 6 and 9

FIGURE 12: Site MM 5. This photo was taken in 2008 and in 2010 hardly anything was visible.

FIGURE 13: Site MM 6 (2008)

4.4.2 Sites MM 8, 10

S 3(2) NHRA heritage resource	(a) Identification		(b) Significance	(c) Impact		(d) Recommended impact management
	Site	GPS		Study area	Impact type, certainty and significance	
Buildings, structures, places and equipment of cultural significance	MM 10	25°52'11.54"S 29°25'44.29"E	Low local	Alternative 1 Pipeline	Probably neutral (outside alignment)	Remains of Goedehoop farmstead. Some parts could be 60 years and older. Document before destruction if unavoidable.
Graves and burial sites	MM 8	25°52'37.00"S 29°26'2.00"E	Medium local	Goedehoop Dam	Neutral	Farm cemetery, well outside pipeline corridor. No action.

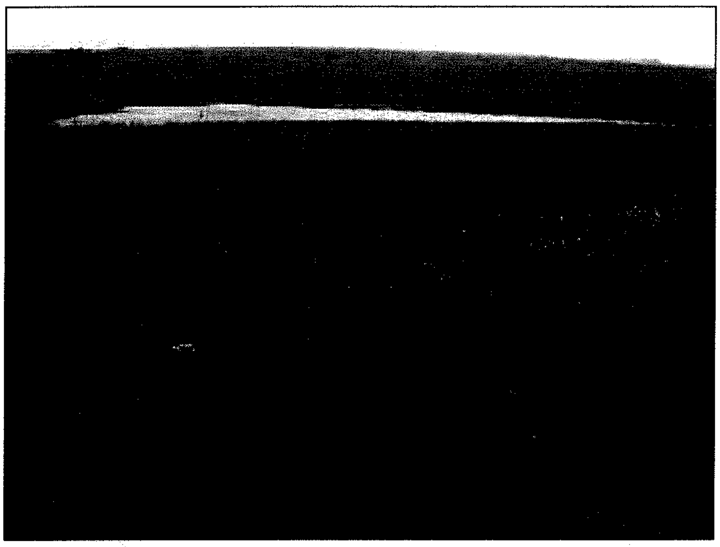


FIGURE 14: Site MM 8 (farm workers' cemetery), with the Goedehoop Dam in the distance (2006)

FIGURE 15: Google Earth image (2009) of the northern pipeline section indicating the locations of MM 8 and MM 10

4.4.3 Summarised impact assessment

TABLE 10: Identification of heritage features, impacts and impact management measures

S 3(2) NHRA heritage resource	(a) Identification		(b) Significance	(c) Impact		(d) Recommended impact management
	Site	**GPS**		**Study area**	**Impact type, certainty and significance**	
Buildings, structures, places and equipment of cultural significance	MM 5[11]	25°54'28.70"S 29°23'55.80"E	Low local	WWTP site	Neutral (outside pipeline alignment and plant site)	Ruin. No action.
	MM 6	25°54'22.30"S 29°24'9.10"E	Low local	WWTP site	Probably neutral, depending on final pipeline	Homestead ruin with old rubbish dump and car wrecks. Sample (excavate) dump and document ruin before

[11] Includes sites identified in the April 2009 HIA report

2) NHRA ritage source	(a) Identification		(b) Significance	(c) Impact		(d) Recommended impact management
	Site	**GPS**		**Study area**	**Impact type, certainty and significance**	
					alignment	destruction should it be negatively affected by the Alternative 2 pipeline alignment, otherwise no action.
	MM 9	25°54'51.90"S 29°23'48.14"E	Low local	WWTP	Probably neutral (just outside waste site)	Old borrow pit. No action.
	MM 10	25°52'11.54"S 29°25'44.29"E	Low local	Alternative 1 Pipeline	Probably neutral (outside alignment)	Remains of Goedehoop farmstead. Some parts could be 60 years and older. Document before destruction if unavoidable.
Areas to which oral traditions are attached or which are associated with intangible heritage	None	-	-	-	-	-
Historical settlements and landscapes	None	-	-	-	-	-
Landscapes and natural features of cultural significance	Natural pan	25°53'57.78"S 29°24'12.54"E	Unknown	Alternative 1 Pipeline and WWTP site	Neutral	Although no artefacts were found, natural pans often contain scattered deposits of Stone Age artefacts. The pan is a sensitive natural feature and falls outside the development areas.
Geological sites of scientific or cultural importance	None	-	-	-	-	-
Archaeological and palaeontological sites	Chance finds	Unknown	Low local?	WWTP and pipeline	Unknown (WWTP site and pipeline corridor are already transformed land)	Mitigation: Report and evaluate any graves or archaeological features and artefacts when found during site preparation work
Graves and burial sites	MM 8	25°52'37.00"S 29°26'2.00"E	Medium local	Goedehoop Dam	Neutral	Farm cemetery, well outside pipeline corridor. No action.
Features associated with labour history	None	-	-	-	-	
Movable objects	None	-	-	-	-	

4.5 Social and economic benefits

The development will have no direct benefits related to the conservation of heritage resources (structures) since none of significance that will be directly affected has been identified. However, if important archaeological features are exposed during site preparation activities, this may present an opportunity to conduct a Phase 2 (archaeological) investigation that may generate new information, before such features could be destroyed.

The project is part of a scheme to alleviate the critical shortage of water in the Middelburg area by collecting and treating excess mine water, an activity that in the long term will minimise pollution.

4.6 Consultation with affected communities

This is part of the EIA process. Reports that will be submitted to the heritage authorities must include the EIAs public participation reports.

4.7 Identification of other risk sources

The following project actions may impact negatively on any potential palaeontological and archaeological sites and remains.

The actions are likely to occur during the preparation phases of the proposed project:

- Earthworks and excavations may expose or uncover objects and artefacts and unmarked human burials.

4.8 Key mitigation and enhancement measures before and during construction

- Monitor for chance finds (e.g. burial sites, old waste disposal sites, artefacts)

4.9 Consideration of alternatives

The nature and significance of what has been found in terms of heritage is not of such importance that the proposed treatment plan location and Klipfontein pipeline alignment should be changed and that alternative sites should be considered.

Comparing the western (Alternative 1) and eastern (Alternative 2) pipelines connecting the treatment plant with the Spookspruit, the eastern pipeline (Alternative 2) is preferred since it will affect no heritage features in contrast to Alternative 1 that may affect two heritage features where mitigation could be required (namely the Goedehoop farmstead MM 10 and a homestead ruin MM 6).

4.10 Summarised findings and recommendations

The proposed water pipelines and treatment plant are located in a cultural landscape classified primarily as a combination of relic farm land and a historic farm land landscape. This type of landscape is of low heritage sensitivity because it is able to absorb new development with few adverse effects on heritage.

- The proposed original pipeline (Alternative 2) will traverse old farm land and run past a colliery and along an existing farm road. This pipeline will have no effect on any heritage features since these areas represent transformed land that would have destroyed any heritage features; hence, none were identified.
- The proposed alternative pipeline (Alternative 1) will traverse cultivated land (maize) and grazing areas, which represent transformed land that would have destroyed any heritage features, with the exception of the remains of the old Goedehoop farmstead (MM 10) and a ruin on the treatment plant site (MM 6), even though these features are of low cultural significance. Alternative 1 may affect these two heritage features.
- The Klipfontein pipeline will traverse former and existing farm land (cultivated and grazing) and will run past farm roads and mining land. All this represents transformed land that would have destroyed any heritage features; hence, none were identified.
- The proposed treatment plant will be located on environmentally degraded land, characterised by heritage features such as ruins (MM 5), old cultivated and grazing land, an old borrow pit (MM 9) and the remains of eucalyptus plantations. These features are of low cultural significance and any direct impacts will therefore be very low.

Visual impacts are of less importance because the general environment has already been visually transformed by development (mining, power generation and transmission, farming), implying that the proposed development will not imply a visual intrusion into the cultural landscape. Noise, dust, pollution and restrictions of access patterns as indirect impacts are also not issues, except during installation work.

From a historic built environment perspective no features of real heritage significance were identified and those features that are extant (bordering on the western pipeline corridor) are of fairly recent origin and of low cultural significance.

From an archaeological perspective no finds or artefacts of significance were identified.

Cultmatrix states that there are no compelling reasons not to approve either of the proposed alternative pipelines (although preference is given to Alternative 2), the Klipfontein pipeline, the Niekerk Spruit Discharge Point and the treatment plant and that the project can continue provided that the following mitigation measures are adopted in order to minimise adverse impacts:

1. Should any hidden human remains be disturbed, exposed or uncovered during site clearing and excavations, these should immediately be reported to an archaeologist. Burial remains should not be disturbed or removed until inspected by an archaeologist.
2. Site preparation activities must also be monitored for the occurrence of any hidden archaeological material (Stone Age tools, potsherds) and similar chance finds (such as historic middens and foundations) and if any are exposed, this should be reported to an archaeologist so that an investigation and evaluation of the finds can be made.
3. Should Alternative 1 be selected, the homestead ruin and rubbish dump (MM 6) should be documented and sampled (excavated) in case they will be affected and should therefore be destroyed.
4. Should Alternative 2 be selected, the remains of the Goedehoop farmstead should be documented in case it will be affected and therefore will be destroyed.

APPENDIX 1: SOCIO-CULTURAL HISTORY OF DEVELOPMENT AREA

Early Stone Age

In South Africa the ESA dates from about 2 million to 250 000 years ago, from the early to middle Pleistocene. Over this time, the archaeological evidence shows, as our early ancestors advanced physically, mentally and socially they invented stone and bone tools and learned to control fire and exploit natural resources effectively. The earliest tools clearly manufactured by our ancestors and their relatives (early hominids) date to 2,5 million years ago, from the site of Gona in Ethiopia. These tools showed that early hominids were able to select a suitable raw material and flake it for a specific purpose. As many of the bones found in association with early tools bear cut marks, scientists have inferred that early hominids were chipping flakes off cobbles in order to create a sharp edge with which to cut meat from animal carcasses. It would seem that these early stone tools helped early hominids to access a high-protein food source in sufficient quantity to develop their brains – the brain being metabolically the most expensive organ in the body.

This earliest stone tool industry is called the Oldowan, after Olduvai Gorge in Tanzania where the tools and their importance to hominid development were first recognised by Mary Leakey in the 1960s.

To date Oldowan tools have only been found in Africa. This early technology is fairly consistent across Africa, in that the tools are mainly simple flakes struck from cobbles, a technology that appears to have been sufficient to meet the needs of early hominids as it persisted for a long time. At sites like Olduvai Gorge and Koobi Fora in Kenya, Oldowan tools remained unchanged until about 1,5 million years ago. Oldowan technology thus represents a long period of successful adaptation, which lasted for almost a million years. In South Africa the Oldowan Industry dates from about 2 million years ago. There is still some debate about which hominid made the Oldowan tools as there were at least two hominids in South Africa at that time which were capable of doing so. The first was an early form of Homo, and the second was Paranthropus robustus, which went extinct approximately one million years ago. Because the technology did not disappear when Paranthropus went extinct, it is often assumed that Homo was the toolmaker.

About 1,7 million years ago more specialised tools appeared, developing first in Africa then spreading to Asia and Europe through the movement of hominids out of Africa. These core tools, which are known as Acheulean tools after the French site, Saint Acheul, where they were first discovered in the 1800s, were intentionally designed to have sharper and straighter edges and studies suggest they were used to carry out a range of activities including butchering animals, chopping wood, digging up roots and cracking bone. Interestingly, even though the tools were named after a French site, they only appeared in Europe about 500 000 years ago.

The hominid species Homo ergaster has been credited with the manufacture of the Acheulean tools in South Africa. Compared with earlier hominids, Homo ergaster was physically almost like us; it had a larger brain, and was relatively modern in face, body proportion and height. In fact, it had a body very much like our own. Homo ergaster ranged over vast areas of territory, and occupied a variety of habitats, including drier, more open grassland settings. Most importantly, Homo ergaster became more dependent on tools; it became a habitual tool user.

Oldowan and Acheulean tools are widely distributed across South Africa, where they are most commonly found in association with water sources such as lakes and rivers. Unfortunately, because of this there are very few sites where the tools are found in a primary context, that is, exactly where the user left them. Most of the tools have either been washed into caves or eroded out of riverbanks and washed down rivers.

(Source: Peter Delius (ed), 2006, *Mpumalanga – Reclaiming the Past, Defining the Future)*

There are only a few places in Mpumalanga where Early Stone Age tools have been found and the Middelburg Mine area is not known as a site.

Middle Stone Age

By 250 000 the large hand axes and cleavers of the Earlier Stone Age had begun to diminish in numbers, and our ancestors started to employ a different technique in order to produce a greater variety of tools of diverse shapes and sizes. This change in technology marks the beginning of the Middle Stone Age (MSA). MSA tools are generally smaller, and, unlike ESA tools, which were produced by removing flakes, MSA tools were the flakes. These flakes were of a predetermined size and shape and were produced by preparing the core and striking the flake off. Long, parallel-sided blades, as well as triangular flakes, were commonly produced. The hafting of stone tools onto bone or wood to produce spears, knives or axes also became popular during the MSA, which reflected a shift from scavenging to spear hunting. During the MSA early humans still settled along or near water sources, but also took shelter in caves. Importantly, the MSA marks the transition from a more archaic Homo to anatomically modern humans, Homo sapiens. With this physical development the first signs of art, decoration and symbolism began to emerge.

Although the MSA has not been extensively studied in Mpumalanga, evidence for this period has been excavated from Bushman Rock Shelter, a well-known site situated on the farm Klipfonteinhoek in the Ohrigstad District.

(Source: Peter Delius (ed), 2006, *Mpumalanga – Reclaiming the Past, Defining the Future)*

Middle Stone Age sites often occur near rivers and rocky outcrops. Great care was taken in surveying those that were easily accessible but no artefacts were found.

Late Stone Age

The Later Stone Age (LSA), which occurred from about 20 000 years ago, is signalled by a series of technological innovations and social transformations within these early hunter-gatherer societies. The hunting apparatus now included two important innovations, the bow and the link-shaft arrow. Link-shaft arrows were constructed with a poisoned bone tip, a link and shaft that fell away on impact, leaving the poison tip imbedded in the animal. Other innovations included bored stones, used as digging-stick weights to aid in uprooting tubers and roots; small stone tools, often less than 25 mm in length, used for cutting meat and scraping hides; polished bone tools such as needles; twine made from plant fibre or leather; tortoiseshell bowls; fishing equipment, including hooks and sinkers; bone tools with decoration; high frequencies of ostrich eggshell beads and an increase in ornaments and artwork.

There appears to be a gap in the Mpumalanga LSA record between 9 000 BP and 5 000 BP. This may have to do with the general dearth of Stone Age research in the province, but it also encompasses a period of rapid warming and major climate fluctuation, which may have forced people to seek out more protected and viable environments in this area.

We pick up the Mpumalanga Stone Age record again in the mid-Holocene at the farm Honingklip (HKLP) near Badplaas in the Carolina District. Here two LSA sites were found on opposite sides of a bend in the Nhlazatshe River, about 1km west of its confluence with the Teespruit. The HKLP sites are in the foothills of the Drakensberg, where the climate is warmer than the Highveld but cooler than the lowveld.

(Source: Peter Delius (ed), 2006, *Mpumalanga – Reclaiming the Past, Defining the Future)*

No artefacts associated with the Later Stone Age were identified in the study area.

Early Iron Age occupation

The expansion of early farmers, who, among other things, cultivated crops, raised livestock, mined ore and smelted metals, occurred in this area between AD 400 and AD 1100. Dates from Early Iron Age sites indicated that by the beginning of the 5th century AD Bantu-speaking farmers had migrated down the eastern lowlands and settled in the Mpumalanga lowveld. Subsequently, farmers continued to move into and between the lowveld and Highveld of Mpumalanga until the 12th century. These Early Iron Age sites tend to be found in similar locations. Sites were found within 100m of water, either on a riverbank or at the confluence of streams. The close proximity to streams meant that the sites were often located on alluvial fans. The nutrient rich alluvial soils would have been favoured for agriculture. The availability of floodplains and naturally wetter soils would have been important for the practice of dryland farming. This may have been particularly so during the Early Iron Age when climate reconstruction for the interior of South Africa suggests decreased rainfall between AD 900 and AD 1100 and again after AD 1450.

Burned dagha and plaster with pole impressions found at these early lowveld sites indicated that early farmers lived in fairly permanent agricultural villages. Grindstones and an imprint of millet or domestic Pennisetum in a piece of pottery from an AD 400 site on the northern border of Mpumalanga provided the first evidence of the cultivation of millet in South Africa. Remains of iron tools indicated that metalworking was also practised. Iron was an important commodity, and ores in the form of haematite and magnetite were either picked up off the surface or mined from shafts dug into the ground. Large cattle byres with pits were also significant features of EIA Highveld sites dating from AD 600.

(Source: Peter Delius (ed), 2006, *Mpumalanga – Reclaiming the Past, Defining the Future)*

Mining and farming activities have transformed the Middelburg Mine sections and there no traces of Early Iron Age settlements were found.

Late Iron Age occupation

While there is some evidence that the EIA continued into the 15th century in the lowveld, on the escarpment it had ended by AD1100. The Highveld, particularly around Lydenburg, Badfontein, Sekhukhuneland, Roossenekal, and Steelpoort, became active again from the 15th century onwards. This later phase, termed the Late Iron Age (LIA), was accompanied by extensive stonewalled settlements.

Trade no doubt played an important role in the economy of these early societies. Goods were traded both locally and further afield. Control of resources such as metal provided a solid economic base that was fairly impervious to changes in the environment. Traditional sources of wealth were easily bolstered as metals were used in place of cattle to encourage key marriage alliances, and at the same time used to purchase livestock and other trade items from outside the country.

Local trade consisted of metal, salt, thatch, poles, cattle and grain. Salt was produced from alkaline springs. This valuable commodity could be obtained by paying a tithe to the chief on whose land the salt was located. However, there were examples of mass production where salt was 'balled' for transport and sold for huge profit in salt scarce areas. By the 1700s, with growing trade wealth, economically driven centres of control began to emerge and, following the establishment of Portuguese trade posts, the Mpumalanga landscape became an important thoroughfare for both local and foreign traders.

(Source: Peter Delius (ed), 2006, *Mpumalanga – Reclaiming the Past, Defining the Future)*

Typical late Iron Age features such as stone-walled settlements, potsherds, hut floors, middens and iron artefacts were not found in the study area due to disturbance by farming and mining activities.

Pre-colonial settlement

Mpumalanga was populated by multiple and ethnically diverse but interrelated communities. It was inhabited by the San (Hunter-Gatherer, Basarwa or Bathwa) groupings prior to the settlement of various Late Iron Age (LIA) farming communities, the ancestors of modern Sotho-Tswana and Nguni societies. The north-western and southern portions of the region came to be broadly occupied by the Kgatla (Bakgatla), Rolong (Barolong), Ntwane (Bantwane), Koni (Bakone), Kopa (Bakopa) and Southern Ndebele mixed farming communities.

Despite their general association with LSA and their assumed disappearance, it is clear that San groups continued to interact with farmers in the Eastern Transvaal, as was the case elsewhere, and the evidence of a range of forms of coexistence warns us against drawing rigid distinctions between the two cultures. Material assemblages from excavated sites, San rock paintings and engravings and cultural and linguistic evidence point to some forms of peaceful contacts between these diverse communities.

According to other recorded oral traditions ancestors of Bakone groupings occupied parts of the low country (Phalaborwa and Bokgaga near Leydsdorp) at an uncertain date. The main body of the Bakone appears to have been under the Matlala ruling lineage at the time of their fragmentation into a multiplicity of groups and subsequent chiefdoms around the 15th to 16th centuries. While some groups remained in the low country others ventured further west and southwards and Koni groups came to settle in the areas later called Ohrigstad, Lydenburg and Middelburg.

Either before or at the start of the 17th century an early Nguni-speaking community entered the orbit of the Sotho-Tswana communities in the Transvaal and in particular the north-eastern Highveld. The Sotho-Tswana people commonly called this early Nguni offshoot Matebele, denoting Pursuers. According to P. Lekgoathi these Nguni groups accepted the appellation Matebele but pronounced it as Amandebele. Anthropologists and historians later rendered both Sotho-Tswana and Nguni terms as Ndebele.

In due course relations between other royal contenders degenerated into open confrontation. The Manala (Mabena) and Mhwaduba sections remained independently in and around Pretoria areas while the Ndzundza and Mthombeni groups moved north-eastward into the environs of the Steelpoort (Tubatse) River valley and the slopes of Bothasberg in Middelburg.

There is evidence that Mzilikazi's Ndebele invaded the south-eastern and central Transvaal areas. Accounts of the Southern Ndebele, the Koni, the Kgatla, the Rolong and the Ntwane attest to Mzilikazi's sporadic plunder and their own counter raids of Mzilikazi's frequent raids. The Koni, Kopa and some Eastern Sotho fortified settlements in the Middelburg, Nelspruit (Waterval Boven, Sudwala Caves) and Lydenburg areas were attacked by intruding armies.

(Source: Peter Delius (ed), 2006, *Mpumalanga – Reclaiming the Past, Defining the Future)*

Colonial settlement

In 1845 the establishment of a Boer settlement at Ohrigstad marked the beginning of a new phase in the history of the Eastern Transvaal. The first Trekkers to settle in the area were the followers of A H Potgieter, who moved from Mooi River in the south-western Transvaal. Trekkers from Natal led by J J Burger joined them. Tensions between the two groups soon surfaced and the difficulties facing the community were compounded by malaria, which decimated the population, and stock disease, which ravaged their herds. In 1848, partly to escape this disease and conflict-ridden community, Potgieter and his followers moved north and founded the town of Schoemansdal. Most of those who remained behind moved to higher-lying lands to the south. The town of Lydenburg became the new centre of the community and white settlers slowly established themselves in the wider region. The Trekkers' political fractiousness did not, however, diminish. In 1856 the Lydenburg community seceded from the Zuid Afrikaansche Republiek (ZAR) – a development that was symptomatic of the fragility of the wider state. Political instability and racial exclusivity – blacks were infamously denied any equality in church or state – however, co-existed with strong traditions of popular democracy. It was not until 1864 that political unity was achieved among the main Trekker communities in the Transvaal and even thereafter the state remained both rudimentary and cash strapped.

Once the Trekkers had established what they saw as their right to the land they set about distributing it among themselves. The land was demarcated into large farms and title deeds were issued. The initial policy was that all burghers (citizens) were entitled to two farms of 3 000 morgen each (about 6 330 acres or 2 564 hectares) from the state. White newcomers to the Transvaal were quickly granted citizenship and the land that went with it. Farms, which were not distributed, remained government property and the ZAR, which battled to raise revenue, increasingly fell back on its principal asset – land.

This profligate distribution of land could not be sustained. From 1860 land grants to burghers were reduced to one 3 000 morgen farm each. After 1866 newcomers no longer received any grant of land and from 1871 this prohibition applied even to the sons of burghers.

The most consistent supply of labour for those farmers able to enforce their claim to ownership of the land came from African families living on their property. The practice that developed in the area was that five families of a group were expected to render unpaid labour service to the landowner but were then spared from further demands on their labour or their produce by officials or neighbouring farmers. Elements of a patriarchal pact underpinned these arrangements as male elders within African communities used their authority over both women and youths to meet the farmers' appetite for workers. Over the subsequent decades the amount of labour that could be extracted from resident workers would be a source of recurring strife. Communities settled on land owned by absentee landlords were often able to secure their tenure through payments of rent in cash or kind, to the considerable irritation of their white neighbours, who believed they should be forced to work for them.

(Source: Peter Delius (ed), 2006, *Mpumalanga – Reclaiming the Past, Defining the Future)*

The homestead ruin (MM 6) and foundations (preferred treatment plant site) are associated with African tenant farmers living on Hartbeestfontein. Many such tenant farmers were forced to relocate to townships and "homelands" in the 1960s in terms of apartheid legislation. The cemetery (MM 8) is associated with the farm workers of the area.

The study area covers the following three farms, associated with the natural environment when they were handed out by the Boer government to white farmers, as well as with personalities:

FARM NAME	MEANING	DATE	FIRST OWNER
Hartbeestfontein 339 JS	Spring frequented by hartebeest	1869	PH Holtzhausen
Goedehoop 315 JS	Good Hope	Unknown	SPE Trichardt was involved when the farm was surveyed in the 1890s
Rietfontein 314 JS	Spring surrounded by reeds	Unknown	Unknown

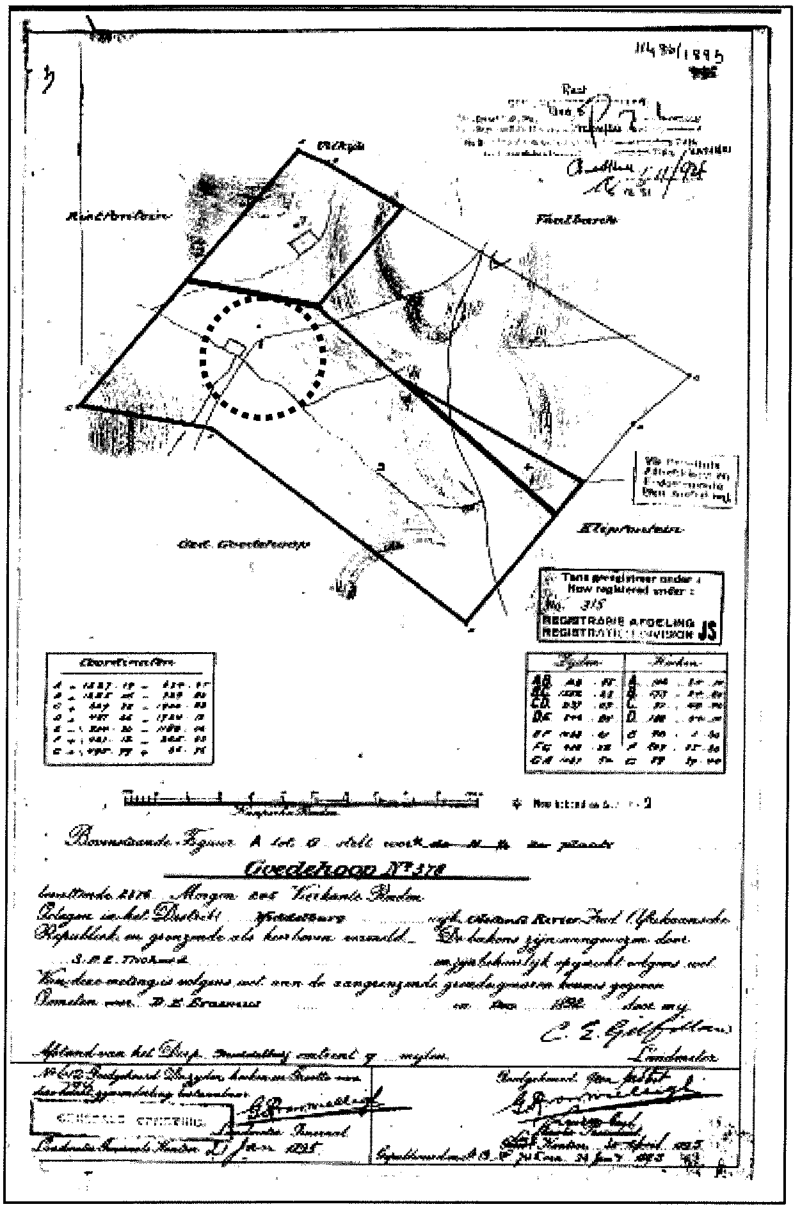


FIGURE 16: Survey diagram of Goedehoop 315 JS (1892) indicating the location of the farmstead remains (MM 10) (circle) (Courtesy Chief Surveyor-General)

Some of the farms were divided and subdivided many times over. Each subdivided portion often had a separate farmstead where the owner lived. Black tenant farmers and sharecroppers were allowed to live on the land in return for providing farm labour to the white farmers. They lived in homesteads away from the main farmstead.

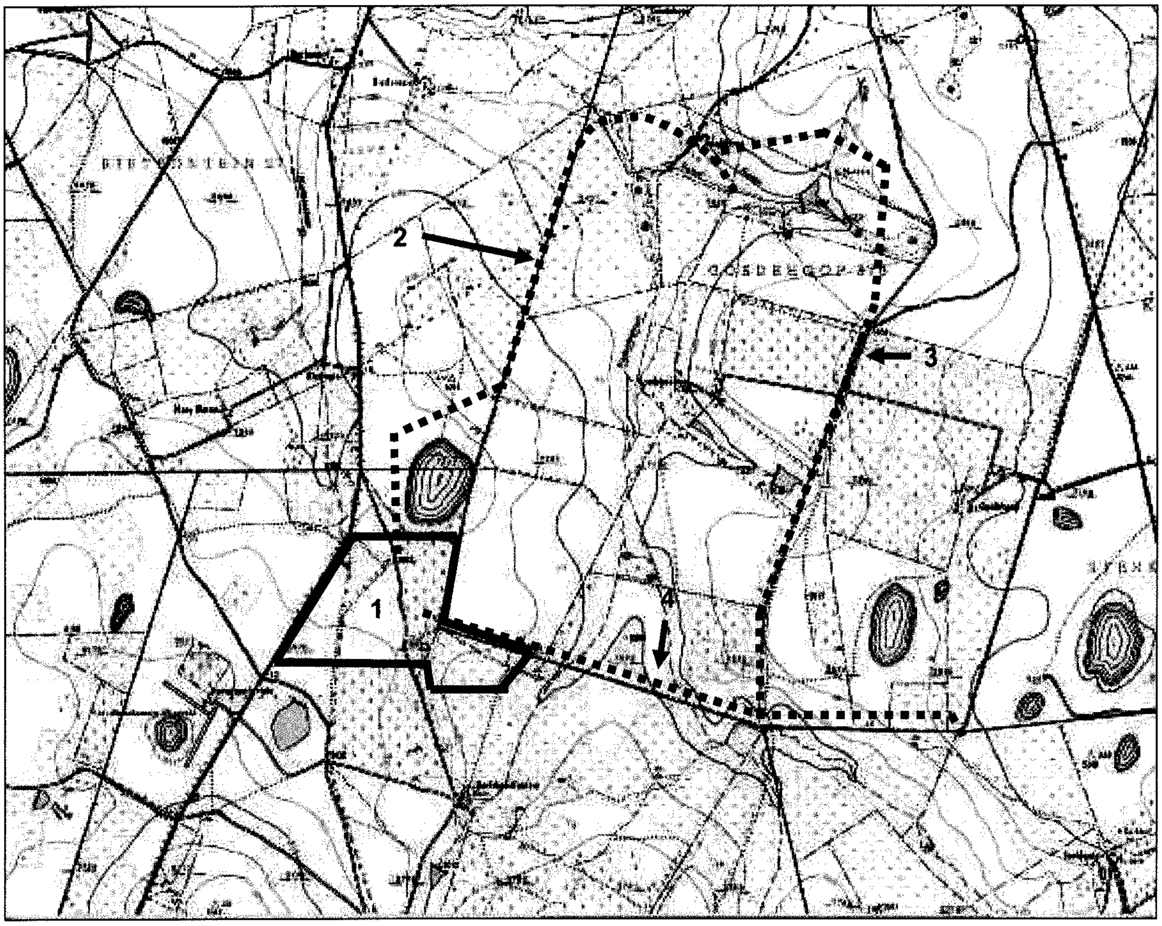


FIGURE 17: Section of 2529 CD (1954) indicating the environment at the time with the treatment plant site (1), the Alternative 1 pipeline (2), the Alternative 2 pipeline (3) and the Klipfontein pipeline (4)

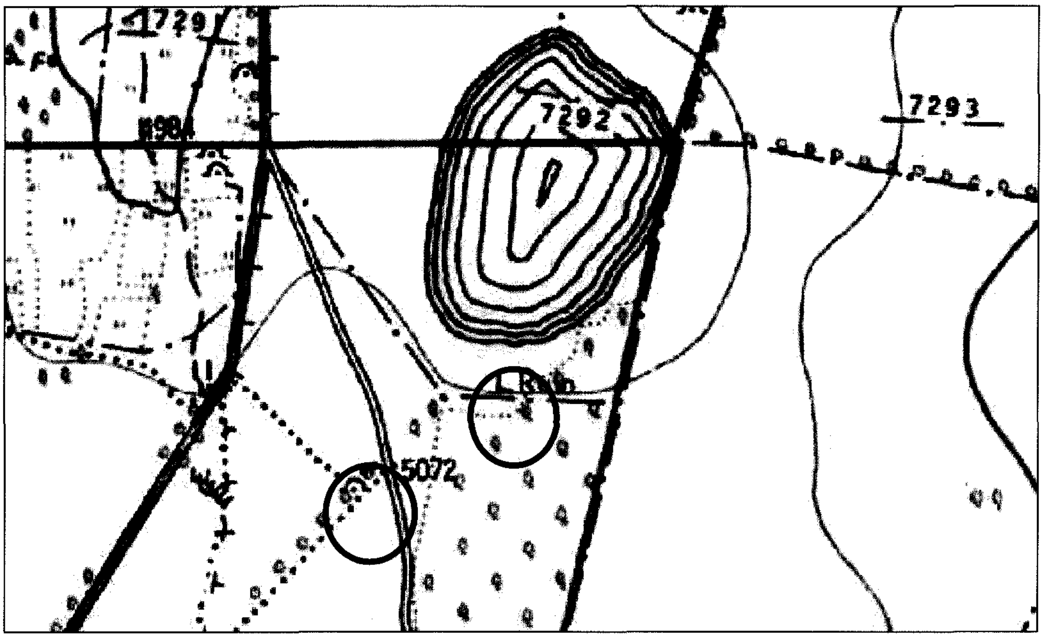


FIGURE 18: Enlargement of 2529 CD (1954) indicating the natural pan with sites MM 5 (left) and MM 6 (ruin)

FIGURE 18: Enlargement of 1943 aerial image of the treatment plant area, indicating the pan (top), the location of MM 6 (circle) and a large dam (left) that no longer exists, with the R 575 road on the far left

APPENDIX 2: INFORMATION SOURCES USED IN THIS REPORT

Databases

Environmental Potential Atlas, Department of Environmental Affairs and Tourism.
Heritage Sites Database, Pretoria
SAHRA database of archaeological impact assessment reports (2009)

Literature

BERGH, JS (ed), 1999, *Geskiedenisatlas van Suid-Afrika. Die vier noordelike provinsies.* Pretoria: JL van Schaik.

DELIUS, P (ed), 2006, *Mpumalanga – Reclaiming the Past, Defining the Future.* Pietermaritzburg: UKZN Press.

ICOMOS Australia. 1999. *The Australia ICOMOS Burra Charter for the conservation of places of cultural significance.*

Living with the land. A manual for documenting cultural landscapes in the Northwest Territories. Yellowknife (Canada), 2007.

MASON, R, *Prehistory of the Transvaal.*

National Heritage Resources Act (Act 25 of 1999)

Standard Encyclopedia of Southern Africa.

WILSON, MGC, & ANHAEUSSER, CR, 1998, *The mineral resources of South Africa*, Council for Geoscience Handbook 16. Pretoria: Council for Geoscience.

Maps

2529 CD Middelburg (1954, 1996)
Cadastral diagrams of the farms (Chief Surveyor-General)
Maps provided by client

Aerial photos

Job 38/1943 strip 32 no 05575
Google Earth 2009

Unpublished reports

CULTMATRIX cc, 2006, *HIA report for Middelburg Mine EMP.* Prepared for Jones and Wagener.

CULTMATRIX cc, 2009, *HIA report for proposed Middelburg Mine Water Treatment Plant.* Prepared for Jones and Wagener.

APPENDIX 3: GLOSSARY OF TERMS

Cultural significance (Burra Charter)

Aesthetic, historic, scientific, social or spiritual importance, meaning or noteworthiness for past, present or future generations

Cultural significance is embodied in the place itself (intrinsic significance), its fabric, setting, use, associations, meanings, records, related places and related objects.

Cultural significance is assessed in terms of the following criteria, some of which are embodied in the NHRA:

- Historic value: Material or intangible evidence resulting from changing social, political and environmental circumstances or conditions
- Rarity: Unique or unusual features also possess rarity value, apart from their age. Section 34 of the NHRA provided general protection for all structures older than 60 years. This does not imply that recently erected structures cannot possess rarity, or for that matter cultural value.
- Scientific value: Indicates research potential (the capacity to yield more knowledge)
- Typical: Indicates that the feature is a good example of a certain class or type of heritage resource
- Aesthetic: Other than artistic or architectural expression, aesthetic value can also be evident in craftsmanship, technique, visual cohesion (harmony), visual evidence of permanence and stability, setting etc.
- Technological: Indicates value in terms of a technological achievement
- Personal/Community: Indicates value in terms of association with a certain person, community, organisation or cultural group
- Landmark: A sense of place or belonging involves the physical and visual relationship between a feature and its environment.
- Condition (material integrity): Indicates substantial evidence of authentic fabric with minor degree of lost or obliterated fabric; also refers to a structure's restoration potential
- Sustainability: The potential for lasting economic viability (use) and the perpetuation of the original use or part thereof.

Heritage resources/features (NHRA)

Any place or object of cultural significance, including:
(a) places, buildings, structures and equipment of cultural significance;
(b) places to which oral traditions are attached or which are associated with living heritage;
(c) historical settlements and townscapes;
(d) landscapes and natural features of cultural significance;
(e) geological sites of scientific or cultural importance;
(f) archaeological and palaeontological sites;
(g) graves and burial grounds, including—
(i) ancestral graves;
(ii) royal graves and graves of traditional leaders;
(iii) graves of victims of conflict;
(iv) graves of individuals designated by the Minister by notice in the *Gazette*;
(v) historical graves and cemeteries; and
(vi) other human remains, which are not covered in terms of the Human Tissue Act, 1983 Act No. 65 of 1983);
(h) sites of significance relating to the history of slavery in South Africa;
(i) movable objects, including—

(i) objects recovered from the soil or waters of South Africa, including archaeological and palaeontological objects and material, meteorites and rare geological specimens;
(ii) objects to which oral traditions are attached or which are associated with living heritage;
(iii) ethnographic art and objects;
(iv) military objects;

(v) objects of decorative or fine art;
(vi) objects of scientific or technological interest; and
(vii) books, records, documents, photographic positives and negatives, graphic, film or video material or sound recordings, excluding those that are public records as defined in section 1(xiv) of the National Archives of South Africa Act, 1996 (Act No. 43 of 1996).

Heritage significance (NHRA)

(a) its importance in the community, or pattern of South Africa's history;
(b) its possession of uncommon, rare or endangered aspects of South Africa's natural or cultural heritage;
(c) its potential to yield information that will contribute to an understanding of South Africa's natural or cultural heritage;
(d) its importance in demonstrating the principal characteristics of a particular class of South Africa's natural or cultural places or objects;
(e) its importance in exhibiting particular aesthetic characteristics valued by a community or cultural group;
(f) its importance in demonstrating a high degree of creative or technical achievement at a particular period;
(g) its strong or special association with a particular community or cultural group for social, cultural or spiritual reasons;
(h) its strong or special association with the life or work of a person, group or organisation of importance in the history of South Africa; and
(i) sites of significance relating to the history of slavery in South Africa.

Historic period

Since the arrival of the white settlers - c. AD 1840 in this part of the country

Impact

A description of the effect of an aspect of the development on a specified component of the biophysical, social or economic environment within a defined time and space

Impact assessment

Issues that cannot be resolved during screening (Level 1) and scoping (Level 2) and thus require further investigation

Intangible heritage

Defined in terms of the UNESCO Convention for the Safeguarding of the Intangible Cultural Heritage (2003) as:

- Oral traditions and expressions, including language as a vehicle of the intangible cultural heritage;
- Performing arts;
- Social practices, rituals and festive events;
- Knowledge and practices concerning nature and the universe;
- Traditional craftsmanship.

The "intangible cultural heritage" means the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts and cultural spaces associated therewith – that communities, groups and, in some cases, individuals recognize as part of their cultural heritage. This intangible cultural heritage, transmitted from generation to generation, is constantly recreated by communities and groups in response to their environment, their interaction with nature and their history, and provides them with a sense of identity and continuity, thus promoting respect for cultural diversity and human creativity.

Visual and social impact assessments as part of an HIA are directly associated with intangible cultural heritage.

Iron Age

Early Iron Age (EIA)	AD 200 - AD 1000
Late Iron Age (LIA)	AD 1000 - AD 1830

Issue

A question that asks what the impact of the proposed development will be on some element of the environment

Maintenance

Keeping something in good health or repair

Management actions

Actions that enhance benefits associated with a proposed development or avoid, mitigate, restore, rehabilitate or compensate for the negative impacts

Preservation

Conservation activities that consolidate and maintain the existing form, material and integrity of a cultural resource

Reconstruction

Re-erecting a structure on its original site using original components

Rehabilitation

Re-using an original building or structure for its historic purpose or placing it in a new use that requires minimal change to the building or structure characteristics and its site and environment.

Restoration

Returning the existing fabric of a place to a known earlier state by removing additions or by reassembling existing components

SAHRA - South African Heritage Resources Agency

Stone Age

Early Stone Age (ESA)	2 000 000 - 150 000 Before Present
Middle Stone Age (MSA)	150 000 - 30 000 BP
Late Stone Age (LSA)	30 000 - until c. AD 200

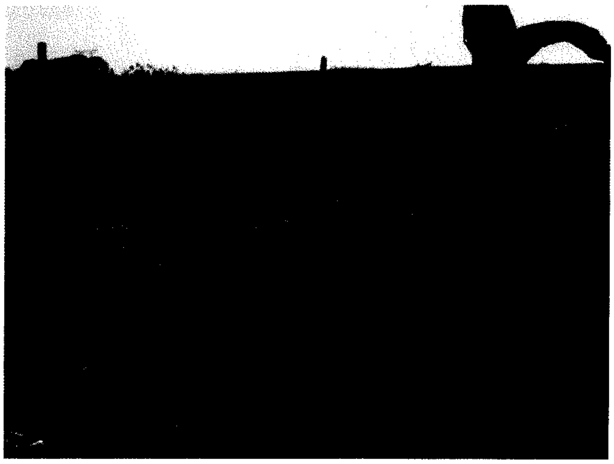
Value

Worth, conservation utility, desirability to conserve etc in terms of physical condition, level of significance (importance), economy (feasibility), possible new uses and associations/comparisons with similar features elsewhere

G&A Heritage
Heritage Management Consultants

Phase 1 Heritage Impact Assessment Report

Heritage Impact Assessment for the Middelburg Water Reclamation Project



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23/06/2011

CREDIT SHEET

[redacted]

[redacted]

Disclaimer; *Although all possible care is taken to identify all sites of cultural importance during the investigation of study areas, it is always possible that hidden or sub-surface sites could be overlooked during the study. G&A Heritage and its personnel will not be held liable for such oversights or for costs incurred as a result of such oversights.*

SIGNED OFF BY: STEPHAN GAIGHER

MANAGEMENT SUMMARY

The purpose of the management summary is to distil the information contained in the report into a format that can be used to give specific results quickly and facilitate management decisions. It is not the purpose of the management summary to repeat in shortened format all the information contained in the report, but rather to give a statement of results for decision making purposes.

This study focuses on a single amendment to the untreated mine water pipeline associated with the Middelburg Water Reclamation Project. Previous heritage investigations were performed by Cultmatrix cc on the original alignment of the pipeline. The occurrence of a sensitive wetland has however resulted in a realignment of one section of this pipeline. This study reports on the cultural sensitivity of the new alignment.

A preliminary alignment has been drawn to lead the study; however this could be altered to some extent to avoid any identified heritage sites.

The area is a possible repository for fossil materials as was indicated in the original report by Dr. de Jong. The information supplied by Roger Price, Council for Geoscience, is still applicable and it was found unnecessary to duplicate the paleontological study here.

The purpose of this heritage impact assessment is to outline the cultural heritage sensitivity of the proposed development area and to advise on mitigation should any heritage sites or landscapes be affected.

Findings

A small family graveyard was identified within the cow pasture close to the present alignment of the pipeline. The site contained five dressed graves.

The remains of some type of built structure were identified close to the graveyard. This was too dilapidated to be identifiable. It is very possible that the structure is associated with the graves.

Several stone heaps could be seen throughout the pastures. These are the result of field clearing and have no cultural value

No culturally sensitive landscape types could be identified within any of the study areas.

Recommendations
It is recommended that the structural remains and the graveyard be avoided by the construction. A safety zone of 50m should be adhered to.

Fatal Flaws

23/06/2011

No fatal flaws were identified.

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LIST OF FIGURES

LIST OF ABBREVIATIONS

Bp..Before Present

EIA .... Early Iron Age

ESA..Early Stone Age

Fm.. Femtometre (10^{-15}m)

GPS .... Geographic Positioning System

HIA ....Heritage Impact Assessment

LIA.. Late Iron Age

LSA .... Late Stone Age

MYA ....Million Years Ago

MSA .... Middle Stone Age

NHRA ....National Heritage Resources Act no 22 of 1999

SAHRA ....South African Heritage Resource Agency

S&EIR...Scoping & Environmental Impact Reporting

Um .... Micrometre (10^{-6} m)

WGS 84 .... World Geodetic System for 1984

Chapter 1 **PROJECT RESOURCES**

HERITAGE IMPACT REPORT

HERITAGE IMPACT ASSESSMENT REPORT FOR THE PROPOSED MIDDELBURG WATER RECLAMATION SCHEME.

INTRODUCTION

Legislation and methodology

G&A Heritage was appointed by Jones & Wagener Consulting Civil Engineers to undertake a heritage impact assessment for the proposed construction and operation of an untreated mine water pipeline for the Middelburg Water Reclamation Project. Section 27(1) of the South African Heritage Resources Act (25 of 1999) requires that a heritage impact assessment is undertaken for:

(a) construction of a road, wall, power line, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length;
(b) construction of a bridge or similar structure exceeding 50 m in length; and
(c) any development, or other activity which will change the character of an area of land, or water –
  (1) exceeding 10 000 m^2 in extent;
  (2) involving three or more existing erven or subdivisions thereof; or
  (3) involving three or more erven, or subdivisions thereof, which have been consolidated within the past five years; or
(d) the costs of which will exceed a sum set in terms of regulations; or
(e) any other category of development provided for in regulations.

A heritage impact assessment is not limited to archaeological artefacts, historical buildings and graves. It is far more encompassing and includes intangible and invisible resources such as places, oral traditions and rituals. A heritage resource is defined as any place or object of cultural significance i.e. of aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance. This includes the following:

(a) places, buildings, structures and equipment;
(b) places to which oral traditions are attached or which are associated with living heritage;
(c) historical settlements and townscapes;
(d) landscapes and natural features;
(e) geological sites of scientific or cultural importance;
(f) archaeological and paleontological sites;
(g) graves and burial grounds, including –
  (1) ancestral graves,
  (2) royal graves and graves of traditional leaders,
  (3) graves of victims of conflict (iv) graves of important individuals,
  (4) historical graves and cemeteries older than 60 years, and
  (5) other human remains which are not covered under the Human Tissues Act, 1983 (Act No.65 of 1983 as amended);
(h) movable objects, including ;
  (1) objects recovered from the soil or waters of South Africa including archaeological and paleontological objects and material, meteorites and rare geological specimens;
  (2) ethnographic art and objects;
  (3) military objects;
  (4) objects of decorative art;
  (5) objects of fine art;
  (6) objects of scientific or technological interest;
  (7) books, records, documents, photographic positives and negatives, graphic, film or video material or sound recordings; and

(8) any other prescribed categories, but excluding any object made by a living person;
(i) battlefields;
(j) traditional building techniques.

A '**place**' is defined as:
(a) A site, area or region;
(b) A building or other structure (which may include equipment, furniture, fittings and articles associated with or connected with such building or other structure);
(c) a group of buildings or other structures (which may include equipment, furniture, fittings and articles associated with or connected with such group of buildings or other structures); and (d) an open space, including a public square, street or park; and in relation to the management of a place, includes the immediate surroundings of a place.

'**Structures**' means any building, works, device, or other facility made by people and which is fixed to land and any fixtures, fittings and equipment associated therewith older than 60 years.

'**Archaeological**' means:
(a) material remains resulting from human activity which are in a state of disuse and are in or on land and are older than 100 years, including artefacts, human and hominid remains and artificial features and structures;
(b) rock art, being a form of painting, engraving or other graphic representation on a fixed rock surface or loose rock or stone, which was executed by human agency and is older than 100 years including any area within 10 m of such representation; and
(c) wrecks, being any vessel or aircraft, or any part thereof, which was wrecked in South Africa, whether on land or in the maritime cultural zone referred to in section 5 of the Maritime Zones Act 1994 (Act 15 of 1994), and any cargo, debris or artefacts found or associated therewith, which are older than 60 years or which in terms of national legislation are considered to be worthy of conservation;
(d) features, structures and artefacts associated with military history which are older than 75 years and the sites on which they are found.

'Paleontological' means any fossilised remains or fossil trace of animals or plants which lived in the geological past, other than fossil fuels or fossiliferous rock intended for industrial use, and any site which contains such fossilised remains or trace.

'Grave' means a place of interment and includes the contents, headstone or other marker of and any other structures on or associated with such place. The South African Heritage Resources Agency (SAHRA) will only issue a permit for the alteration of a grave if it is satisfied that every reasonable effort has been made to contact and obtain permission from the families concerned.

The removal of graves is subject to the following procedures as outlined by the SAHRA:

- Notification of the impending removals (using English, Afrikaans and local language media and notices at the grave site);
- Consultation with individuals or communities related or known to the deceased;
- Satisfactory arrangements for the curation of human remains and / or headstones in a museum, where applicable;
- Procurement of a permit from the SAHRA;
- Appropriate arrangements for the exhumation (preferably by a suitably trained archaeologist) and re-interment (sometimes by a registered undertaker, in a formally proclaimed cemetery);
- Observation of rituals or ceremonies required by the families.

The limitations and assumptions associated with this heritage impact assessment are as follows;
- Limited field investigations were performed on foot and by vehicle where access was readily available.
- Sites were evaluated by means of description of the cultural landscape, direct observations and analysis of written sources and available databases.
- It was assumed that the site layout as provided by Jones & Wagener is accurate.
- We assumed that the public participation process performed as part of the Scoping and Environmental Impact Reporting (S&EIR) process was sufficiently encompassing not to be repeated in the Heritage Assessment Phase.

Table 1. Impacts on the NHRA Sections

Act	Section	Description	Possible Impact	Action
National Heritage Resources Act (NHRA)	34	Preservation of buildings older than 60 years	Structural ruin at Site MWP 003	Re-align pipeline route to avoid site
	35	Archaeological, paleontological and meteor sites	No impact	None
	36	Graves and burial sites	Informal graveyard at site MWP003	Re-alignment of pipeline route
	37	Protection of public monuments	None	None
	38	Does activity trigger a HIA?	Yes	HIA

Table 2. NHRA Triggers

Action Trigger	Yes/No	Description
Construction of a road, wall, power line, pipeline, canal or other linear form of development or barrier exceeding 300m in length.	Yes	Untreated mine water pipeline exceeding 300m
Construction of a bridge or similar structure exceeding 50m in length.	No	N/A
Development exceeding 5000 m^2	No	N/A
Development involving more than 3 erven or sub divisions	No	N/A
Development involving more than 3 erven or sub divisions that have been consolidated in the past 5 years	No	N/A
Re-zoning of site exceeding 10 000 m^2	No	N/A
Any other development category, public open space, squares, parks or recreational grounds	No	N/A

Background Information

Proposed Middelburg Water Reclamation Project

Project Description

The original intention was to collect and treat excess mine water at a treatment plant site located east of the R 575 (the road between Vandyksdrift and Kriel) in the north-western corner of the farm Hartbeestfontein 339 JS. This plant would discharge the water to the Spookspruit. In April 2009 Cultmatrix prepared and submitted a Heritage Impact Assessment report in connection with the proposed pipelines and treatment plant.

Because of issues related to the location of this pipeline, an alternative and shorter pipeline was proposed later, situated further to the west and located on farm land (cultivated and grazing) on the farms Rietfontein 314 JS and Goedehoop 315 JS, thereby avoiding the mine property that would be traversed by the original pipeline. In addition, it was proposed to enlarge the treatment plant site by extending it to the south in order to locate the plant itself, its holding dam and its waste disposal site further away from a sensitive natural pan, situated immediately north of the original treatment plant site, closer to less sensitive old mining land characterised by slimes dams and other features.

After completion of the Cultmatrix Heritage Impact assessment (HIA) an environmental study identified the wetland which the pipeline would traverse as highly sensitive. The result of the realignment of the pipeline was that the new alignment would have to be subjected to a heritage study.

Site Location

The pipeline is located on the farm Goedehoop 315 JS. This in turn is located to the west of the R575 road to the south of the town of Middelburg. Currently the property belongs to BHP Billiton.

Alternatives Considered

Two alternatives were considered

- The original alignment to the south of the current alignment.
- No-go option where no development takes place.

METHODOLOGY

This study defines the heritage component of the S&EIR process being undertaken for the Middelburg Water Reclamation Project. It is described as a first phase (HIA). This report attempts to evaluate both the accumulated heritage knowledge of the area as well as information derived from direct physical observations.

EVALUATING HERITAGE IMPACTS

A combination of document research as well as the determination of the geographic suitability of areas and the evaluation of aerial photographs determined which areas could and should be accessed.

After plotting of the site on a GPS the areas were accessed using suitable combinations of vehicle access and access by foot. Vehicular access was facilitated by the client to comply with the mine's safety standards.

Sites were documented by digital photography and geo-located with GPS readings using the WGS 84 datum.

Further techniques (where possible) included interviews with local inhabitants, visiting local museums and information centers and discussions with local experts. All this information was combined with information from an extensive literature study as well as the result of archival studies based on the SAHRA provincial databases.

Geological maps guided investigations into the paleontological riches of the area.

ASSESSING VISUAL IMPACT

Visual impacts of developments result when sites that are culturally celebrated are visually affected by a development. The exact parameters for the determination of visual impacts have not yet been rigidly defined and are still mostly open to interpretation. CNdV Architects and The Department of Environmental Affairs and Development Planning (2006) have developed some guidelines for the management of the visual impacts of wind turbines in the Western Cape, although these have not yet been formalised. In these guidelines they recommend a buffer zone of 1km around significant heritage sites to minimise the visual impact.

ASSUMPTIONS AND RESTRICTIONS

- It is assumed that the SAHRA database locations are correct
- It is assumed that the paleontological information collected for the project is comprehensive.
- It is assumed that the social impact assessment and public participation process of the S&EIR will result in the identification of any intangible sites of heritage potential.

Chapter 2 PROJECT RESOURCES

HERITAGE INDICATORS WITHIN THE RECEIVING ENVIRONMENT

REGIONAL CULTURAL CONTEXT

PALEONTOLOGY

The Barberton Greenstone Belt (BGB) is a geological formation in Mpumalanga that has produced some of the oldest evidence of life anywhere in the World. This formation is not limited to the Barberton area and several versions of it are found close to the study area. These include the Kromberg, Onverwacht and Hoogenoeg sites. The BGB comprises 5 to 6 km of predominantly komatitic and basaltic pillow lavas and sheet flows and related intrusions that are interlayered with cherts and overlain by cherts, banded iron formations, and shales. This magmatic sequence has been interpreted to represent 3480- to 3220-million-year-old oceanic crust and island arc assemblages. These rocks have undergone metamorphism from prehnite-pumpellyite to green-schist facies. Within the originally glassy rims of many BGB pillow lavas, dense populations of mineralized tubular structures 1 to 9 um in width (average width, 4 Fm) and up to 200 Fm in length (average length, 50 Fm) are observed. These structures consist of fine-grained titanite and extend away from healed fractures along which seawater once flowed.

According to Roger Price, Council for Geoscience, there are lots of fossils and trace fossils. Several studies have been done in the past by mining companies but most of the studies have probably been sedimentological rather than paleontological, with comments on palaeontology as an afterthought. It is impossible to predict where fossils and trace fossils might occur and the only way to find out is to randomly check for any occurrences during site preparation work (*Cultmatrix, 2009*).

STONE AGE

This area is home to all three of the known phases of the Stone Age, namely: the Early- (2.5 million – 250 000 years ago), Middle- (250 000 – 22 000 years ago) and Late Stone Age (22 000 – 200 years ago). The Late Stone Age in this area also contains sites with rock art from the San and Khoi San cultural groups. Early to Middle Stone Age sites are uncommon in this area, however rock-art sites and Late Stone Age sites are much better known.

No substantial number of Stone Age sites from any period of the Stone Age is however known to exist in this specific area – primarily as a result of a lack of research and general ignorance amongst the layman in recognizing stone tools that often may occur on the surface of the earth. However, it is possible that the first humans in the Middelburg area may have been preceded by Homo erectus, who roamed large parts of the world during the Aucheulian period of the Early Stone Age, 500 000 years ago. The forbearer of H. erectus, Australopithecus, considered to be the earliest ancestor of humans, lived in the Blaauwbank Valley around Krugersdorp (today part of the Cradle of Humankind – a World Heritage Site) several million years ago.

During the Middle Stone Age, 200 000 years ago, modern man or Homo sapiens emerged, manufacturing a wider range of tools, with technologies more advanced than those from earlier periods. This enabled skilled hunter-gatherer bands to adapt to different environments. From this time onwards, rock shelters and caves were used for occupation and reoccupation over very long periods of time.

The Late Stone Age, considered to have started some 20 000 years ago, is associated with the predecessors of the San and Khoi Khoi. Stone Age hunter-gatherers lived well into the 19th century in some places in SA, but may not have been present in Middelburg when the first European colonists crossed the Vaal River during the early part of the 19th century. Stone Age sites may occur all over the area where an unknown number may have been obliterated by mining activities, urbanisation, industrialisation, agriculture and other development activities during the past decades.

IRON AGE

A considerable number of Late Iron Age, stone walled sites, dating from the 18^{th} and the 19^{th} centuries (some of which may have been occupied as early as the 16^{th} century), occur along and on top of the rocky ridges of the eastern part of the Klipriviersberg towards Alberton. These settlements and features in these sites, such as huts, were built with dry stone, reed and clay available from the mountain and the Klip River (Mason 1968, 1986).

Stone walled settlements are concentrated in clusters of sites and sometimes are dispersed over large areas making them vulnerable to developments of various kinds. A site consists of a circular or elliptical outer wall that is composed of a number of scalloped walls facing inwards towards one or more enclosures. Whilst the outer scalloped walls served as dwelling quarters for various family groups, cattle, sheep and goat were stock in the centrally located enclosures. Huts with clay walls and floors were built inside the dwelling units. Pottery and metal items are common on the sites. However, iron and copper were not produced locally on these sites.

The Historic Era

This area is well known for its rich historic character and contains sites connected with several historic military and political conflicts. Historic cemeteries (victim of conflict sites), provincial and private museums, battlefield sites and other historic sites are found here.

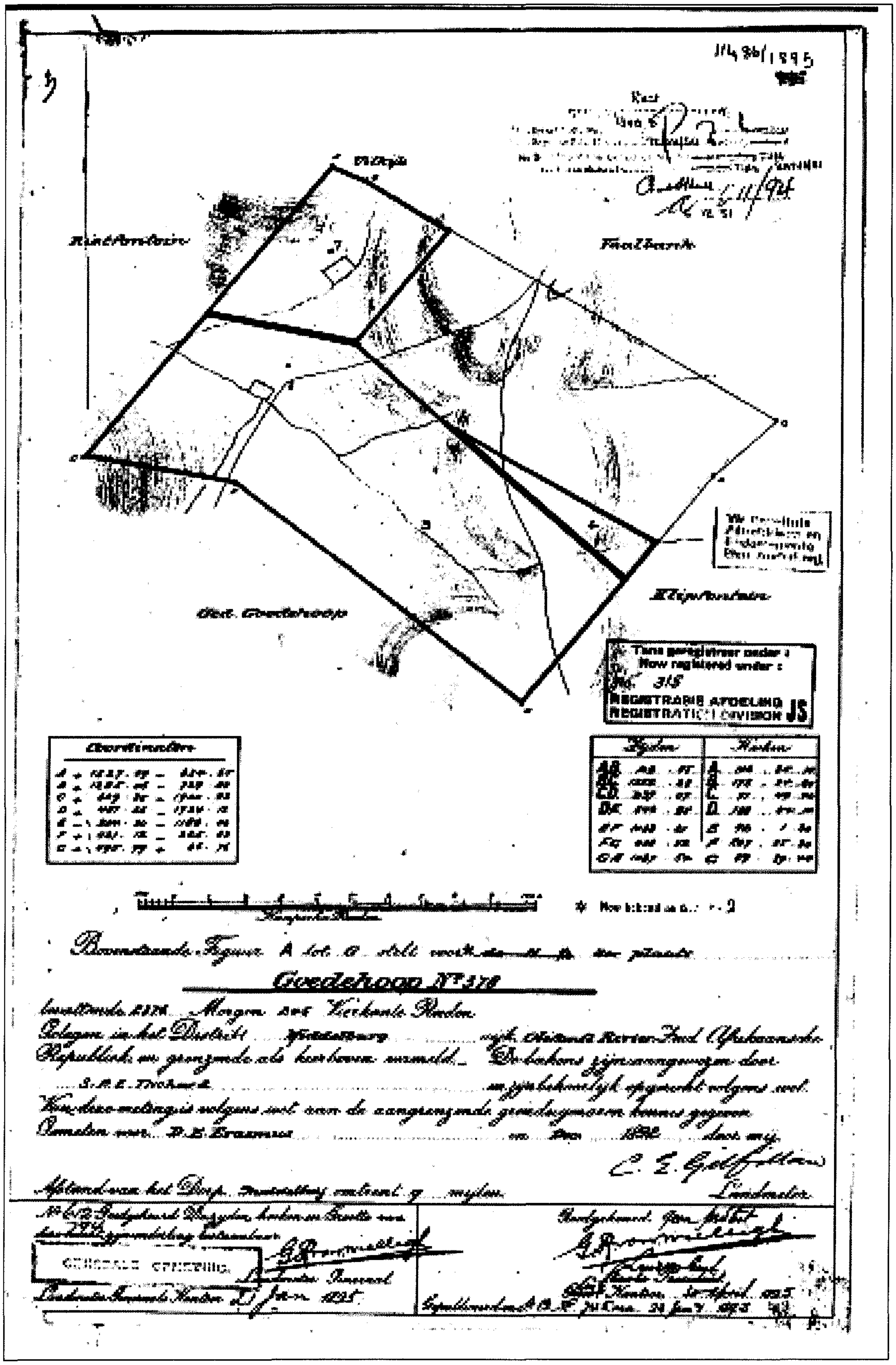

Figure 1: The 1892 property act survey for the farm Goedehoop 315 JS.

CULTURAL LANDSCAPE

The main cultural landscape type associated with this area is one of heavy industrial and mining activities combined with agricultural activities and power generation. The mine dumps visible from the site adds to the atmosphere of mining and exploration. This cultural identity has grown to such an extent that it overshadows any previous cultural identity that the area might have had in the past.

The cultural landscape for this area is also richly associated with the colonial period as well as its violent past. A unique stone architectural heritage was established in the Eastern Highveld from the second half of the 19th century well into the early 20th century. During this time period stone was used to build farmsteads and dwellings, both in urban and in rural areas. Although a contemporary stone architecture also existed in the Karoo and in the Eastern Free State Province of South Africa a wider variety of stone types were used in the Eastern Highveld. These included sandstone, ferricrete (.ouklip.), dolerite (.blouklip.), granite, shale and slate.

The origins of a vernacular stone architecture in the Eastern Highveld may be ascribed to various reasons of which the ecological characteristics of the region may be the most important. Whilst this region is generally devoid of any natural trees which could be used as timber in the construction of farmsteads, outbuildings, cattle enclosures and other structures, the scarcity of fire wood also prevented the manufacture of baked clay bricks. Consequently stone served as the most important building material in the Eastern Highveld.

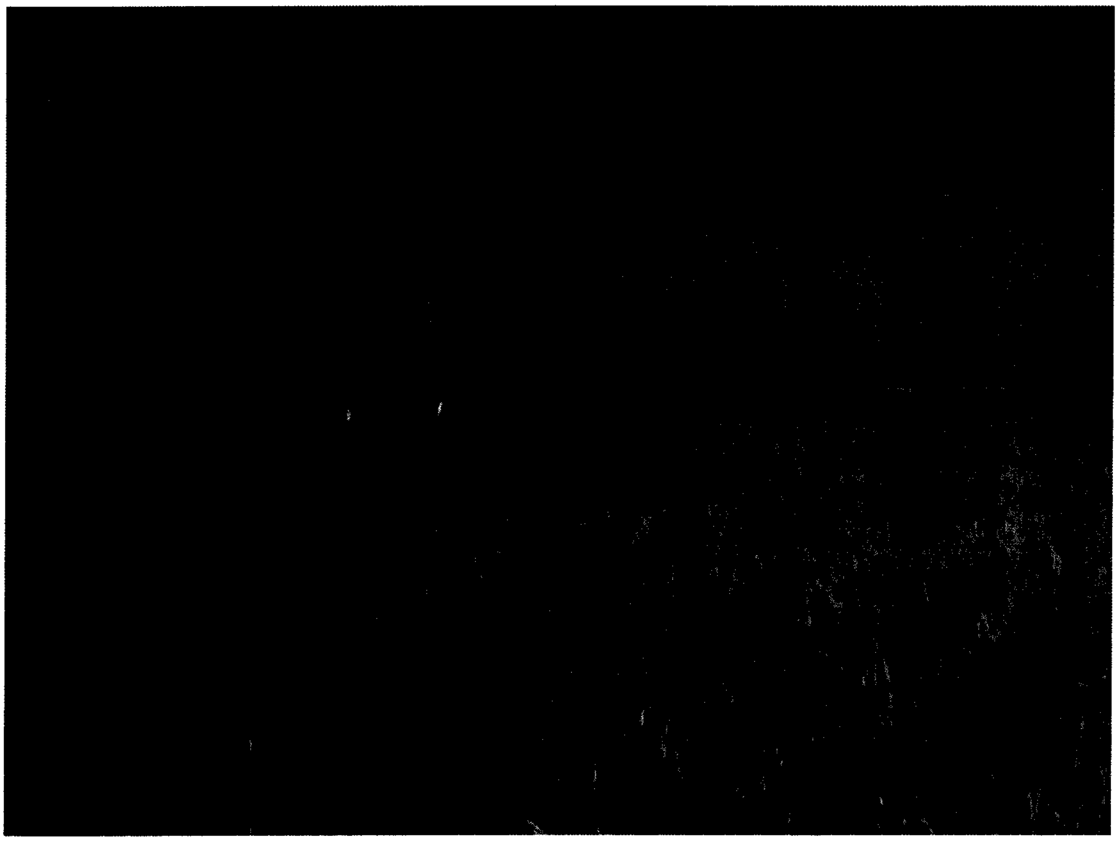

Figure 2: Photo indicating landscape type

Chapter 3 **IMPACT ASSESSMENT**

MEASURING AND EVALUATING THE CULTURAL SENSITIVITY OF THE STUDY AREA

In 2003 the SAHRA compiled the following guidelines to evaluate the cultural significance of individual heritage resources:

TYPE OF RESOURCE

- Place
- Archaeological Site
- Structure
- Grave
- Paleontological Feature
- Geological Feature

TYPE OF SIGNIFICANCE

1. HISTORIC VALUE

   It is important in the community, or pattern of history

   - Important in the evolution of cultural landscapes and settlement patterns
   - Important in exhibiting density, richness or diversity of cultural features illustrating the human occupation and evolution of the nation, province, region or locality.
   - Important for association with events, developments or cultural phases that have had a significant role in the human occupation and evolution of the nation, province, region or community.
   - Important as an example for technical, creative, design or artistic excellence, innovation or achievement in a particular period.

   It has strong or special association with the life or work of a person, group or organisation of importance in history

   - Importance for close associations with individuals, groups or organisations whose life, works or activities have been significant within the history of the nation, province, region or community.

   It has significance relating to the history of slavery

   - Importance for a direct link to the history of slavery in South Africa.

2. AESTHETIC VALUE

   It is important in exhibiting particular aesthetic characteristics valued by a community or cultural group.

   - Important to a community for aesthetic characteristics held in high esteem or otherwise valued by the community.
   - Importance for its creative, design or artistic excellence, innovation or achievement.
   - Importance for its contribution to the aesthetic values of the setting demonstrated by a landmark quality or having impact on important vistas or otherwise contributing to the identified aesthetic qualities of the cultural environs or the natural landscape within which it is located.
   - In the case of an historic precinct, importance for the aesthetic character created by the individual components which collectively form a significant streetscape, townscape or cultural environment.

3. SCIENTIFIC VALUE

   It has potential to yield information that will contribute to an understanding of natural or cultural heritage

- Importance for information contributing to a wider understanding of natural or cultural history by virtue of its use as a research site, teaching site, type locality, reference or benchmark site.
- Importance for information contributing to a wider understanding of the origin of the universe or of the development of the earth.
- Importance for information contributing to a wider understanding of the origin of life; the development of plant or animal species, or the biological or cultural development of hominid or human species.
- Importance for its potential to yield information contributing to a wider understanding of the history of human occupation of the nation, Province, region or locality.
- It is important in demonstrating a high degree of creative or technical achievement at a particular period
- Importance for its technical innovation or achievement.

4. SOCIAL VALUE
   - It has strong or special association with a particular community or cultural group for social, cultural or spiritual reasons
   - Importance as a place highly valued by a community or cultural group for reasons of social, cultural, religious, spiritual, symbolic, aesthetic or educational associations.
   - Importance in contributing to a community's sense of place.

DEGREES OF SIGNIFICANCE

1. RARITY

It possesses uncommon, rare or endangered aspects of natural or cultural heritage.
- Importance for rare, endangered or uncommon structures, landscapes or phenomena.

2. REPRESENTIVITY
   - It is important in demonstrating the principal characteristics of a particular class of natural or cultural places or objects.
   - Importance in demonstrating the principal characteristics of a range of landscapes or environments, the attributes of which identify it as being characteristic of its class.
   - Importance in demonstrating the principal characteristics of human activities (including way of life, philosophy, custom, process, land-use, function, design or technique) in the environment of the nation, province, region or locality.

The table below illustrates how a site's heritage significance is determined

Spheres of Significance	High	Medium	Low
International			
National			
Provincial			
Regional			
Local			
Specific Community			

What other similar sites may be compared to this site?

ASSESSMENT OF IMPACTS

ACTIVITIES THAT WILL AFFECT THE HERITAGE ENVIRONMENT

POST-CONTACT HERITAGE

Nature of Impacts: The development of the pipeline could negatively affect the graveyard site located at MWR 003 through trenching activities. The structural foundation remains found here could also be negatively affected by trenching and road building activities.

Extent of Impacts: Localised damage to the site (see *Impact Statement* section for application).

Nature of Impact: Possible post-contact site could be damaged locally by excavation activities		
	Without Mitigation	**With Mitigation**
Extent	Local	Local
Duration	Long term	Long term
Magnitude	High	Low
Probability	Probable	Improbable
Significance	High	High
Status	Negative	Positive
Reversibility	Irreversible	Irreversible
Irreplaceable loss of resource	Yes	No
Can impacts be mitigated	No	Yes
Mitigation	Alter alignment of pipeline to avoid graveyard	
Cumulative impacts	None	
Residual impacts	Local negativity towards mining activities	

IMPACT STATEMENT

PALEONTOLOGICAL SITES

No paleontological sites of high value could be identified. Paleontological sites could be affected if bedrock was to be disturbed during the trenching activities.

Mitigation

Paleontological monitoring during excavation activities where bedrock is to be disturbed.

ARCHEOLOGICAL SITES

One site of archaeological importance was identified in the study area. This is a small graveyard with at least five graves. There are some associated structural foundations next to the graveyard that could possibly have been the farmstead. This site has a high, local significance.

Figure 3: Graveyard at Site MWR 003

Mitigation

It is recommended that the pipeline route be realigned to avoid the grave site and associated structural ruins. A safety buffer of 50 meters from the edge of the site is recommended.

BUILT ENVIRONMENT

Some modern structures associated with farming were identified on the property adjacent to the site these include;

- Brick shed with corrugated roof (modern)
- Brick outbuildings (modern)
- Metal chicken runs (modern)
- Barb-wire fences (modern)
- Concrete watering troughs (modern)
- Concrete reservoirs (modern)
- Dirt roads (modern)
- Footpaths

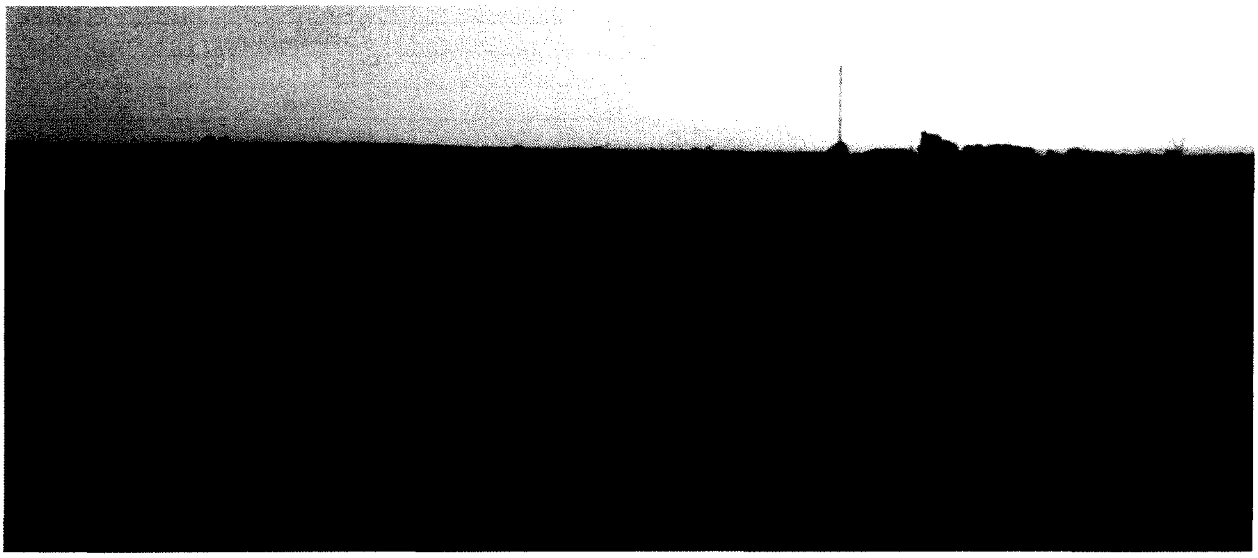

Figure 4: Dirt roads on site

Figure 5: Shed, outbuildings and fences

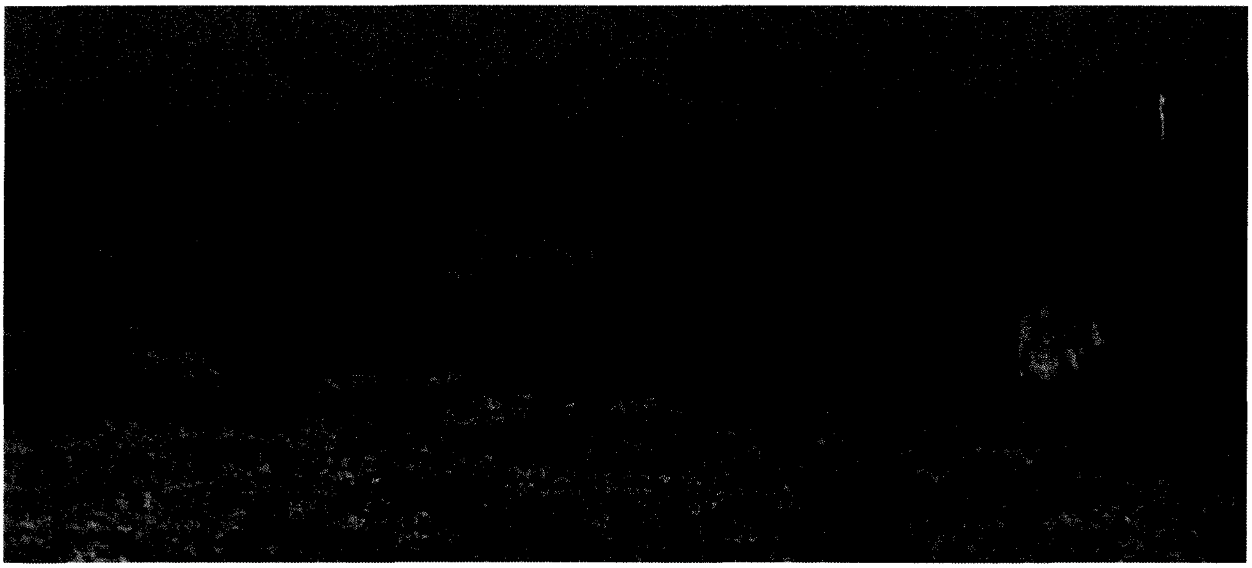

Figure 6: Watering troughs

Mitigation

None of the structures with the exception of the roads and fences will be affected by the trenching activities. It is recommended that the fences and roads be rehabilitated after construction of the pipeline.

Cultural Landscape

The following landscape types were identified during the study.

Landscape Type	Description	Occurrence still possible?	Identified on site?
1 Paleontological	Mostly fossil remains. Remains include microbial fossils such as found in Baberton Greenstones	[redacted]	No
2 Archaeological	Evidence of human occupation associated with the following phases – Early-, Middle-, Late Stone Age, Early-, Late Iron Age, Pre-Contact Sites, Post-Contact Sites	[redacted]	No
3 Historic Built Environment	- Historical townscapes/streetscapes - Historical structures; i.e. older than 60 years - Formal public spaces - Formally declared urban conservation areas - Places associated with social identity/displacement	No	No
4 Historic Farmland	These possess distinctive patterns of settlement and historical features such as: - Historical farm yards - Historical farm workers villages/settlements - Irrigation furrows - Tree alignments and groupings - Historical routes and pathways - Distinctive types of planting - Distinctive architecture of cultivation e.g. planting blocks, trellising, terracing, ornamental planting.	[redacted]	[redacted]
5 Historic rural town	- Historic mission settlements - Historic townscapes	No	No
6 Pristine natural landscape	- Historical patterns of access to a natural amenity - Formally proclaimed nature reserves	No	No

	- Evidence of pre-colonial occupation - Scenic resources, e.g. view corridors, viewing sites, visual edges, visual linkages - Historical structures/settlements older than 60 years - Pre-colonial or historical burial sites - Geological sites of cultural significance.		
7 Relic Landscape	- Past farming settlements - Past industrial sites - Places of isolation related to attitudes to medical treatment - Battle sites - Sites of displacement,	[redacted]	
8 Burial grounds and grave sites	- Pre-colonial burials (marked or unmarked, known or unknown) - Historical graves (marked or unmarked, known or unknown) - Graves of victims of conflict - Human remains (older than 100 years) - Associated burial goods (older than 100 years) - Burial architecture (older than 60 years)		
9 Associated Landscapes	- Sites associated with living heritage e.g. initiation sites, harvesting of natural resources for traditional medicinal purposes - Sites associated with displacement & contestation - Sites of political conflict/struggle - Sites associated with an historic event/person - Sites associated with public memory	No	No
10 Historical Farmyard	- Setting of the yard and its context - Composition of structures - Historical/architectural value of individual structures - Tree alignments - Views to and from - Axial relationships - System of enclosure, e.g. defining walls - Systems of water reticulation and irrigation, e.g. furrows - Sites associated with slavery and farm labour - Colonial period archaeology	No	No
11 Historic institutions	- Historical prisons - Hospital sites - Historical school/reformatory sites - Military bases	No	No
12 Scenic visual	- Scenic routes	No	No
13 Amenity landscape	- View sheds - View points - Views to and from - Gateway conditions - Distinctive representative landscape conditions - Scenic corridors	No	No

Mitigation

It is recommended that the development designs take into account the positive and negative characteristics of the existing cultural landscape type and that they endeavor to promote the positive aspects while at the same time mitigating the negative aspects.

IMPACT ASSESSMENT MATRIX

NHRA Class	Identification		Significance	Impact	Recommendations
	Site	GPS			
Buildings and structures	MWR 001	25° 53' 21" S 29° 23' 54" E	Low	None	None
	MWR 002	25° 53' 12" S 29° 24' 04" E	Low	None	None
Graves and Burial Grounds	MWR 003	25° 53' 04" S 29° 24' 16" E	High	Severe	Alter pipeline route alignment

RESOURCE MANAGEMENT RECOMMENDATIONS

Although unlikely, sub-surface remains of heritage sites could still be encountered during the construction activities associated with the project. Such sites would offer no surface indication of their presence due to the high state of alterations in some areas as well as heavy plant cover in other areas. The following indicators of unmarked sub-surface sites could be encountered:

- Ash deposits (unnaturally grey appearance of soil compared to the surrounding substrate);
- Bone concentrations, either animal or human;
- Ceramic fragments such as pottery shards either historic or pre-contact;
- Stone concentrations of any formal nature.

The following recommendations are given should any sub-surface remains of heritage sites be identified as indicated above:

- All operators of excavation equipment should be made aware of the possibility of the occurrence of sub-surface heritage features and the following procedures should they be encountered.
- All construction in the immediate vicinity (50m radius of the site) should cease.
- The heritage practitioner should be informed as soon as possible.
- In the event of obvious human remains the South African Police Services (SAPS) should be notified.
- Mitigation measures (such as refilling etc.) should not be attempted.
- The area in a 50m radius of the find should be cordoned off with hazard tape.
- Public access should be limited.
- The area should be placed under guard.
- No media statements should be released until such time as the heritage practitioner has had sufficient time to analyze the finds.

CONCLUSION

The area investigated shows numerous signs of human occupation and especially agricultural activities. With the exception of the small graveyard and associated ruins, none of these structures have any cultural heritage significance at this stage. Provided the pipeline route can be deviated to skirt this site with at least a 50m safety buffer, no further mitigation is needed at this site. It is recommended that should bedrock be affected during trenching activities that a palaeontologist be appointed to monitor the construction activities.

Chapter 3

SITE REGISTER

HERITAGE SITES IDENTIFIED WITHIN THE STUDY AREA

SITE MWR 001

GPS Coordinates 25° 53' 21" S
29° 23' 54" E

A concrete watering trough of recent origin is located here. The trough is still in use and functional.

SITE MWR 002

GPS Coordinates 25° 53' 12" S
29° 24' 04" E

At this site a large modern barn and associated outbuildings is located. All the structures are of a modern nature and building design.

Modern structures at MWR 002

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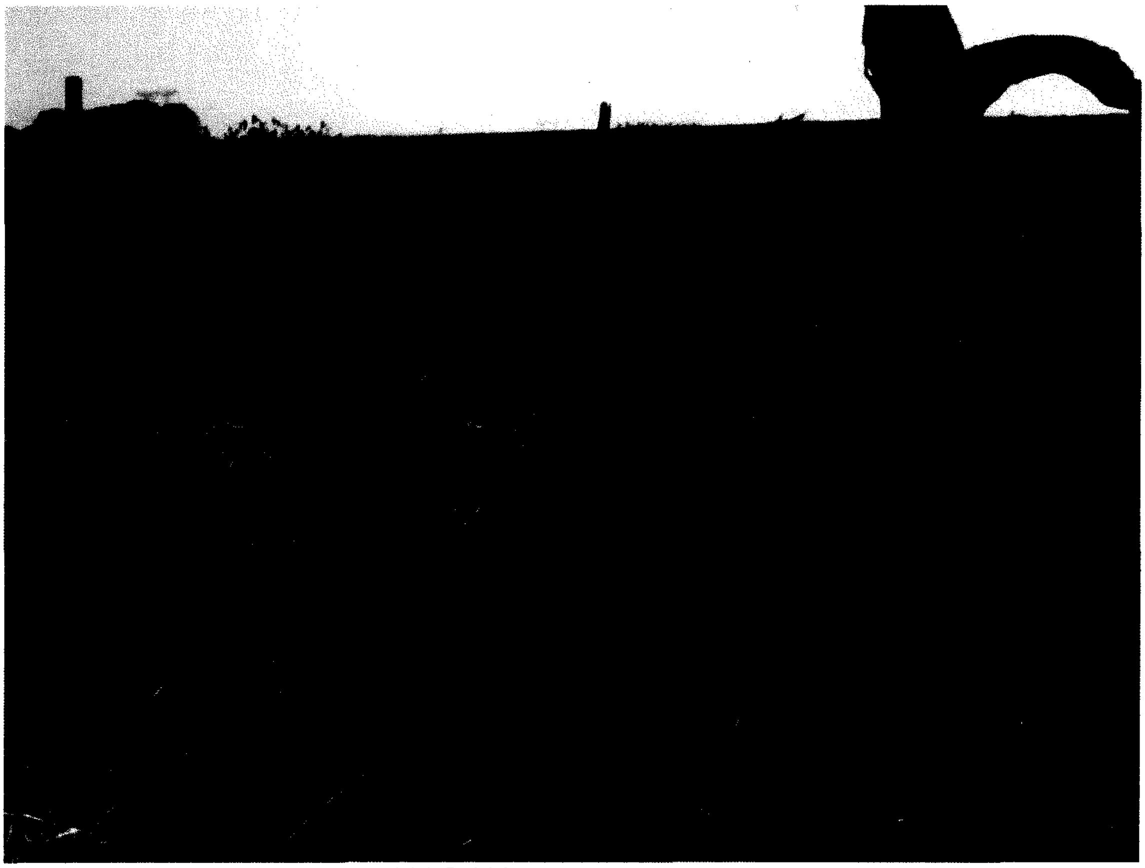
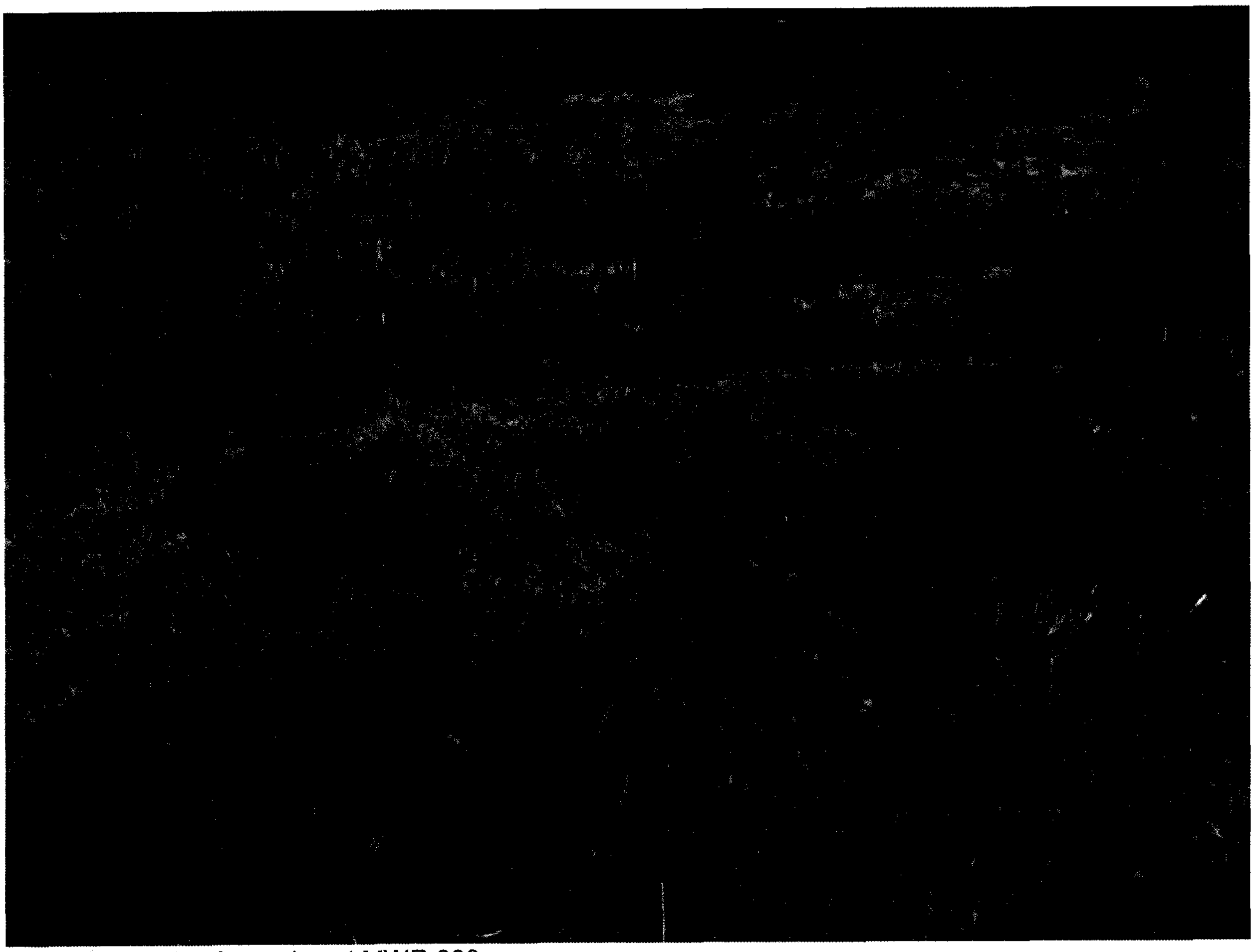
Site MWR 003

GPS Coordinates 25° 53' 04" S
29° 24' 16" E



Graveyard with five graves located at MWR 003



Possible structural remains at MWR 003

A small graveyard is located at this site. It contains at least five marked graves. Some of the graves are marked and dates of 1965, 1958 and 1977 could be discerned. The graves seem to be of western origin.

The site also contains several earthen mounds that could possibly be the remains of a farmstead associated with the graves.

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METHODOLOGY

INVENTORY

Inventory studies involve the in-field survey and recording of archaeological resources within a proposed development area. The nature and scope of this type of study is defined primarily by the results of the overview study. In the case of site-specific developments, direct implementation of an inventory study may preclude the need for an overview.

There are a number of different methodological approaches to conducting inventory studies. Therefore, the proponent, in collaboration with the archaeological consultant, must develop an inventory plan for review and approval by the SAHRA prior to implementation (*Dincause, Dena F., H. Martin Wobst, Robert J. Hasenstab and David M. Lacy 1984)*.

SITE SURVEYING

Site surveying is the process by which archaeological sites are located and identified on the ground. Archaeological site surveys often involve both surface inspection and subsurface testing. For the purposes of heritage investigations, *archaeological sites* refer to any site with heritage potential (i.e. historic sites, cultural sites, rock art sites etc.).

A systematic surface inspection involves a foot traverse along pre-defined linear transects which are spaced at systematic intervals across the survey area. This approach is designed to achieve representative area coverage. Alternatively, an archaeological site survey may involve a non-systematic or random walk across the survey area. Subsurface testing is an integral part of archaeological site survey. The purpose of subsurface testing, commonly called "shovel testing", is to:

(a) assist in the location of archaeological sites which are buried or obscured from the surveyor's view, and

(b) help determine the horizontal and vertical dimensions and internal structure of a site.

In this respect, subsurface testing should not be confused with evaluative testing, which is a considerably more intensive method of assessing site significance (*King, Thomas F., 1978)*.

Once a site is located, subsurface testing is conducted to record horizontal extent, depth of the cultural matrix, and degree of internal stratification. Because subsurface testing, like any form of site excavation, is destructive it should be conducted only when necessary and in moderation.

Subsurface testing is usually accomplished by shovel, although augers and core samplers are also used where conditions are suitable. Shovel test units averaging 40 square cm are generally appropriate, and are excavated to a sterile stratum (i.e. C Horizon, alluvial till, etc.).

Depending on the site survey strategy, subsurface testing is conducted systematically or randomly across the survey area. Other considerations such as test unit location, frequency, depth and interval spacing will also depend on the survey design as well as various biophysical factors. *(Lightfoot, Keng G. 1989)*.

SURVEY SAMPLING

Site survey involves the complete or partial inspection of a proposed project area for the purpose of locating archaeological or other heritage sites. Since there are many possible approaches to field survey, it is important to consider the biophysical conditions and archaeological site potential of the survey area in designing the survey strategy.

Ideally, the archaeological site inventory should be based on intensive survey of every portion of the impact area, as maximum area coverage will provide the most comprehensive understanding of archaeological and other heritage resource density and distribution. However, in many cases the size of the project area may render a complete survey impractical because of time and cost considerations.

In some situations it may be practical to intensively survey only a sample of the entire project area. Sample selection is approached systematically, based on accepted statistical sampling procedures, or judgementally, relying primarily on subjective criteria *(Butler, W., 1984)*.

SYSTEMATIC SURVEY SAMPLING

A systematic sample survey is designed to locate a representative sample of archaeological or heritage resources within the project area. A statistically valid sample will allow predictions to be made regarding total resource density, distribution and variability. In systematic sample surveys it may be necessary to exempt certain areas from intensive inspection owing to excessive slope, water bodies, landslides, land ownership, land use or other factors. These areas must be explicitly defined. Areas characterized by an absence of road access or dense vegetation should not be exempted. *(Dunnel, R.C., Dancey W.S. 1983).*

JUDGEMENTAL SURVEY SAMPLING

Under certain circumstances, it is appropriate to survey a sample of the project area based entirely on professional judgement regarding the location of sites. Only those areas which can reasonably be expected to contain archaeological or heritage sites are surveyed.

However, a sufficient understanding of the cultural and biophysical factors which influenced or accounted for the distribution of these sites over the landscape is essential. Careful consideration must be given to ethnographic patterns of settlement, land use and resource exploitation; the kinds and distribution of aboriginal food sources; and restrictions on site location imposed by physical terrain, climatic regimes, soil chemistry or other factors. A judgemental sample survey is not desirable if statistically valid estimates of total heritage resource density and variability are required *(McManamon F.P. 1984).*

ASSESSMENT

Assessment studies are only required where conflicts have been identified between heritage resources and a proposed development. These studies require an evaluation of the heritage resource to be impacted, as well as an assessment of project impacts. The purpose of the assessment is to provide recommendations as to the most appropriate manner in which the resource may be managed in light of the identified impacts. Management options may include alteration of proposed development plans to avoid resource impact, mitigative studies directed at retrieving resource values prior to impact, or compensation for the unavoidable loss of resource values.

It is especially important to utilize specialists at this stage of assessment. The evaluation of any archaeological resource should be performed by professionally qualified individuals.

SITE EVALUATION

Techniques utilized in evaluating the significance of a heritage site include systematic surface collecting and evaluative testing. Systematic surface collection is employed wherever archaeological remains are evident on the ground surface. However, where these sites contain buried deposits, some degree of evaluative testing is also required.

Systematic surface collection from archaeological sites should be limited, insofar as possible, to a representative sample of materials. Unless a site is exceptionally small and limited to the surface, no attempt should be made at this stage to collect all or even a major portion of the materials. Intensive surface collecting should be reserved for full scale data recovery if mitigative studies are required.

Site significance is determined following an analysis of the surface collected and/or excavated materials (*Miller, C.L. II, 1989).*

SIGNIFICANCE CRITERIA

There are several kinds of significance, including scientific, public, ethnic, historic and economic, that need to be taken into account when evaluating heritage resources. For any site, explicit criteria are used to measure these values. Checklists of criteria for evaluating pre-contact and post-contact archaeological sites are provided in Appendix B and Appendix C. These checklists are not intended to be exhaustive or inflexible. Innovative approaches to site evaluation which emphasize quantitative analysis and objectivity are encouraged. The process used to derive a measure of relative site significance must be rigorously documented, particularly the system for ranking or weighting various evaluated criteria.

Site integrity, or the degree to which a heritage site has been impaired or disturbed as a result of past land alteration, is an important consideration in evaluating site significance. In this regard, it is important to recognize that although an archaeological site has been disturbed, it may still contain important scientific information.

Heritage resources may be of scientific value in two respects. The potential to yield information which, if properly recovered, will enhance understanding of Southern African human history is one appropriate measure of scientific significance. In this respect, archaeological sites should be evaluated in terms of their potential to resolve current archaeological research problems. Scientific significance also refers to the potential for relevant contributions to other academic disciplines or to industry.

Public significance refers to the potential a site has for enhancing the public's understanding and appreciation of the past. The interpretive, educational and recreational potential of a site are valid indications of public value. Public significance criteria such as ease of access, land ownership, or scenic setting are often external to the site itself. The relevance of heritage resource data to private industry may also be interpreted as a particular kind of public significance.

Ethnic significance applies to heritage sites which have value to an ethnically distinct community or group of people. Determining the ethnic significance of an archaeological site may require consultation with persons having special knowledge of a particular site. It is essential that ethnic significance be assessed by someone properly trained in obtaining and evaluating such data.

Historic archaeological sites may relate to individuals or events that made an important, lasting contribution to the development of a particular locality or the province. Historically important sites also reflect or commemorate the historic socioeconomic character of an area. Sites having high historical value will also usually have high public value.

The economic or monetary value of a heritage site, where calculable, is also an important indication of significance. In some cases, it may be possible to project monetary benefits derived from the public's use of a heritage site as an educational or recreational facility. This may be accomplished by employing established economic evaluation methods; most of which have been developed for valuating outdoor recreation. The objective is to determine the willingness of users, including local residents and tourists, to pay for the experiences or services the site provides even though no payment is presently being made. Calculation of user benefits will normally require some study of the visitor population *(Smith, L.D. 1977)*.

Assessing Impacts

A heritage resource impact may be broadly defined as the net change between the integrity of a heritage site with and without the proposed development. This change may be either beneficial or adverse.

Beneficial impacts occur wherever a proposed development actively protects, preserves or enhances a heritage resource. For example, development may have a beneficial effect by preventing or lessening natural site erosion. Similarly, an action may serve to preserve a site for future investigation by covering it with a protective layer of fill. In other cases, the public or economic significance of an archaeological site may be enhanced by actions which facilitate non-destructive public use. Although beneficial impacts are unlikely to occur frequently, they should be included in the assessment.

More commonly, the effects of a project on heritage sites are of an adverse nature. Adverse impacts occur under conditions that include:

(a) destruction or alteration of all or part of a heritage site;

(b) isolation of a site from its natural setting; and

(c) introduction of physical, chemical or visual elements that are out-of-character with the heritage resource and its setting.

Adverse effects can be more specifically defined as direct or indirect impacts. Direct impacts are the immediately demonstrable effects of a project which can be attributed to particular land modifying actions. They are directly caused by a project or its ancillary facilities and occur at the same time and place. The immediate consequences of a project action, such as slope failure following reservoir inundation, are also considered direct impacts.

Indirect impacts result from activities other than actual project actions. Nevertheless, they are clearly induced by a project and would not occur without it. For example, project development may induce changes in land use or population density, such as increased urban and recreational development, which may indirectly impact upon heritage sites. Increased vandalism of heritage sites, resulting from improved or newly introduced access, is also considered an indirect impact. Indirect impacts are much more difficult to assess and quantify than impacts of a direct nature.

Once all project related impacts are identified, it is necessary to determine their individual level-of-effect on heritage resources. This assessment is aimed at determining the extent or degree to which future opportunities for scientific research, preservation, or public appreciation are foreclosed or otherwise adversely affected by a proposed action. Therefore, the assessment provides a reasonable indication of the relative significance or importance of a particular impact. Normally, the assessment should follow site evaluation since it is important to know what heritage values may be adversely affected.

The assessment should include careful consideration of the following level-of-effect indicators, which are defined in Appendix D:

- magnitude
- severity
- duration
- range
- frequency
- diversity
- cumulative effect
- rate of change

The level-of-effect assessment should be conducted and reported in a quantitative and objective fashion. The methodological approach, particularly the system of ranking level-of-effect indicators, must be rigorously documented and recommendations should be made with respect to managing uncertainties in the assessment. *(Zubrow, Ezra B.A., 1984).*

The study area was surveyed using standard archaeological surveying methods. The area was surveyed using directional parameters supplied by the GPS and surveyed by foot. This technique has proven to result in the maximum coverage of an area. This action is defined as;

'an archaeologist being present in the course of the carrying-out of the development works (which may include conservation works), so as to identify and protect archaeological deposits, features or objects which may be uncovered or otherwise affected by the works' (DAHGI 1999a, 28).

Standard archaeological documentation formats were employed in the description of sites. Using standard site documentation forms as comparable medium, it enabled the surveyors to evaluate the relative importance of sites found. Furthermore GPS (Global Positioning System) readings of all finds and sites were taken. This information was then plotted using a ***Garmin Colorado*** GPS (WGS 84- datum).

Indicators such as surface finds, plant growth anomalies, local information and topography were used in identifying sites of possible archaeological importance. Test probes were done at intervals to determine sub-surface occurrence of archaeological material. The importance of sites was assessed by comparisons with published information as well as comparative collections.

Test excavation is that form of archaeological excavation where the purpose is to establish the nature and extent of archaeological deposits and features present in a location which it is proposed to develop (though not normally to fully investigate those deposits or features) and allow an assessment to be made of the archaeological impact of the proposed development. It may also be referred to as archaeological testing' (DAHGI 1999a, 27).

'Test excavation should not be confused with, or referred to as, archaeological assessment which is the overall process of assessing the archaeological impact of development. Test excavation is one of the techniques in carrying out archaeological assessment which may also include, as appropriate, documentary research, field walking, examination of upstanding or visible features or structures, examination of aerial photographs, satellite or other remote sensing imagery, geophysical survey, and topographical assessment' (DAHGI 1999b, 18).

Scientific Significance

(a) Does the site contain evidence which may substantively enhance understanding of culture history, culture process, and other aspects of local and regional prehistory?

internal stratification and depth

chronologically sensitive cultural items

materials for absolute dating

association with ancient landforms

quantity and variety of tool type

distinct intra-site activity areas

tool types indicative of specific socio-economic or religious activity

cultural features such as burials, dwellings, hearths, etc.

diagnostic faunal and floral remains

exotic cultural items and materials

uniqueness or representativeness of the site

integrity of the site

(b) Does the site contain evidence which may be used for experimentation aimed at improving archaeological methods and techniques?

monitoring impacts from artificial or natural agents

site preservation or conservation experiments

data recovery experiments

sampling experiments

intra-site spatial analysis

(c) Does the site contain evidence which can make important contributions to paleoenvironmental studies?

topographical, geomorphological context

depositional character

diagnostic faunal, floral data

(d) Does the site contain evidence which can contribute to other scientific disciplines such as hydrology, geomorphology, pedology, meteorology, zoology, botany, forensic medicine, and environmental hazards research, or to industry including forestry and commercial fisheries?

Public Significance

(a) Does the site have potential for public use in an interpretive, educational or recreational capacity?

integrity of the site

technical and economic feasibility of restoration and development for public use

visibility of cultural features and their ability to be easily interpreted

accessibility to the public

opportunities for protection against vandalism representativeness and uniqueness of the site

aesthetics of the local setting

proximity to established recreation areas

present and potential land use

land ownership and administration

legal and jurisdictional status

local community attitude toward development

(b) Does the site receive visitation or use by tourists, local residents or school groups?

Ethnic Significance

(a) Does the site presently have traditional, social or religious importance to a particular group or community?

ethnographic or ethno-historic reference

documented local community recognition or, and concern for, the site

Economic Significance

(a) What value of user-benefits may be placed on the site?

visitors' willingness-to-pay

visitors' travel costs

Scientific Significance

(a) Does the site contain evidence which may substantively enhance understanding of historic patterns of settlement and land use in a particular locality, regional or larger area?

(b) Does the site contain evidence which can make important contributions to other scientific disciplines or industry?

Historic Significance

(a) Is the site associated with the early exploration, settlement, land use, or other aspect of southern Africa's cultural development?

(b) Is the site associated with the life or activities of a particular historic figure, group, organization, or institution that has made a significant contribution to, or impact on, the community, province or nation?

(c) Is the site associated with a particular historic event whether cultural, economic, military, religious, social or political that has made a significant contribution to, or impact on, the community, province or nation?

(d) Is the site associated with a traditional recurring event in the history of the community, province, or nation, such as an annual celebration?

Public Significance

(a) Does the site have potential for public use in an interpretive, educational or recreational capacity?

visibility and accessibility to the public

ability of the site to be easily interpreted opportunities for protection against vandalism

economic and engineering feasibility of reconstruction, restoration and maintenance

representativeness and uniqueness of the site

proximity to established recreation areas

compatibility with surrounding zoning regulations or land use

land ownership and administration

local community attitude toward site preservation, development or destruction

present use of site

(b) Does the site receive visitation or use by tourists, local residents or school groups?

Ethnic Significance

(a) Does the site presently have traditional, social or religious importance to a particular group or community?

Economic Significance

(a) What value of user-benefits may be placed on the site?

visitors' willingness-to-pay

visitors' travel costs

Integrity and Condition

(a) Does the site occupy its original location?

(b) Has the site undergone structural alterations? If so, to what degree has the site maintained its original structure?

(c) Does the original site retain most of its original materials?

(d) Has the site been disturbed by either natural or artificial means?

Other

(a) Is the site a commonly acknowledged landmark?

(b) Does, or could, the site contribute to a sense of continuity or identity either alone or in conjunction with similar sites in the vicinity?

(c) Is the site a good typical example of an early structure or device commonly used for a specific purpose throughout an area or period of time?

(d) Is the site representative of a particular architectural style or pattern?

Indicators of Impact Severity

Magnitude

The amount of physical alteration or destruction which can be expected. The resultant loss of heritage value is measured either in amount or degree of disturbance.

Severity

The irreversibility of an impact. Adverse impacts which result in a totally irreversible and irretrievable loss of heritage value are of the highest severity.

Duration

The length of time an adverse impact persists. Impacts may have short-term or temporary effects, or conversely, more persistent, long-term effects on heritage sites.

Range

The spatial distribution, whether widespread or site-specific, of an adverse impact.

Frequency

The number of times an impact can be expected. For example, an adverse impact of variable magnitude and severity may occur only once. An impact such as that resulting from cultivation may be of recurring or on-going nature.

Diversity

The number of different kinds of project-related actions expected to affect a heritage site.

Cumulative Effect

A progressive alteration or destruction of a site owing to the repetitive nature of one or more impacts.

Rate of Change

The rate at which an impact will effectively alter the integrity or physical condition of a heritage site. Although an important level-of-effect indicator, it is often difficult to estimate. Rate of change is normally assessed during or following project construction.

Location Map for the Middelburg Water Reclamation Project HIA

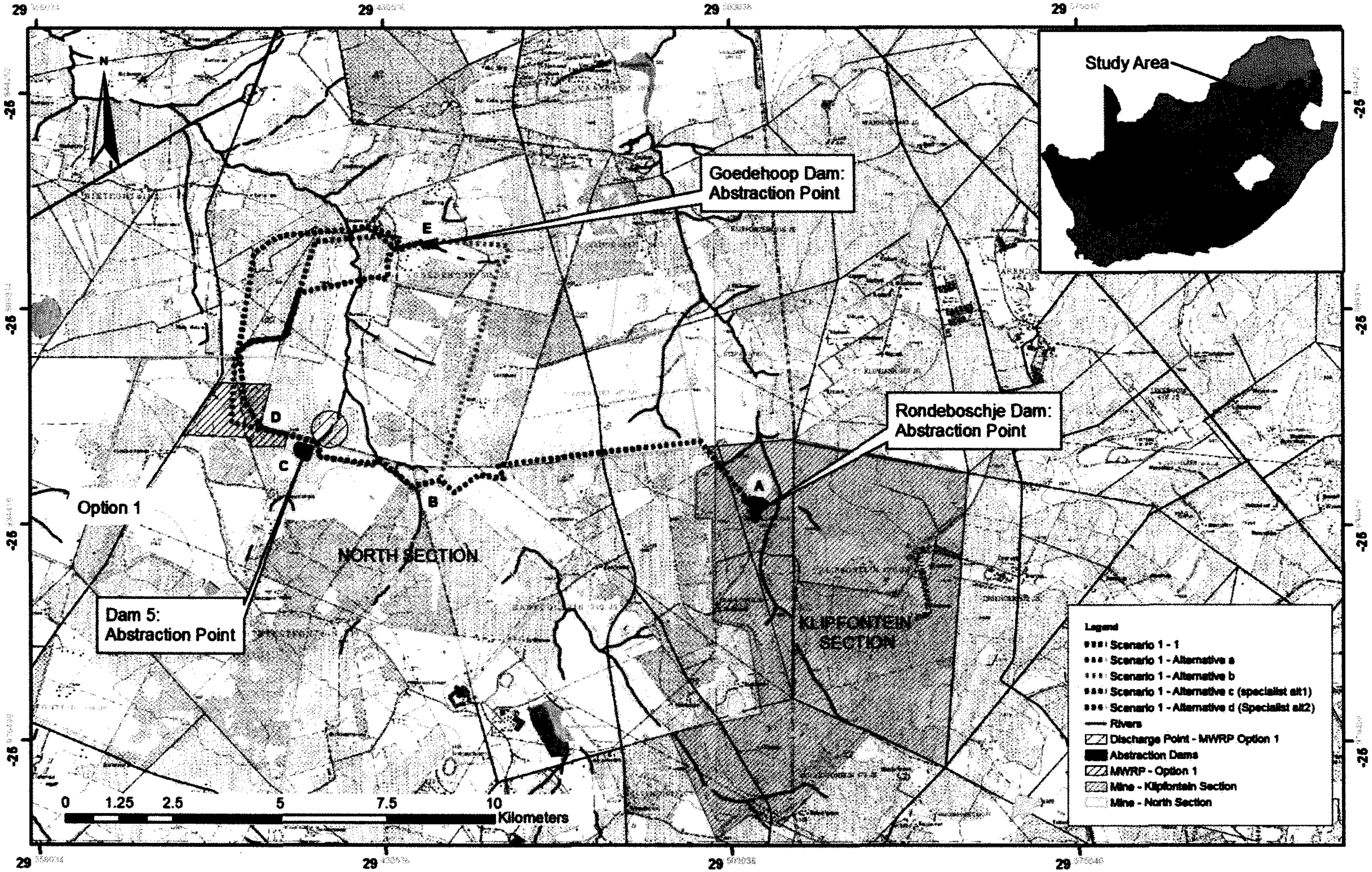
1:50 000 Map Reference 2529CD

G&A Heritage

Heritage Management Consultants

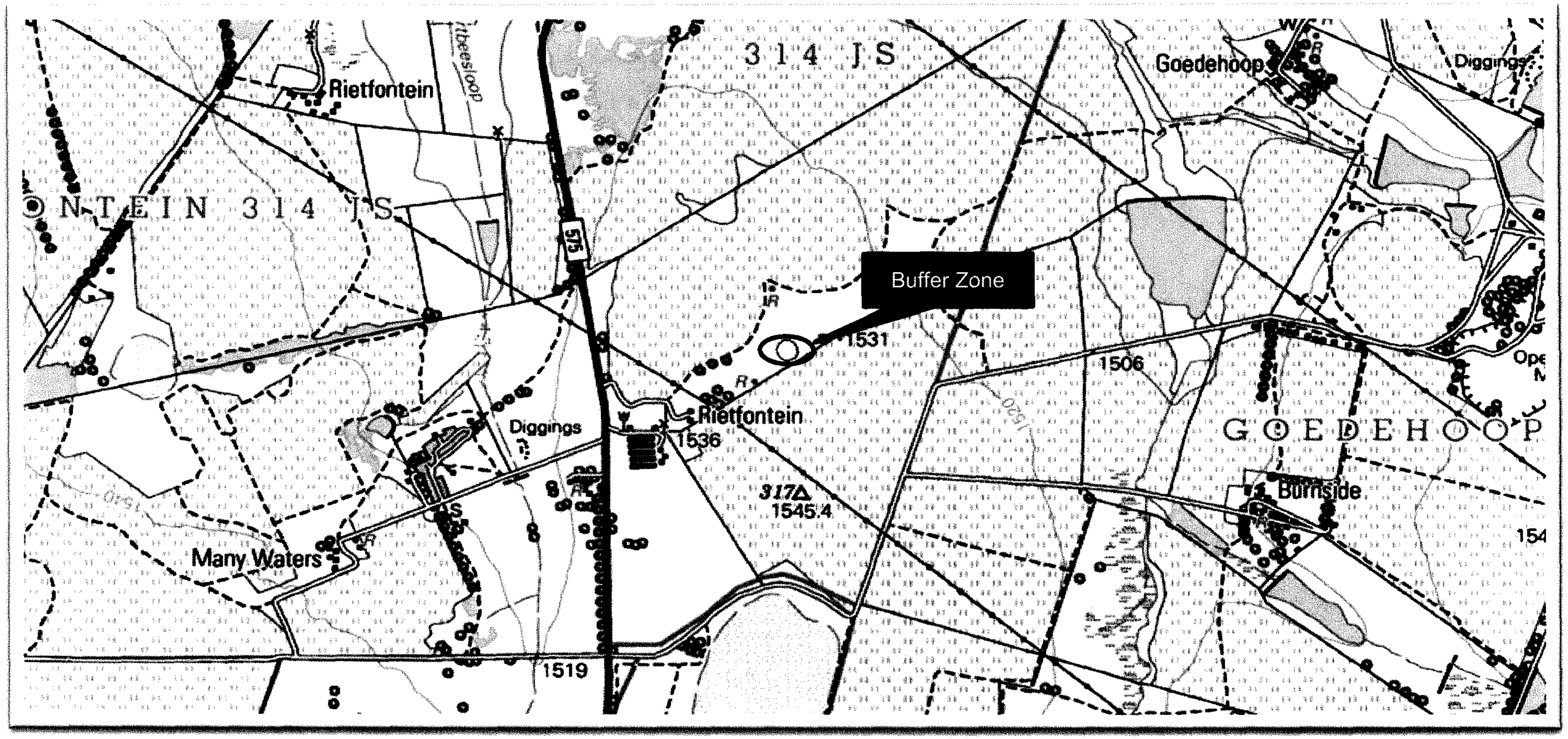
23/06/2011

Original Pipeline Project with Alternative Alignments

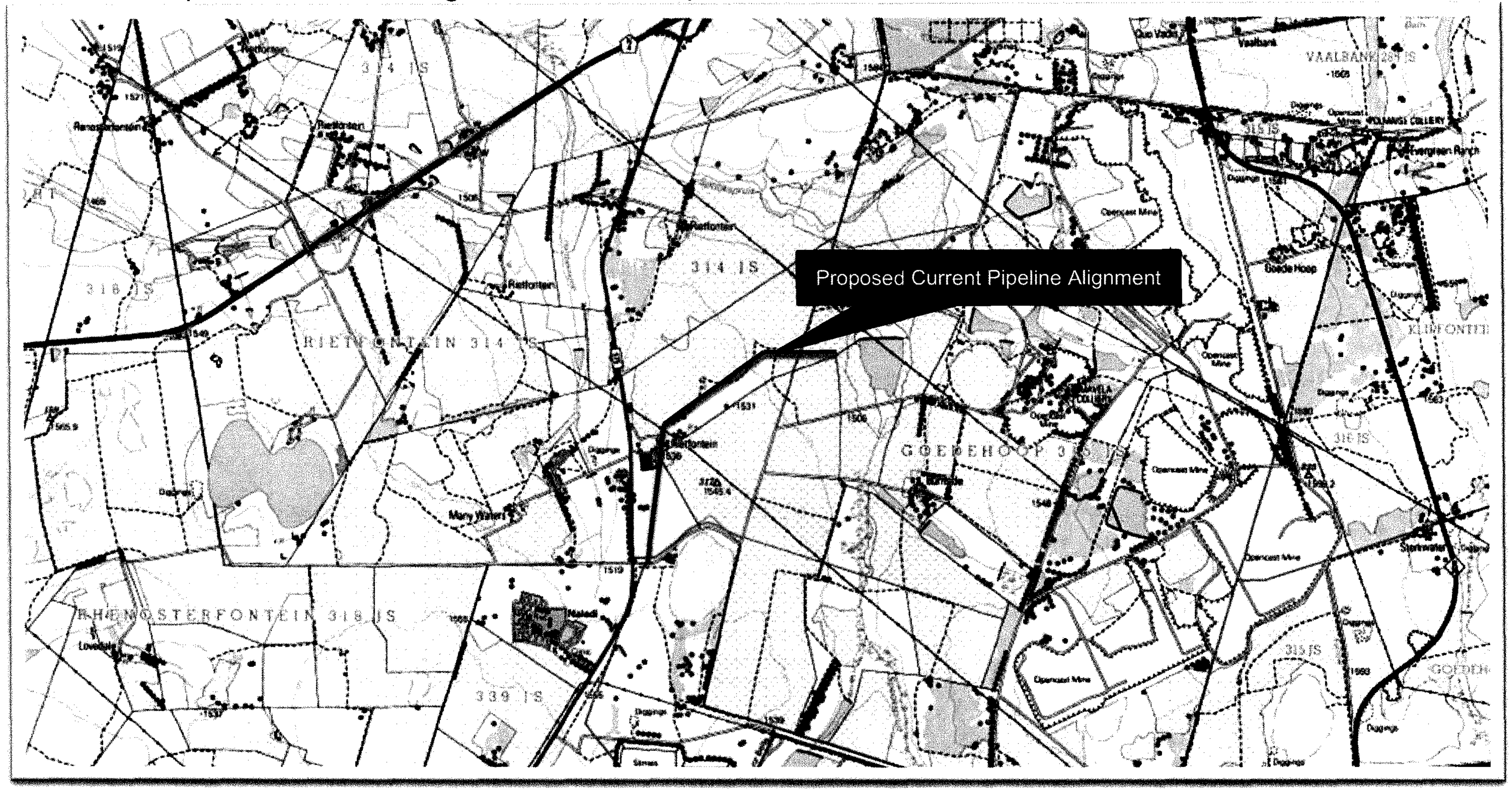


23/06/2011

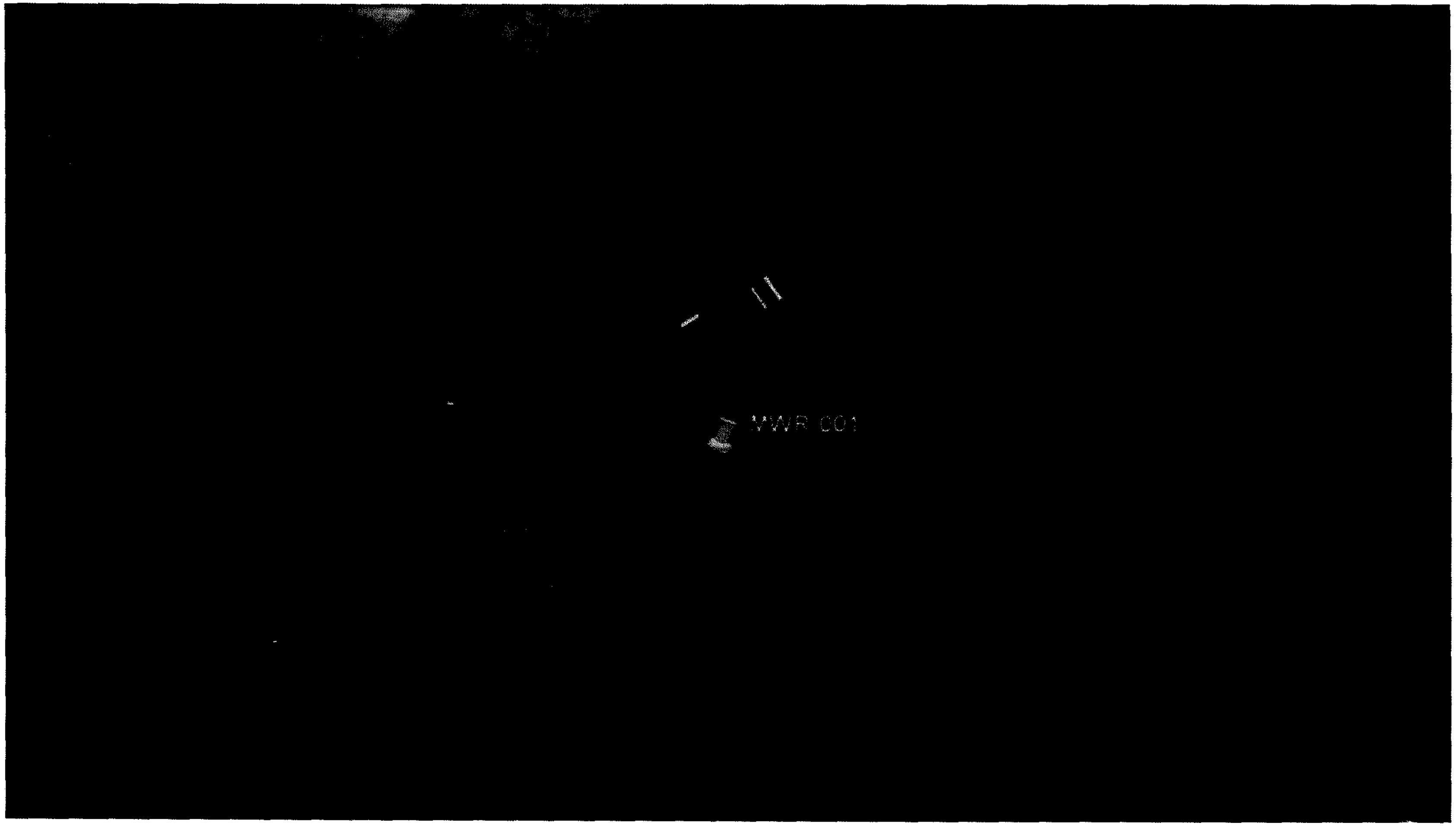
Buffer Zone Applicable to Heritage Site MWR 003



Proposed Current Alignment of the Pipeline



Aerial Photograph Showing the Location of Site MWR 001



Aerial Photograph Showing the Location of Site MWR 002

Aerial Photograph Showing the Location of Site MWR 003

Aerial Photograph Showing the Proposed Exlusion Zone Around Site MWR 003

D.10 Noise Impact Assessment

CONFIDENTIAL

ENVIRONMENTAL REPORT

on

A NOISE IMPACT ASSESSMENT FOR THE MIDDELBURG WATER RECLAMATION SCHEME

conducted on behalf of

JONES AND WAGENER CONSULTING
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2 & 12 JUNE 2008

PROJECT NO: 08273R

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LIST OF MAPS

LIST OF ANNEXURES

1. PURPOSE

Ergosaf conducted a noise impact assessment for the Middelburg Water Reclamation Scheme (MWRS) at **MIDDELBURG MINE, BHP BILLITON ENERGY COAL SOUTH AFRICA (BECSA).**

The purpose of the assessment was as follows:

(a) To identify noise sensitive areas that may be affected by noise producing operations associated with processes at the proposed Option 1 and Option 2 water treatment sites for the MWRS.

(b) To determine actual residual (baseline) noise values during the daytime and night-time intervals at noise sensitive areas.

(c) To measure the sound levels emitted by equipment and processes at a similar water treatment plant in the Witbank area (the Emalahleni Water Reclamation Scheme).

(d) To predict the impact that the above noise producing processes may have on identified noise sensitive areas.

(e) To determine a noise risk rating profile, in order to assess the risk presented to **MIDDELBURG MINE,** because of predicted noise impacts on neighbouring noise sensitive areas.

2. INTRODUCTION

Ms K. Gunnell of Jones and Wagener Consulting Civil Engineers requested Ergosaf to assess the noise impact that the proposed Middelburg Water Reclamation Scheme may have on neighbouring noise sensitive environments.

During the assessment, attention was paid to annoyance that may be caused by noise emanating from the project and the impact that it may have on noise sensitive environments. Noise is generally annoying or otherwise intrusive if the rating level of the noise under investigation exceeds the rating level of the residual (background) noise.

As the intensity of the noise increases, it is judged to be more annoying. In addition, if the noise is intermittent, irregular or rhythmic, or contains recognisable pure tones, it may be considerably more annoying than steady noise of the same intensity, or even the same perceived loudness.

This report deals with the results and findings of a noise impact assessment at the proposed MWRS at **MIDDELBURG MINE**.

3. STATUTORY REQUIREMENTS AND CRITERIA

The statutory requirements and criteria that were used for the noise impact assessment are provided below.

3.1 Noise Sensitive Areas

According to SANS 10328:2003, *Methods for Environmental Noise Impact Assessments,* the operation of a noise source in the proximity of a noise sensitive environment may have acoustical implications.

For the purpose of this assessment, Noise Sensitive Areas included the following:

(a) Educational, residential, office and health care buildings and their surroundings,

(b) Churches and their surroundings,

(c) Auditoriums and concert halls and their surroundings,

(d) Recreational areas, and

(e) Nature reserves.

3.2 Statutory Limits

The National Environmental Management Act promulgated in June 2006, requires an Environmental Noise Impact Assessment to be conducted to establish the impact of activities on the surrounding environment. In the absence of specific noise standards, the Noise Control Regulations promulgated in terms of the Environment Conservation Act (73 of 1989) would be applied. The above mentioned regulations require, inter alia, that no person shall make, produce or cause a disturbing noise, or allow it to be made, produced or caused by any person, machine, device or apparatus or any combination thereof.

TABLE 3.1: ACCEPTABLE RATING LEVELS FOR NOISE IN RURAL RESIDENTIAL DISTRICTS.

Equivalent continuous rating level (L_{ReqT}) for noise (dBA)	
Day Time (06h00 – 22h00)	**Night Time** (22h00 – 06h00)
45	35

Note: The values provided are A-weighted and include corrections for tonal character and impulsiveness of the noise.

3.3 Criteria for Annoyance

SANS Code of Practice 10103:2004, "*The Measurement and Rating of Environmental Noise with respect to Land Use, Health, Annoyance and Speech Communication*", was used to evaluate noise with respect to annoyance.

According to SANS 10103:2004, it is highly probable that the noise is annoying, or otherwise intrusive to the community, or to a group of persons, if the rating level of the ambient noise under investigation exceeds the residual noise level by 7 dBA or more.

The categories of estimated community response that was used for the purpose of this assessment are listed in Table 3.1 on page 2.

TABLE 3.2: CATEGORIES OF COMMUNITY / GROUP RESPONSE. SANS CODE OF PRACTICE 10103:2004.

Excess Δ L_{ReqT} dBA	Estimated Community/ Group Response	
	Category	Description
0 -10	Little	Sporadic complaints
5 – 15	Medium	Widespread complaints
10 – 20	Strong	Threats of community/ group action
> 15	Very Strong	Vigorous community/ group action

* **Calculate Δ L_{ReqT} from the following:**

Δ L_{ReqT} = L_{ReqT} of ambient noise under investigation MINUS the residual noise rating level that was measured.

4. INSTRUMENTATION AND METHODS

The following instrumentation and methods were used:

4.1 Instrumentation

A RION NL-32 integrating sound level meter (Serial No 00151088), fitted with a RION UC-53A 1/3 octave band filter (Serial No 308162), was used to record the results of this survey. Ergosaf calibrated the instrument before and after the survey with a RION NC-73 sound level calibrator (Serial No 11086853).

External calibrations of the instrumentation were performed by De Beer Calibration Services, a SANAS Accredited Laboratory, in accordance with the frequency prescribed in SANS 10083:2004. Measurements are traceable to National Metrology Standards (Certificates of Calibration Nos 2007-939 and 2008-063).

4.2 Methods

The methods that were used for the noise impact assessment are discussed below.

4.2.1 Identification of Noise Sensitive Environments

Noise sensitive areas were identified that may be affected by noise producing operations (Refer to Item 3.1).

4.2.2 Residual (Baseline) Noise Levels

Actual residual sound levels were recorded at neighbouring noise sensitive areas.

The measurement and evaluation of actual residual levels were conducted in accordance with SANS Code of Practice 10103:2004, "*The Measurement and Rating of Environmental Noise with respect to Land Use, Health, Annoyance and Speech Communication*".

4.2.3 Typical Sound Levels emitted by Noise Producing Operations

Noise levels emitted by noise producing operations were measured and the actual values were used to calculate the theoretical propagation, in order to obtain the predicted noise level at noise sensitive environments.

4.2.4 Increase in Ambient Noise Levels

The theoretical propagation of noise was calculated by means of a method described in SANS Code of Practice 0357:2004, *The Calculation of Sound Propagation by the Concawe Method*. The method is applicable to the propagation of sound over distances of up to two kilometres. The calculations included corrections for geometrical divergence (distance), atmospheric absorption, effect of ground surface and meteorological conditions. The height of the source and the height of the receiver as well as the effect of barriers were not taken into account.

The following environmental conditions were used in the calculation:

No	Environmental Parameter	Value/Level Used in Calculation of Noise Propagation
1.	Dry bulb temperature	18,8 °C
2.	Relative Humidity	47 %
3.	Ground Surface	Non-absorbent
4.	Solar Load	300 W/m^2
5.	Wind speed	2 m/s
6.	Dominant Wind direction	From noise source to receiver
7.	Barriers	None

°C **degrees Celsius** **%** **percentage**

W/m^2 **watt per square meter** **m/s** **meters per second**

Ambient noise levels produced by the noisy operations were calculated from the results of the noise propagation model and the residual noise rating levels that were measured at neighbouring communities. The ambient noise levels were calculated in accordance with SANS Code of Practice 10103:2004, "*The Measurement and Rating of Environmental Noise with Respect to Land Use, Health, Annoyance and Speech Communication*".

4.2.5 Impact of noise sources on neighbouring noise sensitive areas

The impact that noise producing operations may have on neighbouring noise sensitive areas was assessed by means of the difference between the predicted ambient noise and the measured residual noise rating level. The difference was evaluated against the statutory limit and criteria for annoyance (See Item 3).

The findings were used to assess the risk presented to **MIDDELBURG MINE**, because of predicted noise impacts on neighbouring noise sensitive areas. For this purpose, the Risk Matrix provided in Annexure A was used.

4.3 Meteorological conditions

Meteorological conditions, namely wind speed, temperature and relative humidity were recorded during the assessment. Measurements were taken by means of a Kestrel 3500 Pocket Weather Meter (Serial No 1629849).

The meteorological conditions during the measurement of noise levels were of such a nature that they did not have any significant influence on the noise levels that were recorded.

5. RESULTS AND EVALUATION

The results of an environmental noise impact assessment on noise producing operations associated with processes at the site of the Middelburg Water Reclamation Scheme are provided below.

5.1 NOISE SENSITIVE AREAS

The following noise sensitive areas were identified within a two kilometer radius of the Option 1 site:

(a) Rietfontein Chicken Farm

(b) Naledi Village

No noise sensitive areas were identified within a two kilometer radius of the Option 2 site.

5.2 ACTUAL AMBIENT NOISE RATING LEVELS IN NOISE SENSITIVE AREAS

Actual ambient noise levels were measured at the noise sensitive areas listed in 5.1.1 above. The results are shown in Table 5.1 below.

TABLE 5.1: ACTUAL AMBIENT NOISE LEVELS AT NOISE SENSITIVE AREAS THAT MAY BE AFFECTED BY NOISE PRODUCING ACTIVITIES ASSOCIATED WITH PROCESSES AT THE MIDDELBURG WATER RECLAMATION SCHEME. 2 & 12 JUNE 2008.

No	Area/Location (GPS Coordinates)	Significant Noise Sources	Day time Interval (dBA)	Night Time Interval (dBA)
RURAL AREAS				
1.	Rietfontein Chicken Farm (S 25°53'22.3" E029°23'46.5")	Vehicular traffic on the R575 Provincial Road.	60	49
SUBURBAN AREAS				
2.	Naledi Village Medical Centre (S 25°54'28.4" E028°23'20.5")	Vehicular traffic on the R575 Provincial Road.	61	44

dBA **decibels on the A weighting scale**

GPS **Global Positioning System**

Note 1: **Ambient noise is the noise level in the absence of a noise source under investigation, namely that emitted by the noise producing activities associated with the Middelburg Water Reclamation Scheme.**

Note 2: **Average ambient noise levels reflected in Table 5.1 were used in the calculation of ambient noise levels.**

5.3 NOISE PRODUCING EQUIPMENT

The typical sound levels emitted by noise sources associated with activities at the Emalahleni Water Reclamation Scheme are shown in Table 5.2 below.

TABLE 5.2: TYPICAL NOISE LEVELS EMITTED BY NOISE PRODUCING EQUIPMENT ASSOCIATED WITH OPERATIONS AT THE EMALAHLENI WATER TREATMENT PLANT. 2 & 12 JUNE 2008.

No	Noise Producing Equipment	Octave Band Centre Frequency (Hz)							Equivalent Noise rating Level
		63	125	250	500	1k	2k	4k	
1.	Pumps at Reactors of the Emalahleni Water Treatment Plant	67	65	65	64	63	63	60	69

k **x 1000**

dB **decibels on the linear scale**

dBA **decibels on the A weighting scale**

L_{eq} **equivalent continuous sound pressure level on the linear scale**

Note: **Measurements were taken approximately 10 metres from the noise source.**

5.4 PROPAGATION OF NOISE FROM EQUIPMENT

The propagation of noise from noise producing equipment associated with activities at the site of the Middelburg Water Reclamation Scheme was calculated in accordance with SANS Code of Practice 0357:2004, *The Calculation of Sound Propagation by the Concawe Method.*

The results are shown in Table 5.3 on the next page.

TABLE 5.3: PROPAGATION OF NOISE FROM NOISE SOURCES ASSOCIATED WITH EQUIPMENT AT THE SITE OF THE MIDDELBURG WATER RECLAMATION SCHEME. 12 JUNE 2008.

No	Noise Producing Operation	Direction of Propagation	Calculated distance (m) that is required in order to obtain the Specified Noise Level (dBA)					
			<60 dBA	<55 dBA	<50 dBA	<45 dBA	<40 dBA	<35 dBA
1.	Pumps at Reactors of Water Treatment Plant	From noise source to receiver	70 m	120 m	220 m	380 m	700 m	1200 m

< **less than**

L_{Aeq} **equivalent continuous A-weighted sound pressure level**

m **metres**

dBA **decibels on the A weighting scale**

Note: **Influence of barriers was not taken into account.**

6. NOISE IMPACT ASSESSMENT

A noise impact assessment was conducted at the Middelburg Water Reclamation Scheme. The results were used to predict the impact that the plant may have on sound levels emitted by noise producing equipment at neighbouring noise sensitive areas.

6.1 ACTUAL AMBIENT NOISE RATING LEVELS IN NOISE SENSITIVE AREAS

Two sites have been proposed for the location of the Middelburg Water Reclamation Scheme.

Naledi Village and Rietfontein Chicken Farm in the vicinity of the Option 1 site were identified as noise sensitive areas that may be affected by the proposed plant. No noise sensitive areas were identified within a two-kilometre radius from the Option 2 site.

Actual ambient noise levels were measured during the day time (06h00 – 22h00) and night time (22h00 – 06h00) intervals and the results are reflected in Table 5.1.

The average ambient noise levels during the daytime interval were 60 dBA at the Rietfontein Chicken Farm and 61 dBA at Naledi Village Medical Centre. The average residual noise levels at the noise sensitive area were aggravated by vehicular traffic that travelled along the R575 road.

Night time measurements revealed an average ambient noise level of 49 dBA for the Rietfontein Chicken Farm and 44 dBA at Naledi Village Medical Centre. As with the day time interval, the average ambient noise level for the areas was aggravated by vehicular traffic on the R575 road.

6.2 NOISE LEVELS PRODUCED BY EQUIPMENT THAT MAY BE USED AT THE PROPOSED WATER RECLAMATION PLANT

Table 5.2 shows the typical noise levels emitted by pumps at a similar water treatment site, namely the Emalahleni Water Treatment Plant.

The noise level produced by the main noise source at the Emalahleni Water Treatment Plant, namely the pumps at the Pump Station, was 69 dBA at a distance of 10 metres from the noise source.

The impact of noise from the noise producing operations is discussed in the following section.

6.3 IMPACT OF NOISE PRODUCING EQUIPMENT

The theoretical propagation of sound that may be emitted by noise producing equipment at the proposed Water Reclamation Scheme is shown in Table 5.3. The table also shows the calculated distances from the noise producing equipment where predicted ambient noise levels are likely to exceed the 35 dBA acceptable noise level at margins of 25 dBA, 20 dBA, 15 dBA, 10 dBA, 7 dBA, 5 dBA and 0 dBA.

The pumps at the Pump Station were identified as the main source of noise that may have a potential impact on neighbouring noise sensitive areas. The theoretical propagation of noise produced by the pumps is illustrated in Map A.

It is predicted that the noise from the pumps would attenuate to a level below 35 dBA at a distance of approximately 1 200 meters from the source, at which point it will not be discernable above the background noise levels at Rietfontein Chicken Farm and Naledi Village. Both the Rietfontein Chicken Farm and Naledi Village were located at distances greater than 1 200 metres from the Option 1 site for the Water Reclamation Scheme.

Calculations did not take into account the effect that barriers may have on the distance that noise is propagated. Barriers may include buildings, plant equipment and engineering controls that may attenuate the noise more than predicted. A significant rise above the 35 dBA acceptable rating level for the night time period due to the operation of the proposed new Water Reclamation Scheme is, therefore, unlikely.

The predicted ambient noise level conforms to the acceptable rating levels that correspond to a community group response that is characterized by sporadic complaints (See Table 3.2 on page 3).

6.4 ASSESSMENT AND RATING OF THE RISK

The environmental noise impacts associated with the Middelburg Water Reclamation Scheme was assessed and rated in accordance with the Risk Matrix that is provided in Annexure A on page 16.

The assessment and rating of the environmental noise impacts are provided in Table 6.1. The risk assessment is relevant for the noise sensitive environments that were identified.

TABLE 6.1: NOISE RISK RATING PROFILE FOR NOISE PRODUCING OPERATIONS ASSOCIATED WITH EQUIPMENT AT THE MIDDELBURG WATER RECLAMATION SCHEME. 2 & 12 JUNE 2008.

Risk Rating	=	Severity Rating	x	Exposure Rating	x	Probability Factor
	=	Low-level repairable damage to commonplace structures Public concern restricted to local complaints Low-level legal issue	x	Continuous, all the time	x	Conceivable, but only in extreme circumstances
	=	1	x	10	x	0,1
	=	1				
	=	Priority Level 5: Low Priority				

7. CONCLUSION

From the results and findings of a noise impact assessment for noise producing operations associated with equipment at the proposed Middelburg Water Reclamation Scheme, the following may be concluded:

(a) Rietfontein Chicken Farm and Naledi Village were identified as noise sensitive areas that may be affected by the noise producing equipment.

(b) Residual noise levels at the noise sensitive areas exceeded the acceptable rating level during the day and night time intervals and may be attributed to vehicle traffic along the R575 road.

(c) Pumps at the proposed Pump Station were identified as key noise sources that may cause annoyance at the above noise sensitive areas, at the Option 1 site.

(d) Complaints are not expected from members of the Rietfontein Chicken Farm and Naledi Village, since the theoretical propagation of noise emitted by the noise producing equipment is unlikely to cause annoyance.

(e) A Risk Rating Level of 1 was calculated for both the Rietfontein Chicken Farm and Naledi Village that neighbour the proposed Water Reclamation Plant. Action is therefore not required in accordance with the Risk Matrix (See Annexure A).

8. RECOMMENDED ACTIONS

The following actions are recommended in order to mitigate the risk that is presented by ambient noise levels, which may result from the noise producing equipment associated with the operation of the Middelburg Water Reclamation Scheme.

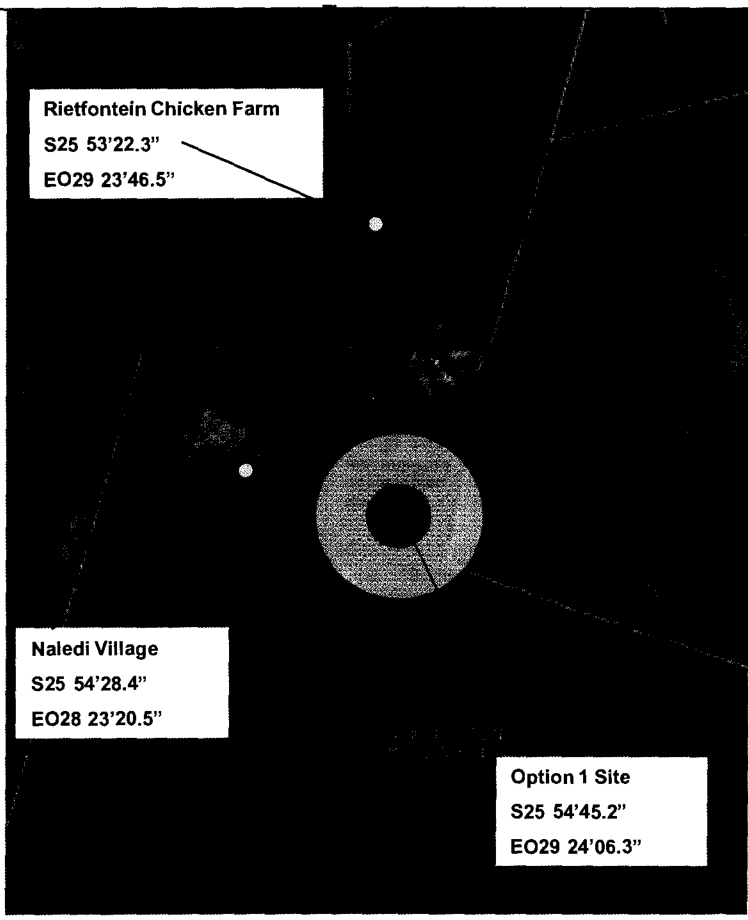
No	Action		
(a)	An environmental noise-monitoring programme should be implemented for the construction phase of the MWRS. Noise measurements should be conducted on an ongoing basis at noise sensitive areas and management should be advised of any significant increase in the ambient sound level as operations continue.		
(b)	The impact that the noise producing activities may have on noise sensitive areas as well as mitigation measures should be communicated to communities that may be affected for the purpose of transparency and good relations.		
(c)	Noise producing activities such as construction should be limited to the daytime interval to limit the noise impact the activities may have on neighbouring communities.		
(d)	A buffer zone of 1 000 meters between the Water Reclamation Plant and noise sensitive areas should be observed.		

MAP A: PROPAGATION OF NOISE EMITTED DURING OPERATION OF PUMPS AT THE PROPOSED WATER TREATMENT PLANT

Calculated distance (m) that is required in order to obtain the Specified Noise Level (dBA) :

< 50 dBA = 220 metres (■) < 45 dBA = 380 metres (▩) < 40 dBA = 700 metres ( )

< 35 dBA = 1200 metres (□)



ANNEXURE A: RISK MATRIX

SEVERITY RATING

Choose a description that best fits the severity rating at which **MIDDELBURG MINE** may be exposed.

Consequence Types						
Severity Level	**Health and safety**	**Natural environ- ment**	**Social/ cultural heritage**	**Community/ Govt/ Reputation/ Media**	**Legal**	**Severity Factor**
a	500 fatalities or very serious irreversible injury to 5000 persons	Very significant impact on highly value species, habitat or eco system	Irreparable damage to highly valued items of great cultural significance or complete breakdown of social order.	Prolonged international condemnation	Potential jail terms for executives and or very high fines for company. Prolonged, multiple litigation	1000
b	>50 fatalities, or very serious irreversible injury to >500 persons.	Significant impact on highly valued species, habitat, or ecosystem.	Irreparable damage to highly valued items of cultural significance or breakdown of social order.	International multi- NGO and media condemnation.	Very significant fines and prosecutions. Multiple litigation.	300
c	Multiple fatalities, or significant irreversible effects to >50 persons	Very serious, long- term Environ- mental impairment of ecosystem function.	Very serious widespread social impacts. Irreparable damage to highly valued items.	Serious public or media outcry (international coverage).	Significant prosecution and fines. Very serious litigation, including class actions.	100
d	Single fatality and/ or severe irreversible disability (> 30%) to one or more persons.	Serious medium term Environ- mental effects.	On- going serious social issues. Significant damage to structures/ items of cultural significance.	Significant adverse national media/ public/ NGO attention.	Major breach of regulation. Major litigation.	30

(continued)

Consequence Types						
Severity Level	**Health and safety**	**Natural environ-ment**	**Social/ cultural heritage**	**Community/ Govt/ Reputation/ Media**	**Legal**	**Severity Factor**
e	Moderate irreversible disability or impairment (< 30%) to one or more persons.	Moderate, short- term effects but not affecting ecosystem function.	Ongoing social issues. Permanent damage to items of cultural significance.	Attention from media and/ or heightened concern by local community. Criticism by NGOs.	Serious breach of regulation with investigation or report to authority with prosecution and/ or moderate fine possible.	10
f	Objective but reversible disability requiring hospitali-zation	Minor effects on biological or physical environ-ment.	Minor medium-term social impacts on local population. Mostly repairable.	Minor, adverse local public or media attention and complaints.	Minor legal issues, non-compliances and breaches of regulation	3
g	No medical treatment required.	Limited damage to minimal area of low significance.	Low- level repairable damage to commonplace structures.	Public concern restricted to local complaints.	Low- level legal issue.	1

EXPOSURE RATING

Choose a description that best fits the frequency at which **Middelburg Water Reclamation Scheme** or its stakeholders may be exposed to the risk issue with Consequences **at the chosen level of Severity.**

Exposure	Description	Exposure Factor
Continuous	All the time	10
Frequent	Once a month or so	3
Occasional	Once or twice a year	1
Unusual	Once or twice every 10 years	0.3
Remote	Once or twice in a 100 years	0.1

PROBABILITY RATING

Choose a description that best fits the chance of **Middelburg Water Reclamation Scheme** or its stakeholders actually experiencing Consequences **at the chosen level of Severity** when exposed to the risk issue.

Probability	Description	Probability Factor
Almost certain	Happens often	10
Likely	Could easily happen	3
Possible	Could happen and has occurred here or elsewhere	1
Unlikely	Hasn't happened yet but could	0.3
Rare	Conceivable, but only in extreme circumstances	0.1

(Residual) Risk Rating = Severity Factor x Exposure Factor x Probability Factor

PRIORITY

Once a risk rating has been calculated, the following scheme should be used to assign priority of action. It should be noted that if action is not taken within the time specified, then the continued toleration of the residual 'downside' risk should be explicitly 'signed-off'. The suggested level of seniority for sign-off is as shown below.

Priority	Risk Rating	Suggested action	Suggested timing	Authority for continued toleration of residual risk
1	Greater than 300	Cessation until the residual risk is reduced to 300 or below – unless exposure is authorised as indicated.	Immediate	CEO and Board
2	91 – 300	Take action to reduce residual risk to 90 or below.	Short term, normally within 1 month	CEO
3	31 – 90	Plan to deal with in keeping with business plan.	Medium term. Normally within 3 months.	CEO's direct reports
4	11 – 30	Plan in keeping with all other priorities	When time allows. Normally within 1 year	Manager
5	Below 10	Low priority	—	—

D.11 Socio-Economic Impact Assessment

EZENDALO
Environmental Solutions

Socio-Economic Impact Assessment of the Middelburg Water Reclamation Project

Prepared for:

Jones and Wagener

Date

15 July 2011

Client address:

59 Bevan Road

PO Box 1434

Rivonia

2128

Executive summary

Water is a critical resource and an economic good. It is fundamental to the requirements of a healthy ecosystem, economic growth and social prosperity. Douglas Tavistock Joint Venture (DTJV) is proposing to construct and operate a water treatment plant for the treatment and release of untreated mine water from the North and Klipfontein Sections of Middelburg Mines (now known as Middelburg Colliery). The water treatment plant will on average treat 20 000 m^3/day of mine affected water. This water will be treated to acceptable water quality standards and released back into the Spookspruit Catchment. The process will thus reduce pollutant loading of the system and improve water quality and quantity. This improvement will be seen by downstream users in the system.

The plant is to be located east of the Naledi Village on the opposite side of the R575 Provincial road. The site falls within mine owned land which is being leased by a farmer. Pipelines will transfer water from the mine, these will be routed within mine owned land. The treatment process will produce gypsum that is to be stored adjacent to the plant in purpose built lined pollution control facilities.

The construction period is expected to last 24-30 months and workers will be housed in neighbouring town and cities. No workers will stay on site besides security personal. This along with the management measures detailed in **Chapter 7** will ensure the construction process is accomplished with minimal social impact to the surrounding communities. Other impacts such as noise, traffic and visual are considered low.

Operationally the plant will employ an estimated 30 people on a full time basis (excluding security personal). The improved water quality will improve ecosystem functioning, allowing for increased water usage for other economic sectors downstream of the site. The facility can also be upgraded at a later stage to increase capacity to 30 000 m^3/day. The facility will be owned by the DTJV, and will be independent of the mine. Hence it can continue operation once the mine is closed.

The catchment is currently stressed. Environmental quality affects economic outputs and social integrity. Water treatment is required for future sustainable development in the catchment. The treatment process will address this balance, by improving the environment provided it is operated efficiently and effectively.

It is thus recommended that the Middelburg Water Reclamation Project (MWRP) be constructed given the environmental, social and economic benefits.

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LIST OF ABBREVIATIONS

BECSA	BHP Billiton Energy Coal South Africa
DTJV	Douglas Tavistock Joint Venture
DWA	Department of Water Affairs (previously known as DWAF)
EIA	Environmental Impact Assessment
EMPr	Environmental Management Program Report
ERA	Environmental Risk Assessment
GGP	Gross Geographic Product
HAZOP	Hazard and Operability Study
HDPE	High Density Polyethylene
HiPRO®	High Recovery Precipitating Reverse Osmosis
HSECO	Health, Safety and Environmental Compliance Officer
MM	Middelburg Mines
MM Klipfontein	Middelburg Mines Klipfontein Section
MM North	Middelburg Mines North Section
MU	Management Unit
MWRP	Middelburg Water Reclamation Project
Olifants WMA	Olifants Catchment Water Management Area
RWQO	Resource Water Quality Objectives

SIA	Social Impact Assessment
SP	Significance Probability
WWTP	Waste Water Treatment Plant
XCSA	Xstrata Coal South Africa

1 Introduction

1.1 Brief project overview

The Douglas Tavistock Joint Venture (DTJV) is proposing to construct and operate a water treatment plant. The plant will treat mine water pumped from the North and Klipfontein Sections of Middelburg Mines (now known as Middelburg Colliery). The North Section consists of the Hartbeesfontein, Goedehoop and Bankfontein Sections. The DTJV is a joint venture between BHP Billiton Energy Coal South Africa (BECSA) (Pty) Limited and Tavistock Collieries (Pty) Limited.

The storage capacity in the mined out sections and in the existing pollution control dams has been exceeded at Middelburg Mines (MM) North and Klipfontein Sections. To prevent future spillages and or discharges of untreated mine water into the Spookspruit catchment, (which forms part of the Upper Olifants River catchment flowing into the Loskop Dam), the DTJV wishes to construct a water treatment plant.

The '**Middelburg Water Reclamation Project (MWRP)**' will be located on MM North Section. The MWRP will be used to treat the excess mine water which is currently stored in dams at the North and Klipfontein Sections of MM and discharge it into the Spookspruit Catchment.

The MWRP will have an initial Phase 1, which can treat on average 20 000 cubic metres (m^3) of untreated mine water per day. Phase 2 will be able to treat on average 30 000 m^3 of water per day. However Phase 2 will be established once the need arises for increased treatment capacity. The MWRP will treat mine affected water to the current (2009) Interim Resource Water Quality Objectives (RWQO) for the Spookspruit Catchment. These objectives were determined by the Department of Water Affairs (DWA) and have been accepted by the various mines operating in the said catchment.

The MWRP comprises the following key components (Jones & Wagner, 2011):

- Pipelines transporting untreated mine water from MM North and Klipfontein sections to the MWRP;
- Balancing dam at the treatment plant;

- Water treatment infrastructure;
- Sewage Treatment Plant;
- Gypsum waste management facilities; and
- Various supporting infrastructure, such as offices, change rooms etc.

The site chosen for the placement of the water treatment plant is located on land owned by MM, and will be situated approximately 1.3 km to the east of the Naledi Village and 3km from the MM North Section (refer to **Figure 2**). The untreated mine water pipelines also fall entirely on land owned by MM (refer to **Figure 3**).

1.2 Client details

1.2.1 Applicant

Applicant Name:	Douglas Tavistock Joint Venture
Postal address:	P.O. Box 61075
	Marshalltown
	2107
Contact person:	Mr S Brown
Designation:	Representative from BHP Billiton Energy Coal South Africa
Telephone number:	013 689 3051

1.2.2 Environmental Assessment Practitioner

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E-mail address:	vanzyl@jaws.co.za

1.2.3 Socio-economic assessment practitioner

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Postal address:	P.O. Box 76174 Lynnwood Ridge, 0040 Pretoria
Contact person:	Daniel Lachenicht
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1.3 Scope and objectives of the study

1.3.1 Scope

The scope of the social and economic assessment (SIA) is defined by the communities, businesses and individuals that have the potential to be impacted upon by the construction and operation of the MWRP. The scope, therefore, includes the immediate communities that have a potential to be impacted upon during the construction phase and the communities and downstream water users that have the potential to be impacted upon during the operational phase of the MWRP.

1.3.2 Objectives

The objectives of the SIA are to:

- Characterise the current socio-economic baseline characteristics;

- Identify potential socio-economic impacts;
- Characterise and evaluate the potential impacts; and
- Provide management measures to mitigate negative impacts and maximise positive impacts.

2 Method for investigation

An overview of the method for the SIA is given in **Figure 1.** Each process is also detailed in the sub-sections below.

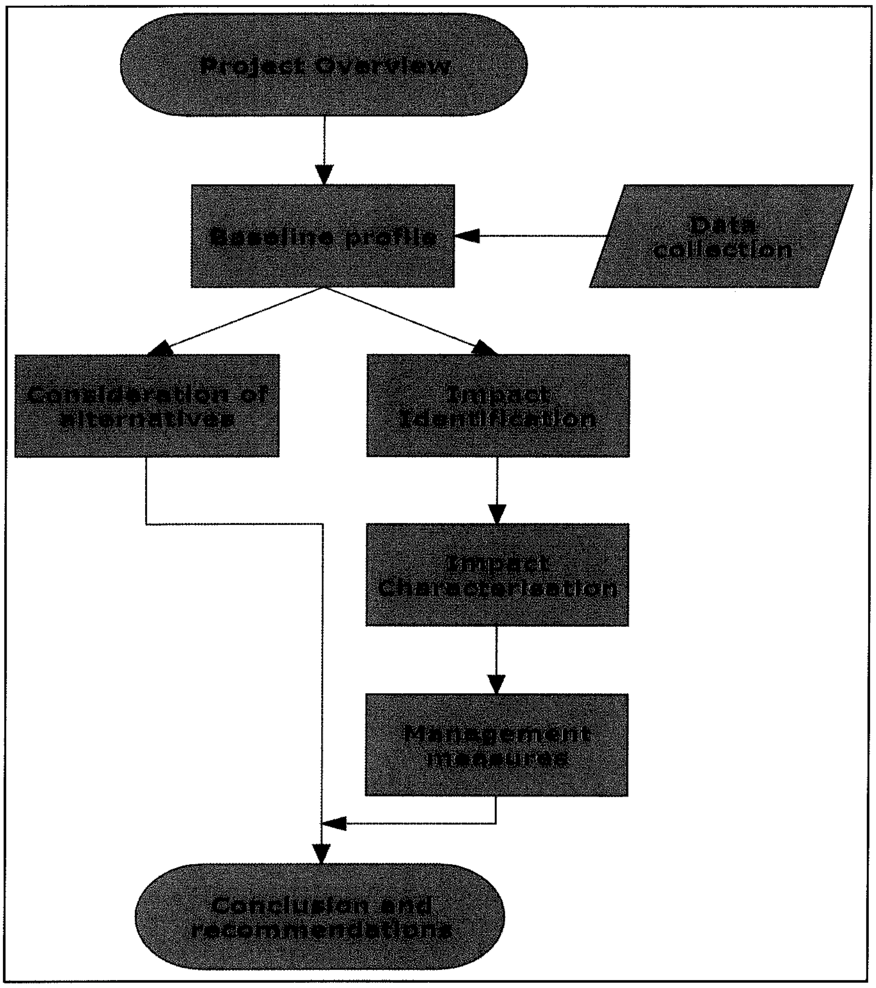


Figure 1: SIA methodology overview

2.1.1 <u>Project overview</u>

A meeting was held with the client to understand the needs, objections, desired outcomes and desirability of the project. Relevant data relating to the project was collected to provide an accurate description of the project so that the SIA process was adequately planned in order to address the needs of the project and the affected communities.

2.1.2 Baseline profile

This entails a detailed description of the current social and economic situation of the study area. The assessment of the socio-economic status of the area has allowed for determining the potential impacts of the MWRP.

A broad profile of the area includes the following:

- Relationship with the biophysical environment;
- The social and economical characteristics of the population; and
- The current HIV/AIDS status of the population.

2.1.3 Consideration of alternatives

Alternatives to the proposed project include alternative locations and processes. The 'no go option' was also considered. A summary of the alternatives investigated is presented to indicate the shortcomings and advantages of the alternatives, and hence to further strengthen the case for the activity to be conducted as presented in the Environmental Impact Assessment (EIA) documentation (and referred to in this report).

2.1.4 Impact identification

Impacts have been identified for both the construction and operational phase of the project. Identification has included both positive impacts (such as job creation, improved ecological functioning downstream of the discharge point, increased agricultural productivity from improved water quality in the system) and negative impacts (such as construction impacts, change of land use etc.). The impacts identification concentrated on impacts on local and affected communities within the surrounding project area.

Each identified socio-economic impact of the MWRP on the various businesses, communities and individuals is classified to determine whether the impact effects the social or economic environment and whether the impact is regarded as positive or negative.

The following parameters were used as the basis of the impact assessment:

- The probability, scale, duration, extent and magnitude of the impact;

- The integration of the SIA within the broader EIA context;
- Development of potential mitigation and management measures; and
- The sustainable development of the study area.

2.1.5 Management measures

This section describes specific management interventions that may be required to address or minimise negative impacts and enhance positive impacts.

2.1.6 Conclusion and recommendations

This section provides a summary of the main outcomes of the investigation.

3 Detailed Project Description

3.1.1 Locality

The MWRP is situated in Mpumalanga within the Nkangala District Municipality with the Steve Tshwete Local Authority acting as the regional services authority. eMalahleni and Middelburg are the nearest towns to the MWRP (refer to **Table 1**) which is located just off the Provincial Road R575.

Table 1: Nearest towns to the MWRP

Nearest Towns	Approximate Distance	Direction
eMalahleni	15km	West
Middelburg	15km	North East

The site will fall within the MM boundary (North Section), and will be situated approximately 1.3 km to the east of the Naledi Village and 3 km from MM North Section (**Figure 2**).

The MWRP falls within the Spookspruit Management Unit (MU) 26 Quaternary Catchment sub-drainage region, which is part of the Upper Olifants River Catchment (refer to **Figure 3**).

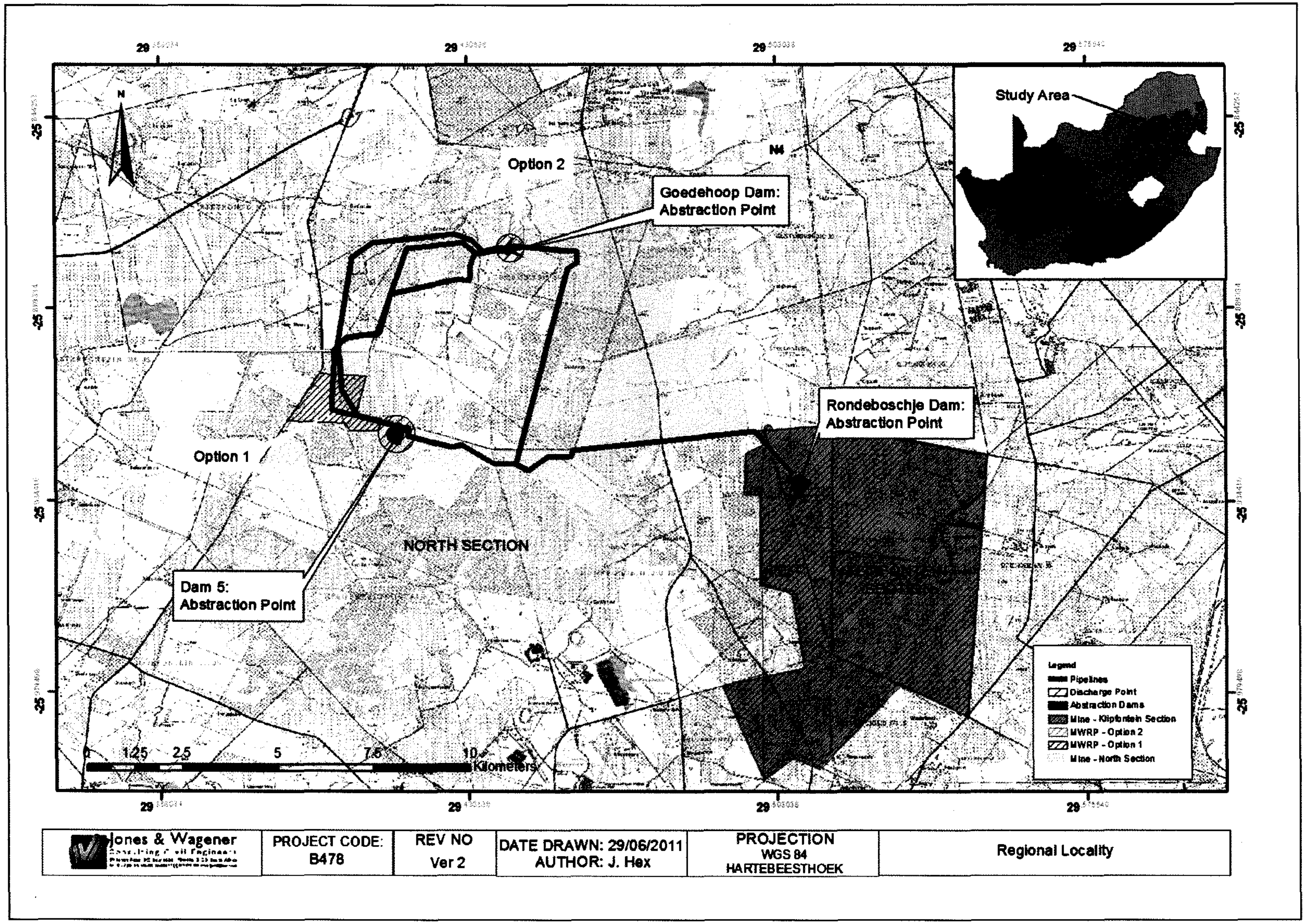


Figure 2: Locality plan

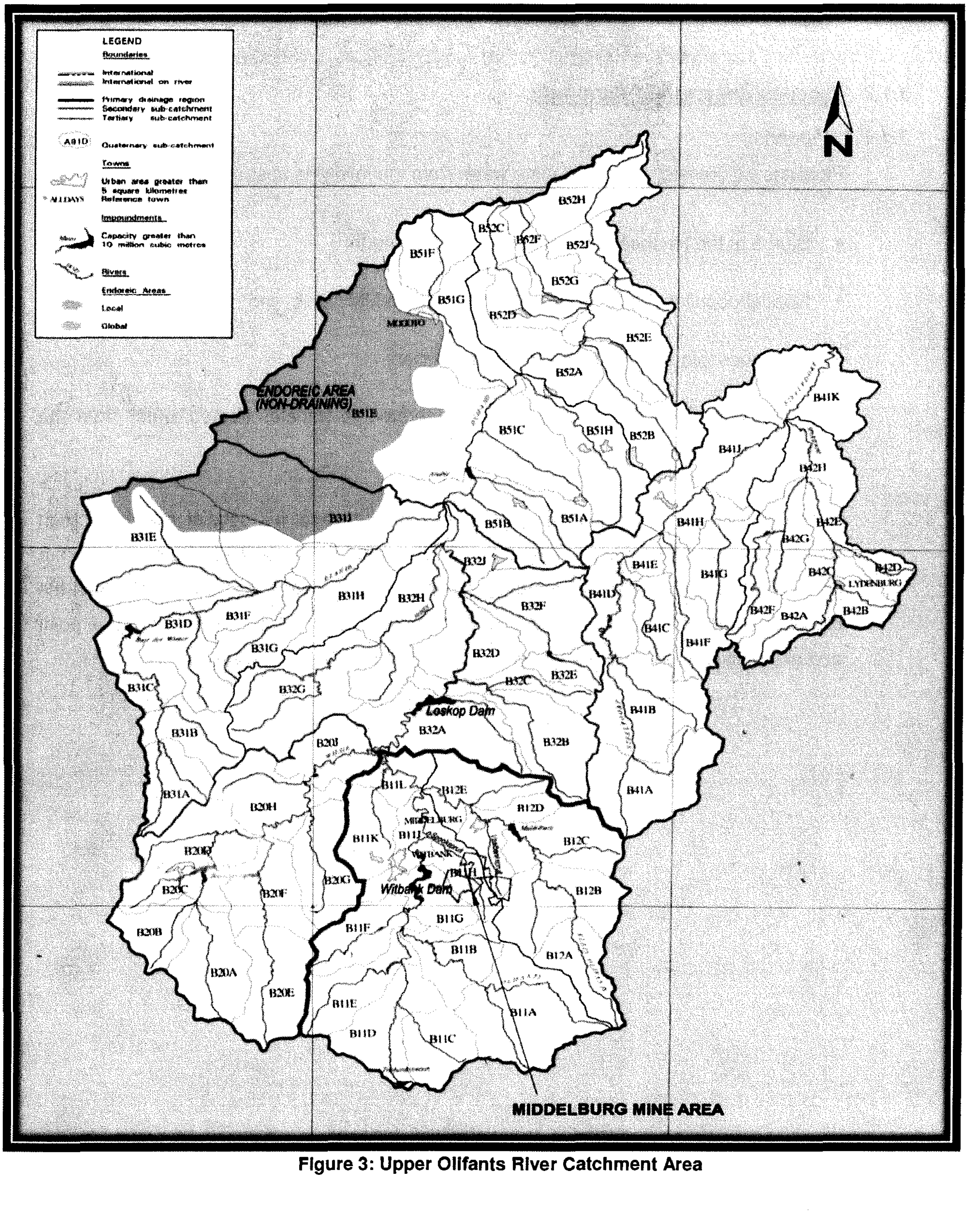


Figure 3: Upper Olifants River Catchment Area

3.1.2 <u>Process description summary</u>

3.1.2.1 Pipelines

Pipelines will transfer untreated mine water from the following abstraction points:

- Dam 5 at the Hartbeesfontein Section on MM North;
- Goedehoop Dam at the Goedehoop Section on MM North; and
- Rondeboschje Dam on MM Klipfontein Section.

Another pipeline will be constructed and operated to transfer treated water from the MWRP to the discharge point.

The pipelines will be buried along most of the route and will consist mainly of High Density Polyethylene (HDPE) with external diameters ranging between 355 and 450 mm and will lead to a combined length of approximately 22 km. Above ground sections of the pipelines will be steel with a HDPE liner. The proposed abstraction points, discharge point and alternative pipeline routes being considered can be seen in **Figure 2**.

3.1.2.2 Treatment plant

The High Recovery Precipitating Reverse Osmosis (HiPRO®) water treatment plant will treat 20 Mℓ/day in Phase 1 and 30 Mℓ/day in Phase 2 of the project. Untreated mine water enters the water treatment plant where it undergoes dosing with chemicals such as lime and limestone, clarification, ultra filtration and finally reverse osmosis. The water treatment plant produces gypsum waste which will be deposited on a gypsum waste disposal facility located adjacent to the water treatment plant. The waste gypsum is produced in two forms. Primary gypsum waste, also termed metal-rich gypsum, will be generated at a rate of approximately 45 - 60 tons/day at 20 Mℓ/day. Secondary cake, also termed gypsum cake, will be generated at a rate of approximately 80 - 100 tons/day at 20 Mℓ/day.

3.1.2.3 Discharge water

Untreated mine water will be treated to meet the current (2009) Interim RWQO developed by the DWA for the Spookspruit Catchment prior to discharge. These quality objectives are listed in **Table 2**.

Table 2: Interim Resource Water Quality Objectives for the Spookspruit Catchment (Jones & Wagner, 2011).

Constituent	Concentration/Value
Conductivity	≤ 90 mS/m
Total dissolved salts	≤ 650 mg/l
Sulphate	≤ 400 mg/l
Sodium	≤ 70 mg/l
Calcium	≤ 150 mg/l
Magnesium	≤ 70 mg/l
SAR	≤ 2.0 meq/ℓ
Aluminium	≤ 0.02 mg/l
Iron	≤ 1.0 mg/l
Manganese	≤ 0.4 mg/l

The treated water will be discharged into the Niekerkspruit a tributary in the Spookspruit River.

3.1.3 Project profile

3.1.3.1 Construction phase

The construction of the plant will take 24 - 30 months to complete. No construction personnel, other than the security guards, will be allowed to overnight at the construction site.

The project will require approximately 1500 - 2000 contractors during the construction period. However these will not all be on site at the same time.

3.1.3.2 Operational phase

The plant will employ between 25 -30 permanent staff. It is planned for the plant to be operated by Keyplan on behalf of the DTJV. A provisional staff organogram is given in **Figure 4**.

4 Identification of alternatives

The process of eliminating various options for treatment sites, processes and operational changes to manage the water was undertaken in detail by BECSA by various committees and workshops held between July 2006 and September 2007.

The fundamental criteria used in screening of the identified water management alternatives are encapsulated in the mine water management hierarchy as depicted **Figure 5**. This hierarchy is core to integrated water management at mining sites and essentially states that mines must, in the first instance seek to optimally implement pollution prevention measures. If these measures do not address all the water management issues then the mine should secondly develop and implement appropriate water reuse and reclamation strategies, which may include a greater or lesser degree of water treatment in order to render the water suitable for reuse. If there is still a residual water management problem, then the mine could evaluate and negotiate options with the DWA for the discharge of untreated water to the water resource. It is, however, understood that the latter option will no longer be allowed by the DWA.

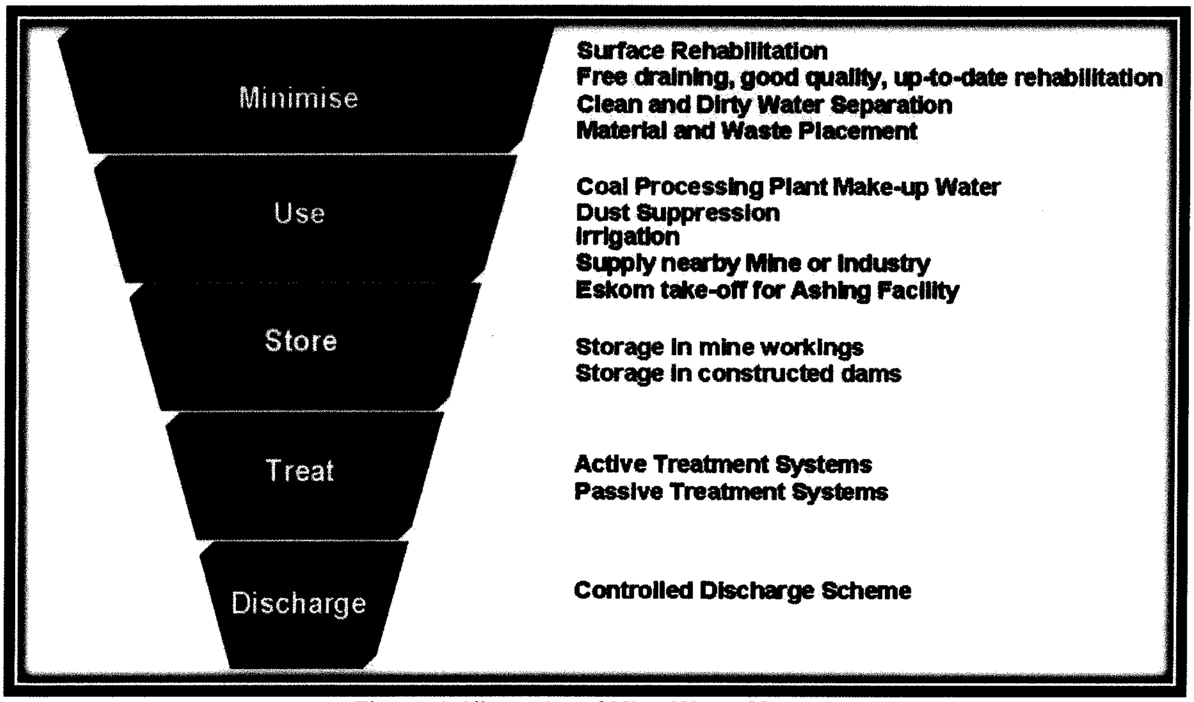


Figure 4: Hierarchy of Mine Water Management

5 Baseline conditions

5.1 Relationship of the treatment plant with biophysical environment

5.1.1 Regional Scale

In terms of water supply, the Olifants WMA is a stressed catchment; with the year 2000 water requirements exceeding the available water by 192 million m^3/annum. Domestic water requirements in the Steve Tshwete and eMalahleni Local Municipalities, as well as the local municipalities in the Western Highveld area, are fast outstripping the water available in the local supply dams. The local water resources have therefore largely been exploited and the water requirements have reached the 50 year yield of the water supply systems (DWAF, 2009).

The water quality in the Olifants WMA is also under threat from a number of sources, particularly the coal mining industry, urban development and poorly performing municipal wastewater treatment plants. The Witbank Dam, Middelburg Dam, Spookspruit and Klipspruit catchments are extensively mined.

The Loskop Dam Catchment is a major supplier of agricultural irrigation. The water quality in the Loskop Dam has seen a steady decline with salinity levels rising at the dam wall as measured by the Department of Water Affairs (DWA) (DWAF, 2009). DWA (DWAF, 2009) also goes on to state that 'severe water quality problems at the Loskop Dam are occurring at the dam inlet and the upper reaches of the dam. This area of the dam receives the acidic water from the Klipspruit, the poor water quality from the Spookspruit and sewage effluent discharged from the Riverview Waste Water Treatment Plant (WWTP).

From the above indications it is seen that the Spookspruit catchment is currently having a negative impact on the water quality in the Loskop Dam.

5.1.2 Local scale

The treatment plant is situated within an area that has been severely overgrazed and comprises largely of invasive species such as Wattle and Blue gum.

Regarding water quality in the Spookspruit Catchment, the DWA (DWAF, 2009) noted that '*the recent water quality profile of the Spookspruit shows that the water at the* *downstream end of the catchment is neutral, but high in sulphates. The sulphate concentration exceeds the guidelines at both the 50 percentile and 95 percentile levels. There were recorded occasions in the past, where the Spookspruit was acidic with the associated high metal concentrations'.*

The MWRP falls within the Spookspruit MU26 Quaternary Catchment sub-drainage region. The treatment plant is located on mine-owned ground with the nearest affected community being those residents living in the mine accommodation at Naledi Village which is approximately 1.3 km to the West. The treated water will be discharged into the Niekerkspruit which is a tributary of the Spookspruit.

Water is a priority resource in the catchment area. Both the volume and quality of water on a local and regional scale has been affected by mining and this has negatively impacted on both the ecological value and economic value (such as domestic consumption and agriculture) of the catchment.

5.2 General population characteristics

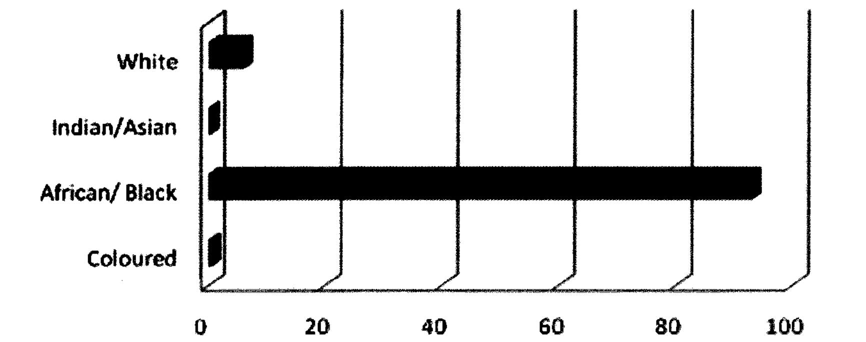
5.2.1 Mpumalanga Province

The province of Mpumalanga occupies 6% (80 000 km^2) of the surface area of South Africa. Approximately 7% of South Africa's population lives in the province. The province's Gross Geographic Product (GGP) represents 7.4% of the country's economy (Mpumalanga Investment Initiative, 2007).

Mpumalanga has a diversified economy that contributes to the GGP:

- Mining – 5%;
- Agriculture and forestry – 18%;
- Manufacture – 19%;
- Electricity generation – 4,5%;
- Tourism – 8%;
- Trade – 10%;
- Finance – 10.5%;
- Transport – 9.5%; and
- Other – 15.5%

Mpumalanga has a population of over 3.3 million of which 48% are male and 52% are female. The population can be dived into the following ethnic groups as depicted in the figure below.



	Coloured	African/ Black	Indian/Asian	White
■ Percentage	0.6	93	0.4	6

Figure 5: Ethnic Delineation (Stats SA, 2007)

The main languages spoken in the province include English, Afrikaans, SiSwati, Ndebele, IsiZulu and Sepedi.

Mpumalanga has an abundance of natural resources, and these include:

- 626 000 ha of planted forests, 200 million tons of coal (mined per year), Gold, Chromite, Nickel, Magnesite, Iron ore, Verdit, Vanadium, Silica, and Granite.

5.2.2 <u>Steve Tshwete Local Municipality</u>

The data contained in this section (unless otherwise indicated) was obtained from Statistics South Africa (Stats SA) and is based on information obtained during their 2007 community survey. This is considered to be the most recent and valid data.

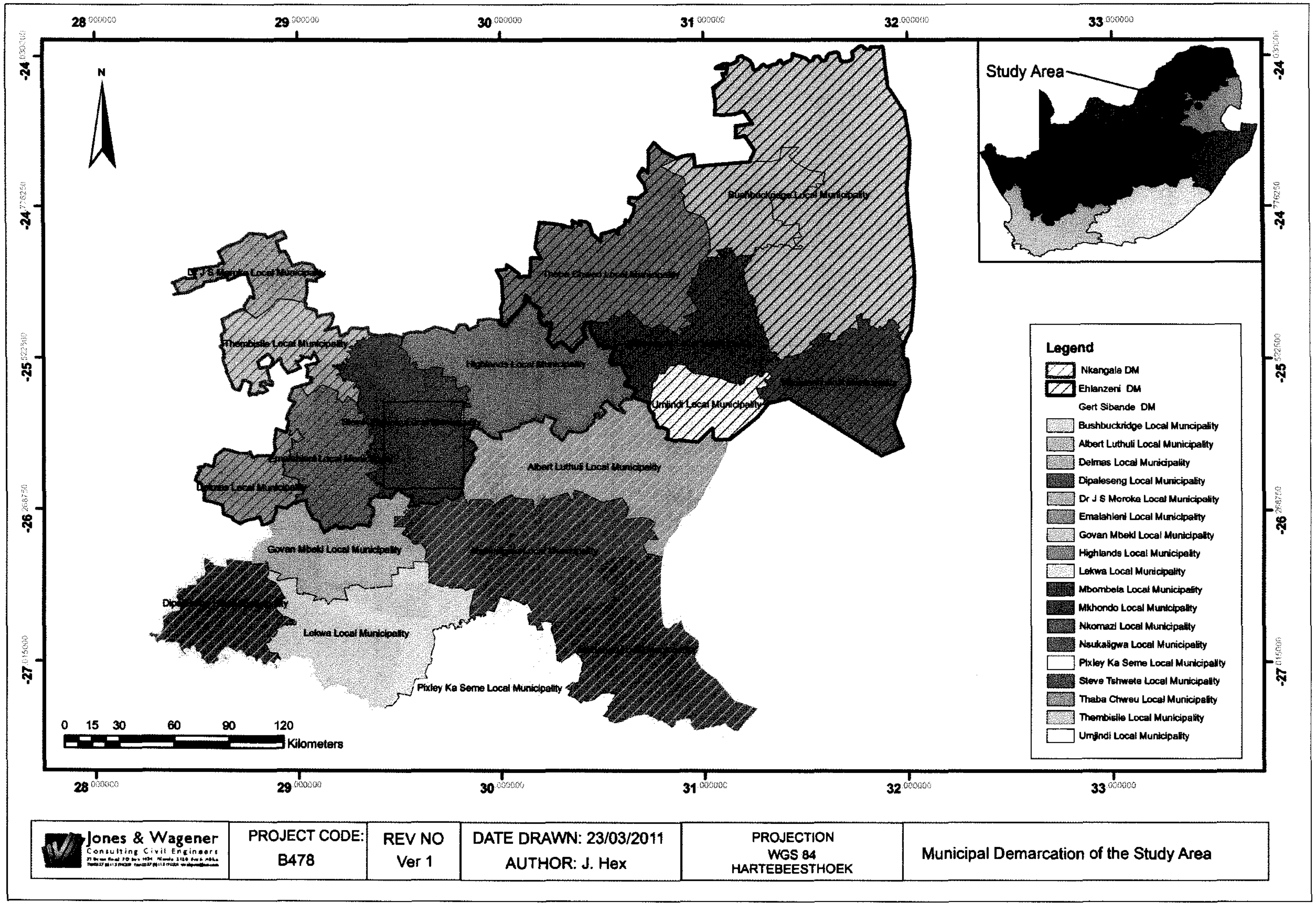


Figure 6: Municipality Locality Plan

5.2.2.1 Population density, growth and location

The total population recorded in the Steve Tshwete Local Municipality at the time of the community census in 2007 was approximately 182,513. The majority (79%) of the population were African/Black (refer to **Table 3**) and 71% of the population are situated in the working age which is between 15 and 65 (refer to **Figure 8**). The gender ratio was fairly equal, as 47% of the population was male and 53% of the population was female.

Table 3: Ethnic delineation

Race	Population
African/Black	144 299
Coloured	5 180
Indian/Asian	2 602
White	30 432

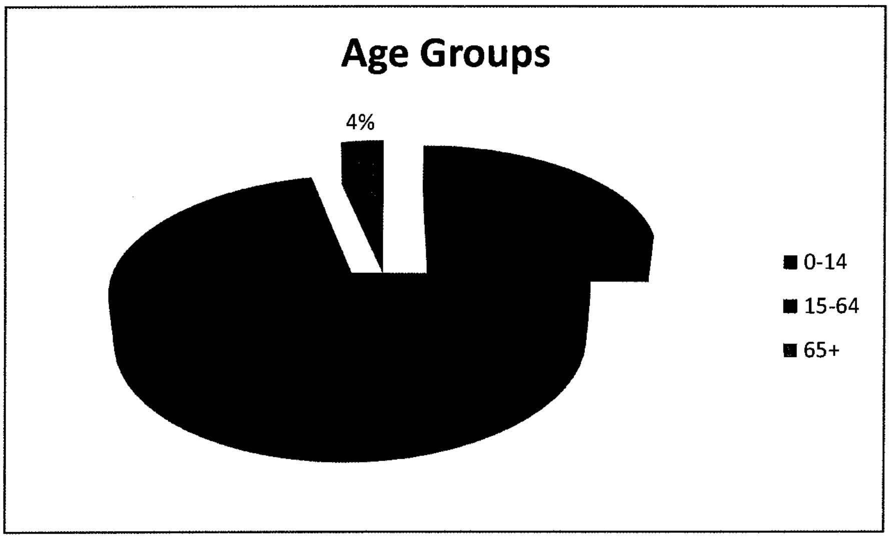


Figure 7: Age Groups (Stats SA Community Survey, 2007)

5.2.2.2 Major economic activities and sources of employment

The majority (51%) of the working population is employed, 16% is considered as unemployed and 28% is classified as economically inactive (refer to **Figure 9**).

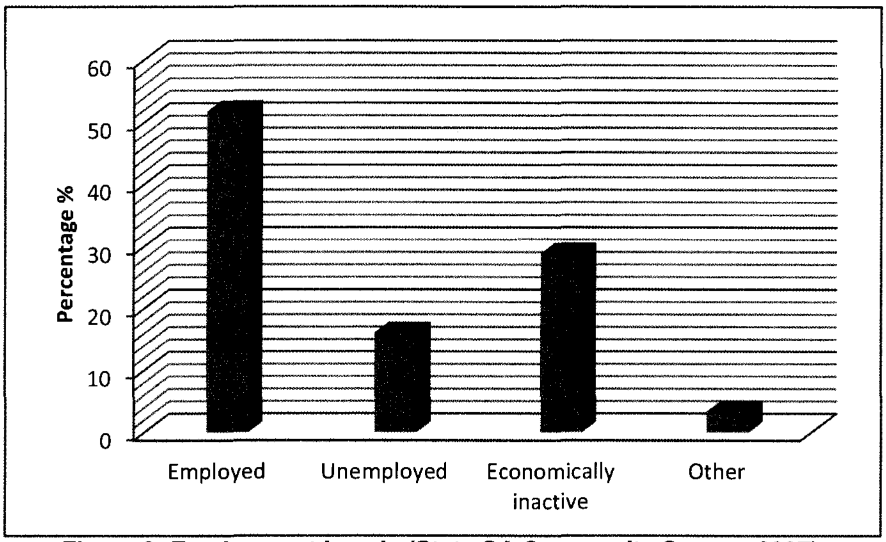


Figure 8: Employment Levels (Stats SA Community Survey, 2007)

The majority (71%) of the employed population earn below R1,600 per month and 18% of the population earn between R1,601 and R6,400 per month. This shows that, at the time of the census, 88% of employed adults earned less than R6,401 per month and were situated in the lowest income bracket (refer to **Figure 10**).

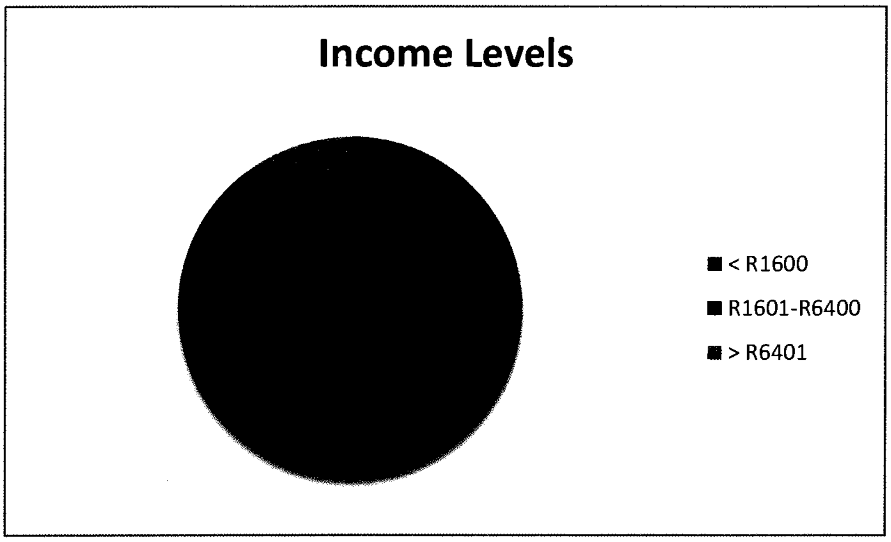


Figure 9: Income Levels (Stats SA Community Survey, 2007)

The different sectors of employment within the municipal area are shown in **Figure 11**. Manufacturing, mining and wholesale are the biggest contributors to employment within the municipal area. This is most likely due to the vast coal reserves found within the area.

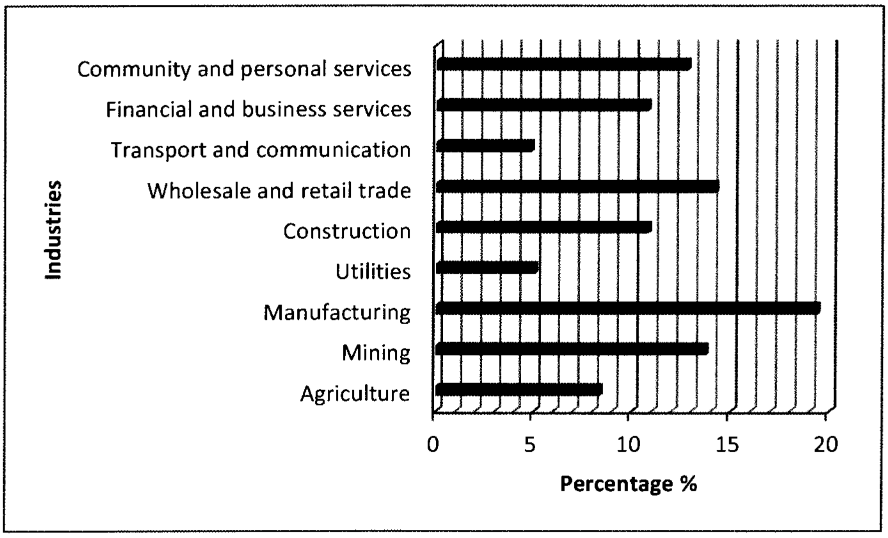


Figure 10: Sectorial Employment (Stats SA Community Survey, 2007)

5.2.2.3 Basic services provision

Water and sanitation

The provision of water within the municipality is detailed in **Figure 12**. The majority of the population (83%) has piped water available on the property, 12% has to travel outside their property for water and 5% of the population gain access to water through other means such as boreholes or rain water.

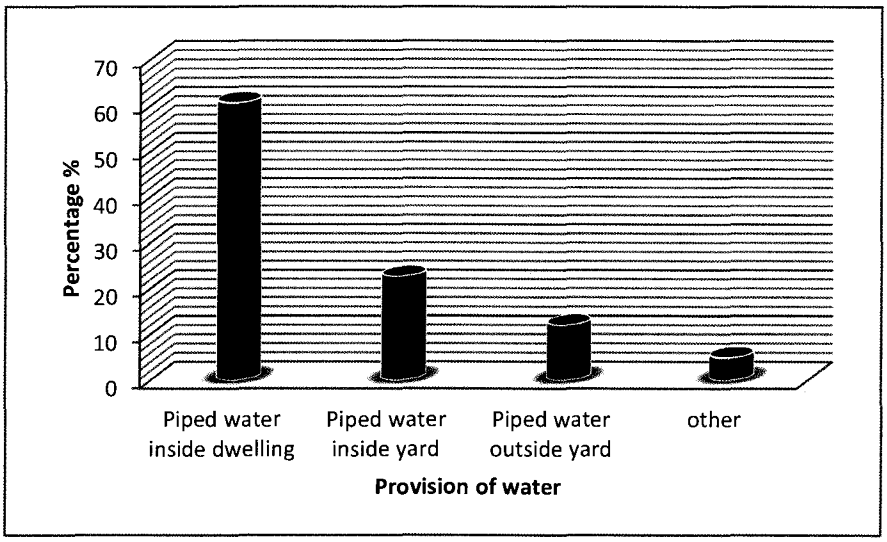


Figure 11: Access to water (Stats SA Community Survey, 2007)

As seen in **Figure 13**, 81% of the population uses flush toilet type sanitation, 12% make use of pit toilet type sanitation facilities and 4% make use of other forms of sanitation such as bucket and chemical toilets. A minor 3% of the population has no access to any form of sanitation.

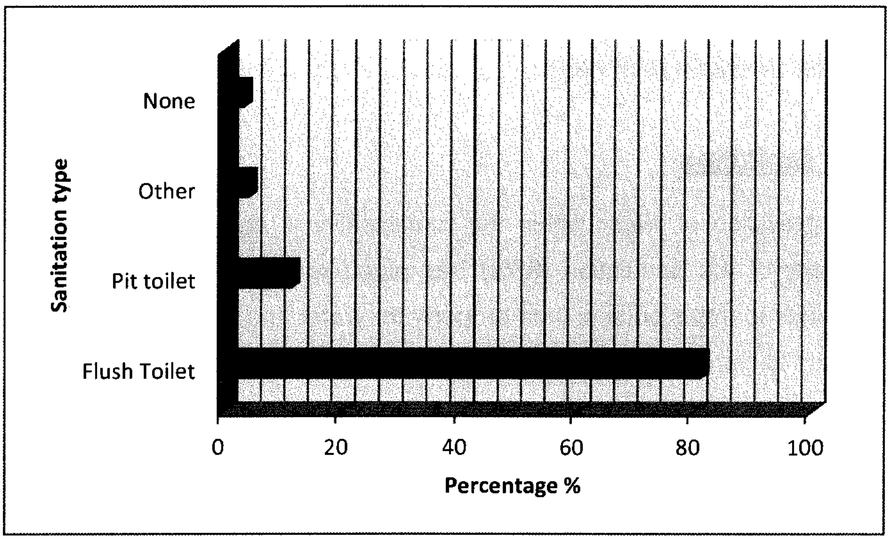


Figure 12: Sanitation Types (Stats SA Community Survey, 2007)

Electricity

The provision of energy in the municipality is shown in **Figure 14** and details the energy sources used for cooking, heating and lighting.

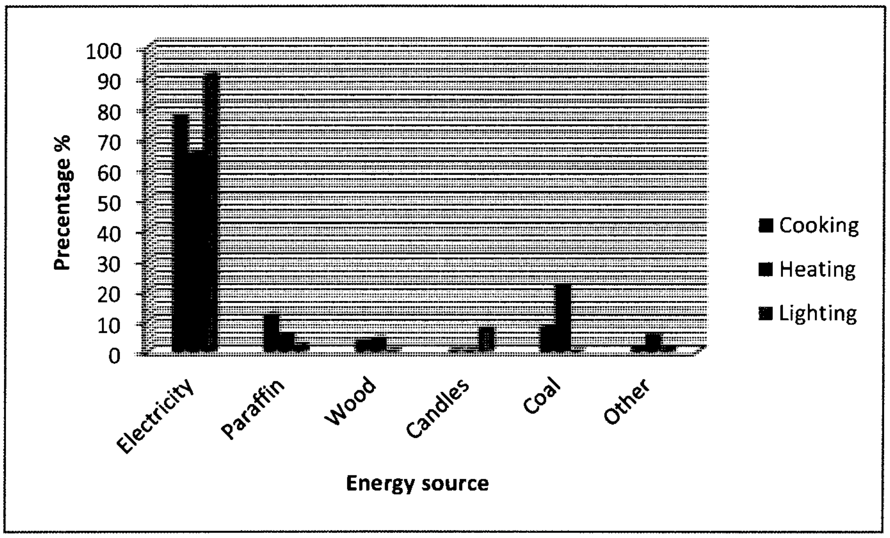


Figure 13: Provision of Electricity (Stats SA Community Survey 2007)

Refuse Removal

The majority (85%) of the population in the municipality have their refuse removed on a regular basis by the local authority, whist 12% utilises either a communal refuse dump or their own refuse dump as a means of refuse disposal. 3% of the population have no means of refuse disposal (refer to **Figure 15**).

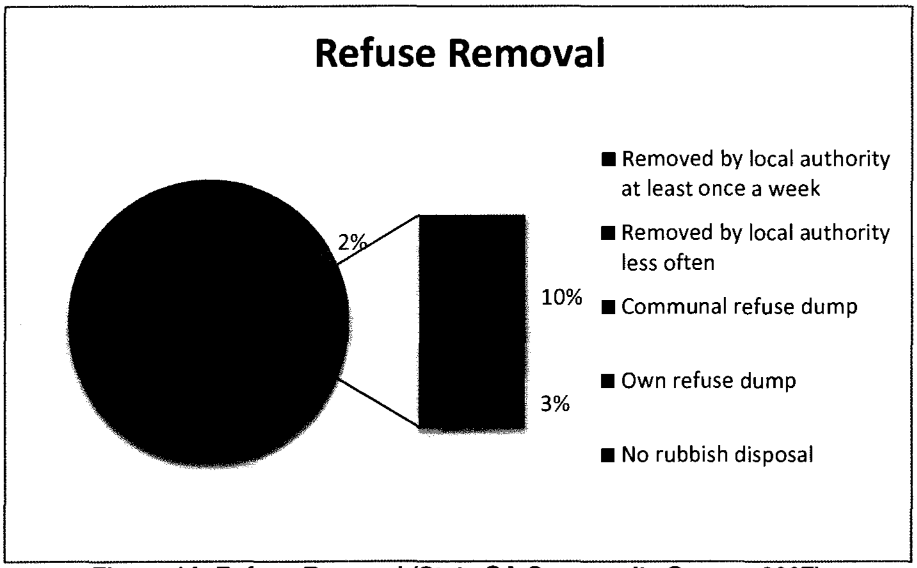


Figure 14: Refuse Removal (Stats SA Community Survey, 2007)

5.2.2.4 Social services provision

Housing

The majority (73%) of the population live in house or brick structures and 15% of the population live in informal settlements. The remaining 12% either live in traditional dwellings, workers' hostel or an alternative form of housing (refer to **Figure 16**).

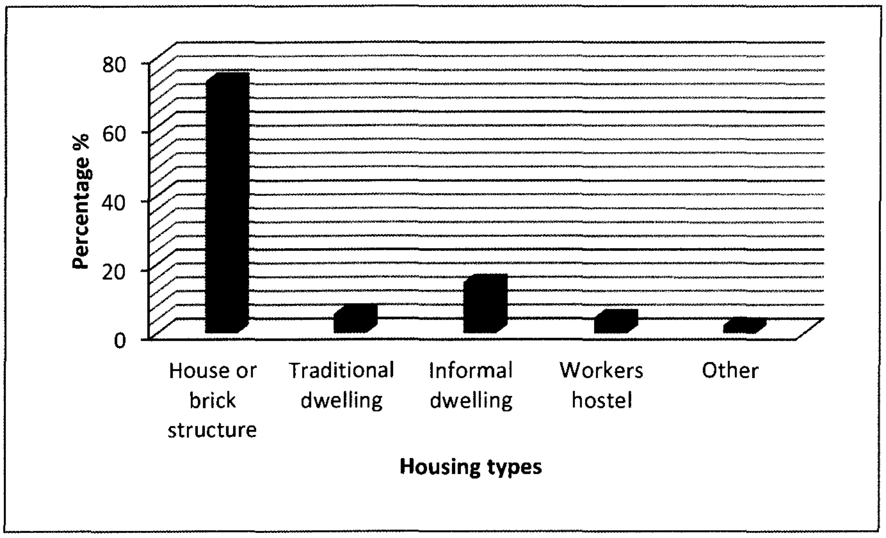


Figure 15: Provision of Housing (Stats SA Community Survey, 2007)

Transportation

The different modes of transportation in the municipality are detailed in **Figure 17**. The majority of the populations' (48%) mode of transportation is by foot.

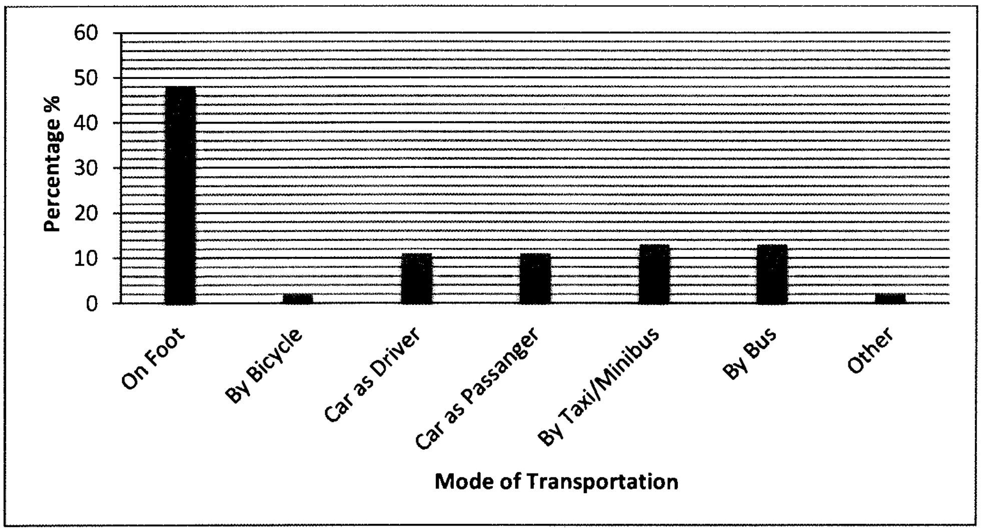


Figure 16: Transportation (Stats SA, 2001 Census)

Education

The educational profile of the population within the municipality is described in **Figure 18**. Due to the low income range that the majority of the population are situated in, the majority of the population have not completed Grade 12 and 8% have not undergone any form of education (and are most likely illiterate).

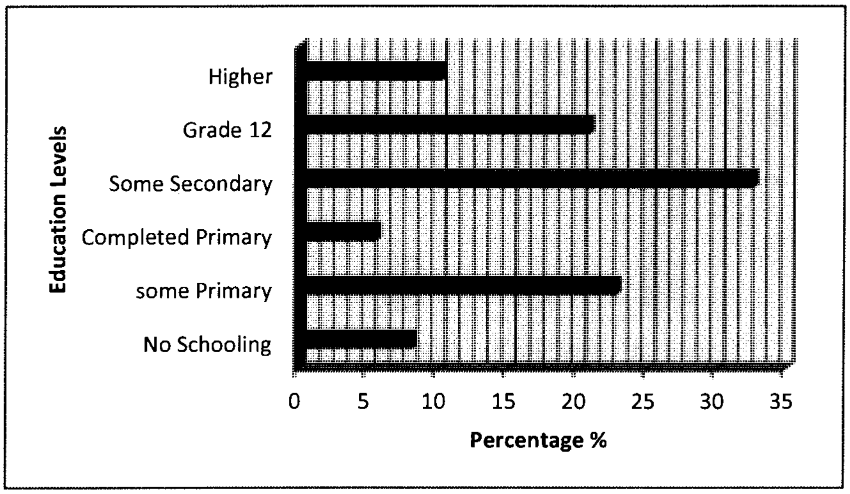


Figure 17: Education Levels (Stats SA Community Survey, 2007)

5.2.3 HIV and AIDS

HIV/AIDS has largely affected population trends within South Africa and its analysis provides insight into the expected shortage of skills.

The South African Department of Health undertook a National HIV and Syphilis prevalence Survey in 2005, the outcome of which indicated that the HIV/AIDS prevalence among antenatal clinic attendees was 30.2% in 2005, with the confidence limits of 29.1% and 31.2%. This is a 5.7% increase since 2000. The second highest HIV prevalence rate among the antenatal clinic attendees was Mpumalanga with an average rate of 34.8%, while its confidence limits were between 31.0% and 38.5%. The greatest percentages of people suffering from HIV/AIDS are aged between 25 and 29 followed by 30-34 years of age.

5.3 Attitudes toward development

The scoping phase undertaken requires detailed public participation. This public particpation is detailed as part of the Scoping Report. As part of this process, a public meeting was held on 12 March 2011 at the Busmid Auditorium in Middelburg. The meeting was attended by representatives from the DTJV, Jones & Wagener and SiVest. The meeting was chaired by Sivest who is the public participation practioner for the project. Comments raised by the public during the meeting where captured and are attached as part of the meeting minutes (refer to the EIA Report).

The minutes showed public sentiment towards the project was either positive or neutral, with no negative feedback received.

6 Social Impact Assessment

6.1 Scoping of impacts

6.1.1 Construction impacts

The construction period is expected to take place over a 24-30 month period employing approximately 2000 contractors on site.

Positive impacts associated with construction are:

- Employment and related wage benefits for construction workers and their associated communities[1];
- Limited expenditure into local economy due to expenditure of goods, materials and services; and
- Potential education opportunities afforded to contractors through skill transferral during employment.

Negative impacts associated with construction are:

- Noise and visual intrusion of construction activities on surrounding farms and the Naledi Village;
- The land is currently being used for agriculture; therefore the construction activities will cause a loss in agricultural productivity. The land was rented out to a farmer by MM;
- Increased traffic volumes;
- Possible migration of job seekers to the area;

[1]The general internationally accepted standard is that for every 1 primary industry job, 4-6 secondary industry jobs and 11 income basis jobs will be generated. This will result in further job creation and income generation thus benefiting the communities in the area.

- Unwanted social interactions between local population and construction workers. This will only apply if construction workers are sourced from outside the immediate surroundings;

- Unregulated spasa shops being set up to feed contract workers. Allows for loitering and littering.

- Influx of workers may result in crime. However this is unlikely to occur given that workers will not be allowed to stay onsite; and

- Increased local housing requirements.

6.1.2 <u>Operational impacts</u>

The operations are not expected to cease, therefore the operational phase will be continuous. As seen in the provisional operational organogram (refer to Figure 4), a staff compliment of 26 people is required to operate the facility (excluding security). Where possible, usage of local skills will be given a priory.

<u>*Positive impacts*</u> associated with operations are:

- Employment and related wage benefits for permanent workers and their associated communities;

- Limited expenditure into local economy due to expenditure of goods, materials and services;

- Potential education opportunities for skill transferral during employment;

- Discharge of treated water into the Niekerkspruit will improve water quality for downstream water users;

- Discharge of treated water into the Niekerkspruit will increase the annual amount of water in the spruit allowing greater downstream usage; and

- Reduced risk of untreated mine water entering the receiving environment.

Negative impacts associated with operations are:

- Possible small influx of jobs seekers from the potential jobs being created;
- The land is currently being used for agriculture therefore the MWRP will cause a loss in agricultural productivity;
- Noise generated impacting on the Naledi Village and surrounding farmers. A noise impact assessment has been undertaken (Ergosaf, 2008) to determine noise impacts from the MWRP. The study concluded that the noise impact was low and would conform to acceptable noise level ratings;
- Unwanted social interaction as a result of temporary workers on site, such as increased hunting, crime and littering;
- Increased traffic volumes; and
- Possible visual intrusion of the MWRP impacting on Naledi Village and surrounding farmers. Although this will be very minor due to high ground situated between the Naledi Village and the MWRP.

6.2 Impact Methodology

6.3 Assessment methodology

The quantitative risk assessment methodology is used in this SIA. The quantitative Environmental Risk Assessment is based on the following key elements:

- *Probability of occurrence:* this describes the likelihood of the impact actually occurring and is indicated as:-
  - Improbable, where the likelihood of the impact is very low;
  - Probable, where there is a distinct possibility of the impact to occur;

- Highly probable, where it is very likely that the impact will occur;
- Definite, where the impact will occur regardless of any management measure.

- *Consequence of occurrence* in terms of:
  - Nature of the impact;
  - Extent of the impact, either local, regional, national or across international borders;
  - Duration of the impact, either short term (0-5 years), medium term (6-15 years) or long-term (the impact will cease after the operational life of the activity) or permanent, where mitigation measures by natural processes or human intervention will not occur;
  - Intensity of the impact, either being low, medium or high effect on the natural, cultural and social functions and processes.

Significance level of the risk posed by the activity this is determined through a synthesis of the probability of occurrence and consequence of occurrence.

The rank of the risks was based on the quantitative assessment as described above and categorised into high, medium, or low risks. Management measures were then identified to mitigate, prevent and/or reduce the risk. These measures primarily focused on the risks identified as high in the ranking matrix, but will also include measures for medium and low risks. The management measures will be taken forward in the SIA as part of the authorisation process.

In order to assess each of the factors for individual impacts, the ranking scales as contained in **Table 4** were used.

Table 4: Ranking factors

PROBABILITY = P	DURATION = D
5 – Definite / don't know	5 – Permanent
4 – High probable	4 – Long-term (ceases with operational life)
3 – Medium probability	3 – Medium-term (5 – 15 years)
2 – Low probability	2 – Short-term (0-5 years)
1 – Improbable	1 - Immediate
0 - None	
SCALE = S	**MAGNITUDE = M**
5 – International	10 – Very high / Don't know
4 – National	8 – High
3 – Regional	6 – Moderate
2 – Local	4 – Low
1 – Site	2 – Minor
0 – None	

Once the factors had been ranked for each impact, the environmental significance of each impact could be assessed by applying the Significance Probability (SP) formula once the factors had been ranked for each impact. The SP formula can be described as:

SP = (magnitude + duration + scale) x probability

The maximum value of SP is 100. Environmental effects could therefore be rated as either high (H), moderate (M), or low (L) significance on the following basis:

- More than 60 points indicates high (H) environmental significance
- Between 30 – 60 points indicates moderate (M) environmental significance
- Less than 30 points indicates low (L) environmental significance

6.4 Detailed impact assessment

6.4.1 Construction phase

Impact Activity	Impact	Cause of Impact	Consequence of Occurrence					Risk Rating
			Scale	Duration	Magnitude	Probability	Significance Points	
Employment creation	Increased expenditure	Stimulus into the local economy due to expenditure of wages and the purchase of goods for construction activities	Positive					
	Increased employment	Construction activities will employ approximately 2000 contractors for a period of 24-30 months	Positive					
Construction activities	Noise generated	Noise generated through the use of heavy machinery and pumps	2	2	4	4	32	Medium
	Visual Impact	Visual intrusion of construction site and heavy machinery	2	2	4	4	32	Medium
	Loss of agricultural productivity	Land will be occupied by construction associated infrastructure and agricultural will no longer occur	1	5	4	5	50	Medium
	Power disruptions	Localised disruption in the provision of power to surrounding communities	2	1	4	2	14	Low

Impact Activity	Impact	Cause of Impact	Consequence of Occurrence					Risk Rating
			Scale	Duration	Magnitude	Probability	Significance Points	
Employment creation	Social interactions	Unwanted social interactions between local population and construction workers	3	2	6	3	33	Medium
	Crime	Increased theft and vandalism of mine infrastructure and surrounding areas	2	2	4	3	24	Low
	Increased housing	Increased local housing requirements will put strain on current infrastructure and residential areas	2	2	4	3	24	Low
Construction and materials deliveries	Increased traffic volumes	Increased traffic volumes as trucks and busses bring in workers and materials on a daily basis	2	2	4	4	32	Medium

6.4.2 Operational phase

			Consequence of Occurrence					
Impact activity	**Impact**	**Cause of impact**	**Extent**	**Duration**	**Magnitude**	**Probability**	**Significance Points**	**Risk Rating**
Employment creation	Increased employment	Operational activities will employ approximately 30 people	Positive					
	Increased expenditure	Stimulus into the local economy due to expenditure of wages	Positive					
Water treatment	Discharge of treated water	Treated water being discharged into Niekerkspruit will improve water quality for downstream users.	Positive					
	Discharge of treated water	Treated water being discharged into Niekerkspruit will increase water quantity available for downstream users	Positive					
Employment creation	Influx of job seekers	Small number of jobs being created may attract job seekers increasing competition, unwanted social interactions and increase population	2	5	3	2	20	Low
Operational activities	Loss of agricultural productivity	Land will be occupied by mining infrastructure and agricultural will no longer	1	5	4	5	50	Medium

Impact activity	Impact	Cause of impact	Consequence of Occurrence					Risk Rating
			Extent	Duration	Magnitude	Probability	Significance Points	
		occur						
	Noise generated	Noise generated through the use of industrial equipment	2	5	2	3	27	Low
	Visual Impact	Visual intrusion of water treatment plant and associated infrastructure	2	5	2	3	27	Medium
	Increased traffic	Increased traffic due to delivery of materials and operational staff	2	5	3	4	27	Medium

Aspect	Issue	Mitigation measure	Purpose	Frequency	Sampling method
Employment creation	Social Interactions	• Make use of local labour, as far as possible. • AIDS education to be included in all contractors training. • Ensure skills transfer takes place, as per the relevant Social and Labour Plans. • Labour camps will not be set up, as workers will not live on site. No hunting or fires allowed on site. EMPr will detail waste management plan to ensure no littering occurs. All contractors provided with training before work can commence.	To ensure improved socio-economic status of the area.	Monthly	Local status to be reviewed annually Contractor packs to clearly address issue of loitering, waste and fires.
	Increased housing	• Make use of local labour as far as possible.	To ensure quality of life is maintained	Annually	Public Forum
	Creation of unregulated spasa shops to feed	• All workers must be either bussed in or arrive by own transport. However no loitering allowed once shift ends.	Control the operation of a spasa shops to prevent littering, loitering and	Weekly inspection	Inspections Public Forum

Aspect	Issue	Mitigation measure	Purpose	Frequency	Sampling method
	contractors	• Spasa shop may not be open after hours • When construction ends, the shop must be removed.	unhygienic food production.		
Operational phase					
Operation	Noise generated	• Ensure all machinery is serviced and adequately maintained. • Machines to be operated Monday to Saturday from 6 am – 6 pm. Limited work on Sundays.	To determine if noise generated is within safe levels – SANS Code of Practice 10103:2004	Monthly	Acoustic measurements
	Visual Impact	• Where possible, Infrastructure should be painted with a muted earth-toned colour and be non-reflective. • Fit 'full cut-off' luminaries and direct sources of light downward to limit the visual impact on the surrounding communities and farmers.	To minimise visual impacts on surrounding communities	During construction	Visual inspection

Aspect	Issue	Mitigation measure	Purpose	Frequency	Sampling method
Employment creation	Influx of job seekers	• Make use of local labour as far as possible. • Ensure skills transfer takes place, as per the relevant Social and Labour Plans.	To ensure improved socio-economic status of the area. Develop social and labour plan with targets for employing local people on a year to year basis.	Annually	Local status to be reviewed annually Feedback to community
Operational phase	Increased traffic	• The MWRP will be located just off the R575. The entrance to the WTP and Naledi Village will be upgraded to ensure adequate traffic flow and increase safety.	To ensure improved socio-economic status of the area. Develop social and labour plan with targets for employing local people on a year to year basis.	Annually	Local status to be reviewed annually Feedback to community

8 Sustainable development

8.1 Current initiatives

The MWRP is a project being undertaken by the DTJV (a joint venture between BECSA and Tavistock Collieries). Both partners currently have community projects which are detailed within their respective Social and Labour Plans.

8.2 Site development and proposed labour plan

The MWRP will take approximately 24-30 months to be constructed and become operational. Approximately 2000 contractors will be employed during the construction phase of the project. No temporary housing will be built on site.

Approximately 25 - 30 permanent workers will be employed during the operational phase of the project. The project is expected to operate continuously. Labour for the permanent staff will be sourced, as far as possible, from the local community.

8.3 Economic spin-offs

The MWRP will benefit the surrounding community and the downstream users of the Spookspruit Catchment and the greater Loskop Dam Catchment both economically and socially.

The economic benefits of the MWRP are as follows:

- Increased employment[2] during both construction and operation phases.
- Increase expenditure on materials during both the construction and operational phases.
- Increased expenditure of workers' wages for food, entertainment etc.
- Treated water being discharged into the Niekerkspruit increases the current water quality which provides:
  - Higher quality water for irrigation, livestock watering and consumption.

[2] Both direct and indirect.

- Treated water being discharged into the Niekerkspruit increases the current water quantity which provides greater usage for downstream users.

The social benefits of the MWRP are as follows:

- Increase in job creation, and therefore an increase in employment numbers in the area (thus leading to a greater social security).
- Skills transfer afforded to employees, thus increasing the skills base in the area, as well as equipping these employees with new/improved skills which will enhance their future employment capability.
- Improved water qualities in the Spookspruit Catchment will, over time, increase biodiversity and aid in mitigating the current pollutant impacts on the water resources by means of dilution. An increase in biodiversity and improvement in water quality, in the catchment will increase quality of life for the catchment residents.
- The improved water quality will allow downstream users the opportunity to use water of a better quality for domestic use, thus decreasing potential health risks.
- The improved water quality will allow agricultural users the opportunity to irrigate their lands with water quality of a better standard than that which is currently available.

9 Assumptions and Knowledge Gaps

The following assumptions and knowledge gaps were ascertained during the undertaking of the SIA:

- The MWRP includes the construction of pipelines from the various water abstraction points. The pipelines will be constructed on mine owned land, thus minimising impacts on surrounding land users.
- The site which the water treatment plant and associated infrastructure is to be constructed is owned by the mine and was being leased by a farmer. The lease agreement is needed to determine if there will be any social and economic impacts.
- The MWRP includes a gypsum waste facility and chemical storage area. A HAZOP study is needed to determine impacts such as dam failure and chemical spillage on the surrounding community with emphasis on the Naledi Village.

10 Conclusions and recommendations

Water is a critical issue, and both the volume and quality of water in the catchment is under stress. The construction of the MWRP will have a significant benefit in improving the water quality in the Niekerkspruit and associated Spookspruit Catchment. The benefits of improved water quality and increased water in the system allow for improved ecological functioning and economic activity. These will far outweigh the costs of potential visual and noise pollution - provided the facility is operated in an acceptable manner.

It is thus recommended that the MWRP be constructed given the environmental, social and economic benefits.

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Statistics South Africa: www.statssa.gov.za.

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Client:	Middelburg Mine Services	Our Ref:	B478
Job:	Middelburg Mine Water Treatment Plant	Set no.:	2/2
Lab:	Civilab	Made by:	MT
Tests:		Date:	16 June 2008

Classification Data

			ASTM	BS	ISO	TRH						
Hole no.							PTP 07	PTP 07	PTP 09	PTP 11	PTP 16	ATP 02
Sample Name							PTP 07/2	PTP 07/2	PTP 09/1	PTP 11/1	PTP 16/1	ATP 02/1
Depth		m					6.0	6.0	1.6	1.0-1.6	0.5	0.3
Description												
Specific Gravity:	G_s											
Grading:			ASTM	BS	ISO	TRH						
		75.0	X	X		X	100	100	100	100	100	100
		63.0	X	X	X	X	100	100	100	100	100	100
		53.0				X	100	100	100	100	100	100
		37.5	X	X		X	100	100	100	100	100	100
		26.5				X	100	100	100	100	100	100
		19.0	X			X	100	100	100	100	100	100
		13.2		X		X	100	100	98	100	98	100
	No 4	4.75	X	X	X	X	100	100	94	70	90	100
	No 10	2.00	X	X	X	X	100	100	91	58	74	98
	No 20	0.850	X				95	95	88	52	63	95
	No 40	0.425	X	X	X	X	85	86	81	45	58	86
	No 60	0.250	X		X		70	71	71	40	51	74
	No 100	0.150	X	X			46	46	60	34	38	58
	No 200	0.075	X	X	X	X	29	29	52	25	26	44
	Hydrometer	0.040					23	24	43	17	22	24
		0.020					19	19	34	13	16	19
		0.006					12	12	25	10	11	12
		0.002	X	X	X	X	8	10	19	8	7	10
Grading Properties												
D_{10}		mm										
D_{30}		*mm*										
D_{60}		*mm*										
Coefficient of Uniformity	CU											
Coefficient of Curvature	CC											
Grading Modulus	**GM**						**0.86**	**0.85**	**0.76**	**1.72**	**1.42**	**0.72**
Gravel	G	%					0	0	9	42	26	2
Sand	S	%					74	74	44	37	50	64
Silt	M	%					18	17	29	13	17	24
Clay	C	%					8	10	19	8	7	10
Fines	M+C	%					26	27	48	21	24	34
Atterberg Limits												
Liquid Limit	LL	%							22	25	19	26
Plastic Limit	PL	%							13	17	12	15
Linear Shrinkage	LS	%										
Plasticity Index	PI	%							9	8	7	11
PI Whole Sample		%							7	4	4	9
Liquidity Index	LI									-0.6		-0.5
Clay Activity	A								0.47	1.00	1.00	1.10
Vd Merwe Swell		%										
Brackley Swell												
Natural Moisture Content	w	%					11.3			12.1		9.5
Dry Density	ρ_d	*kg/m*^{3}										
Saturation	S	%										
Swell @ p(kPa)	50	%										
	125	%										
	250	%										
Classification												
Matrix Description												
British												
AASHTO												
Unified												

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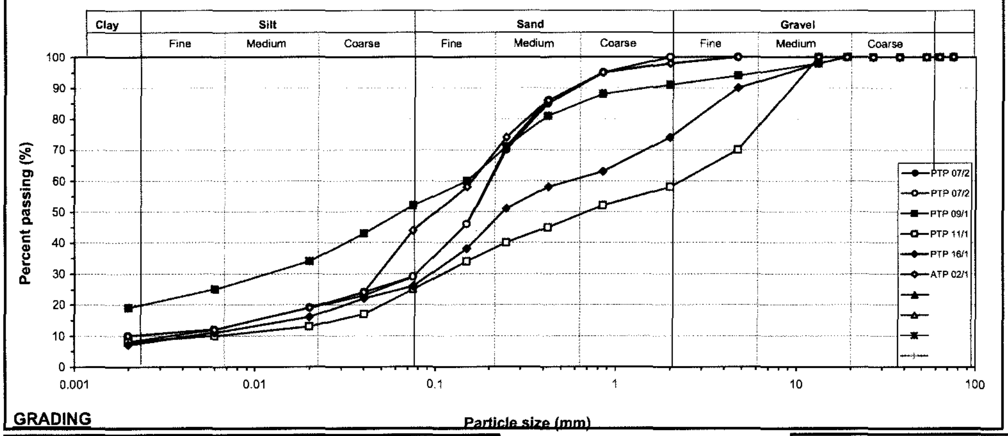
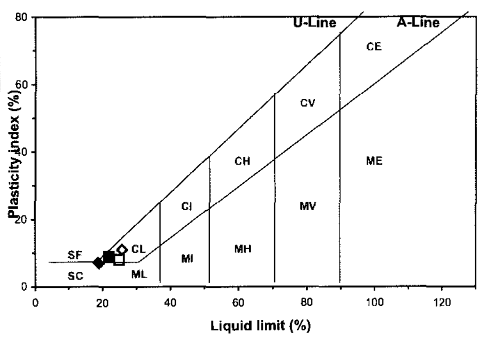
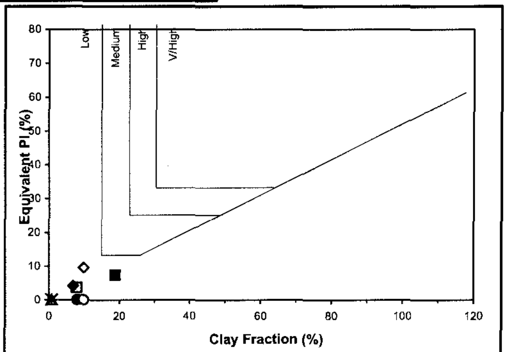
	Job:	Middelburg Mine Water Treatment Plant	Set no.:	2/2
	Lab:	Civilab	Made by:	MT
	Tests:		Date:	16 June 2008



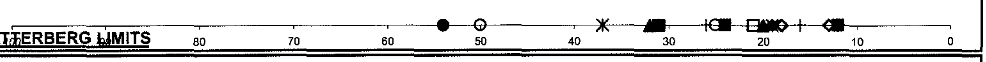
GRADING



CASAGRANDE CHART

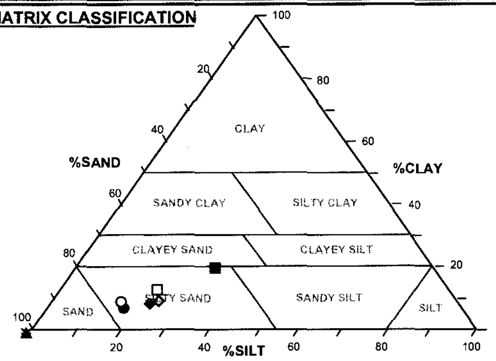


HEAVE CHART

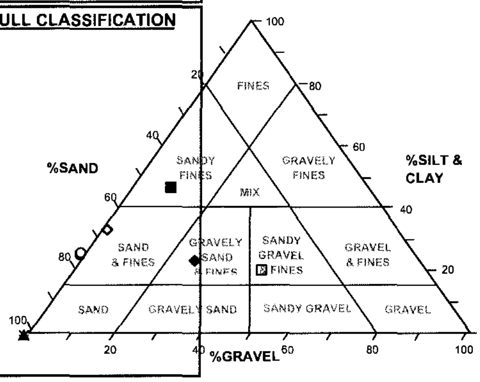


ATTERBERG LIMITS

MATRIX CLASSIFICATION



FULL CLASSIFICATION



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Client:	**Middelburg Mine Services**	**Our Ref:**	**B478**
Job:	**Middelburg Mine Water Treatment Plant**	**Set no.:**	**1/1**
Lab:	**Civilab**	**Made by:**	**MT**
Tests:		**Date:**	**16 June 2008**

Classification Data

Hole no.			**PTP 07**	**PTP 11**
Sample Name			**PTP 07/1**	**PTP 11/1**
Depth		m	**1.8-2.2**	**1.0-1.6**
Description				
Specific Gravity:	G_s			
Grading:				
		75.0	100	100
		63.0	100	100
		53.0	100	100
		37.5	100	100
		26.5	100	100
		19.0	100	100
		16.0	100	100
		13.2	100	100
	No 4	4.75	90	70
	No 10	2.00	70	58
	No 20	0.850	62	52
	No 40	0.425	55	45
	No 60	0.250	48	40
	No 100	0.150	40	34
	No 200	0.075	32	25
	Hydrometer	0.040	22	17
		0.020	16	13
		0.006	14	10
		0.002	9	8
Grading Properties				
D_{10}		mm	0.002	0.006
D_{30}		mm	0.066	0.110
D_{60}		mm	0.697	2.310
Coefficient of Uniformity	CU		279.9	385.0
Coefficient of Curvature	CC		2.5	0.9
Grading Modulus	**GM**		**1.43**	**1.72**
Gravel	G	%	30	42
Sand	S	%	43	37
Silt	M	%	18	13
Clay	C	%	9	8
Fines	M+C	%	27	21
Atterberg Limits				
Liquid Limit	LL	%	26	25
Plastic Limit	PL	%	16	17
Linear Shrinkage	LS	%		
Plasticity Index	PI	%	10	8
PI Whole Sample		%	6	4
Liquidity Index	LI		0.1	-0.6
Clay Activity	A		1.11	1.00
Vd Merwe Swell		%	Low	Low
Brackley Swell				
Natural Moisture Content	w	%	16.8	12.1
Dry Density	ρ_d	kg/m^3		
Saturation	S	%		
Swell @ p(kPa)	50	%		
	125	%		
	250	%		
Classification				
Matrix Description			**Silty SAND**	**Silty SAND**
British			**SCL**	**GCL**
AASHTO			**A-2-4[0]**	**A-2-4[0]**
Unified			**SC**	**SC**

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Job:	Middelburg Mine Water Treatment Plant	Set no.:	1/1
Lab:	Civilab	Made by:	MT
Tests:		Date:	16 June 2008

Compaction Data

Hole no.			**PTP 07**	**PTP 11**
Sample Name			**PTP 07/1**	**PTP 11/1**
Depth		*m*	**1.8-2.2**	**1.0-1.6**
Description				
Compaction Energy	[Mod]			
Moisture Content	1	%	11.1	12.0
	2		13.3	12.8
	3		14.0	14.1
	4			
	5			
	6			
Dry Density	1	*kg/m³*	2109	2009
	2		2003	1914
	3		1921	1814
	4			
	5			
	6			
Maximum Dry Density		***kg/m³***	**2103**	**2005**
Optimum Moisture	**OMC**	**%**	**9.6**	**11.1**
California Bearing Ratio		[Mod]		
Moisture Content		%	9.6	11.1
Dry Density	100	*kg/m³*	60	54
	97		52	45
	95		41	33
	93		30	25
	90		19	17
Swell	100	%	0.00	0.10
	95		0.00	0.00
	90		0.10	0.00
CBR @ 2.54mm	100	%	61	55
	97		43	35
	95		23	18
	93			
	90			
Classification				
Natural - TRH14				

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	Job:	Middelburg Mine Water Treatment Plant	Set no.:	1/1
	Lab:	Civilab	Made by:	MT
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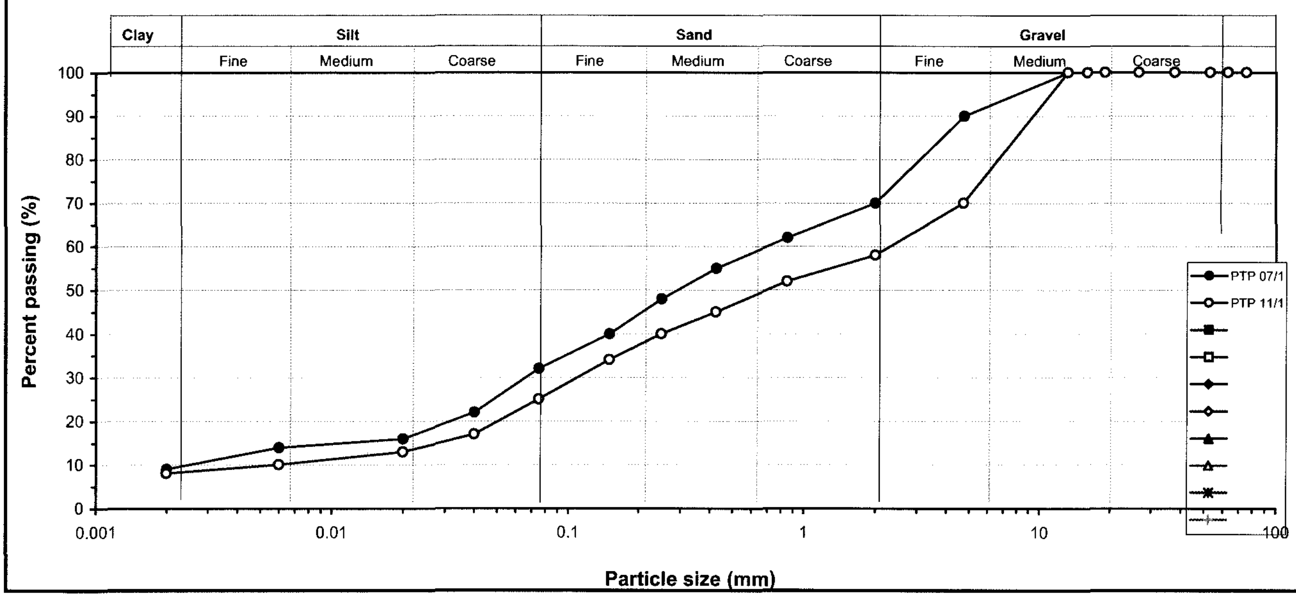
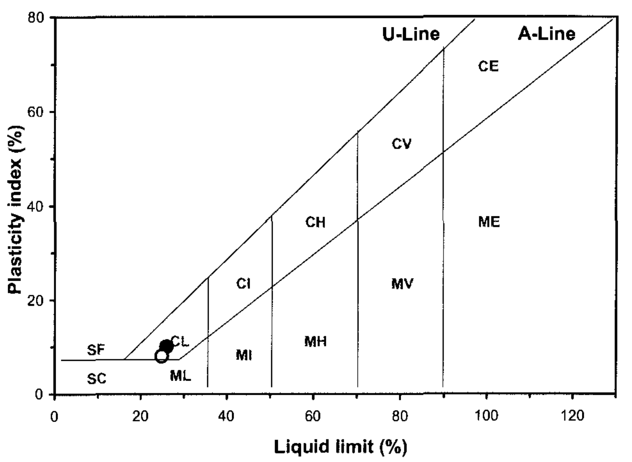
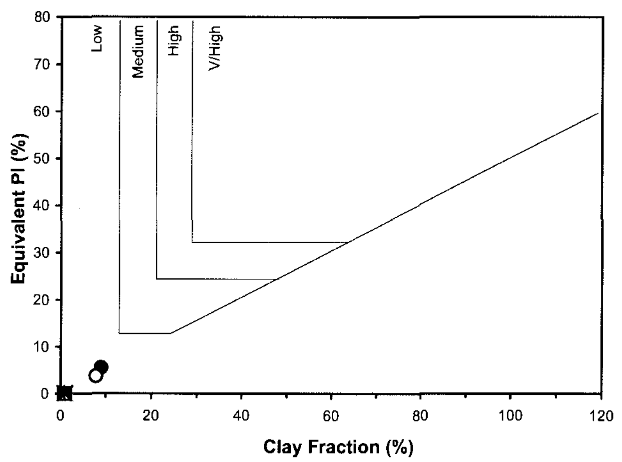
Gradings



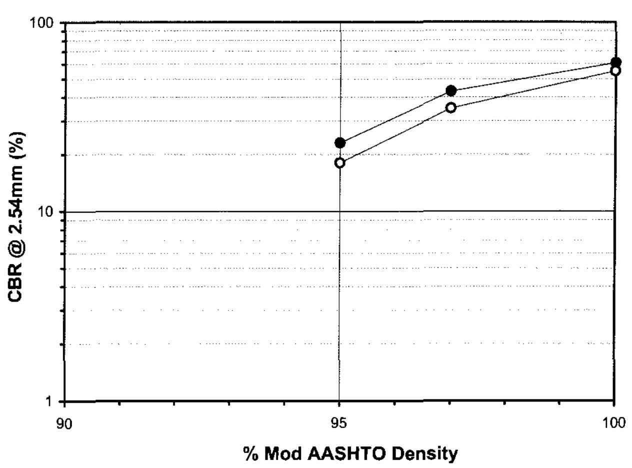
Plasticity Chart



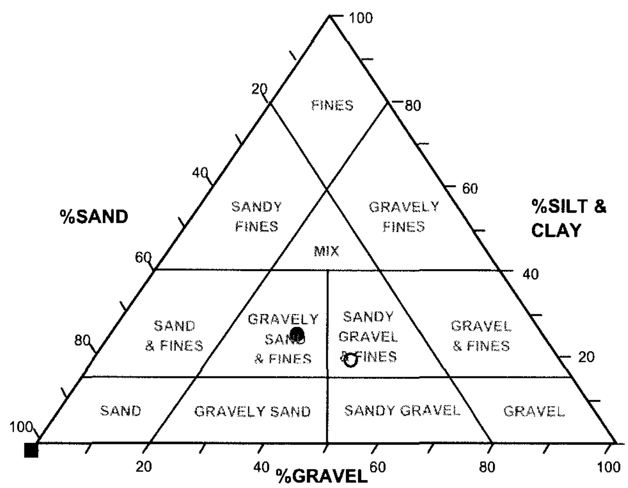
Van der Merwe Heave



California Bearing Ratio



Classification



MIDDELBURG MINE SERVICES

FEASABILITY GEOTECHNICAL STUDY
PROPOSED PIPELINE ROUTES
MMS WATER PROJECT

Report No.: JW136/08/B478 - Rev A

September 2008

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DOCUMENT APPROVAL RECORD

Report No.: JW136/08/B478 - Rev A

ACTION	FUNCTION	NAME	DATE	SIGNATURE
Prepared	Geologist	B. Antrobus	2 Sept 2008	
Reviewed				
Approved				

RECORD OF REVISIONS AND ISSUES REGISTER

Date	Revision	Description	Issued to	Issue Format	No. Copies

SYNOPSIS

An airphoto interpretation terrain evaluation has been carried out for the proposed pipeline routes.

A number of terrain units have been identified and a brief description of the profile, horizon properties and excavation characteristics has been provided.

The pipeline is to comprise HDPE (PE 100 PN 16) pipe that will be buried at a depth of 1,5m.

The terrain evaluation, limited field inspection and data evaluation has indicated that over most of the routes, soft excavation can be expected and that the hillwash sand will provide material that could be considered for bedding and selected fill requirements.

A detailed investigation including TLB test pits and laboratory testing may be required once all routes and type of pipe are finalised.

MIDDELBURG MINE SERVICES

FEASABILITY GEOTECHNICAL STUDY
PROPOSED PIPELINE ROUTES
MMS WATER PROJECT

REPORT NO: JW136/08/B478 - Rev A

CONTENTS

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MIDDELBURG MINE SERVICES

FEASABILITY GEOTECHNICAL STUDY
PROPOSED PIPELINE ROUTES
MMS WATER PROJECT REPORT NO: JW136/08/B478 - Rev A

1. INTRODUCTION

This report presents an analysis of geotechnical parameters identified for the proposed 90 km's of pipeline for the Water Treatment Project.

The geotechnical investigation forms a section of an Environmental Impact Assessment report[1]. for the proposed Water Treatment Facility at Middelburg Mine.

The investigation was undertaken under Order No. 4300153009 requested by Middelburg Mine.

2. METHOD OF INVESTIGATION

The investigation was a feasibility study and was therefore limited to:

- an aerial photographic terrain evaluation.
- analysis of available data.
- limited field work.
- compilation of a geotechnical terrain data map.

3. AIR PHOTO INTERPRETATION (API)

Four defined routes of pipeline are currently proposed. The routes are shown on Drawing B478-02-001. Excavating test pits at regular intervals along each of the different routes to identify profile conditions as part of a feasibility study was not considered practical and

1 Jones & Wagener. Feasibility Geotechnical Evaluation of Two Proposed Water Treatment Plants. Middelburg Mine, Middelburg. Report No. JW107/08/B478 - Rev. A.

consequently airphoto interpretation (API) with limited field work to define and confirm different land facets/elements or terrain units was proposed.

API identifies various terrain units or land elements that occur within the area. A terrain unit defines a specific land element that exhibits similar surface forms, soil, vegetation and lithology. Consequently similar geotechnical characteristics for similar units can also be expected.

Once the terrain units are identified and marked on a map, the expected profile conditions are confirmed by inspecting profile conditions in cuttings, river channels etc and by assessing profile conditions from available sources (e.g. geotechnical reports).

4. GEOLOGY

The general lithology in the area comprises Karoo Sequence sediments that locally consist of sandstones and shales of the Vryheid Formation, Ecca Group and felsites of the Selanorivier Formation, Rooiberg Group, Bushveld Complex and Post Rooiberg Group diabase intrusives are also present.

5. TOPOGRAPHY

The general topography of the area over which the different pipelines will traverse, is gently rolling and undulating.

The Spookspruit and Boesmankransspruit in the north and south respectively define the two rivers draining the study area. Associated with these streams are smaller gully tributaries.

The above landform will therefore typically comprise terrain units defined by alluvial zones, gullies, gentle convex sideslopes and convex crestal areas. Localised pan areas within the crestal zones are also present.

6. TERRAIN EVALUATION

The terrain units identified include

- crestal area on either Karoo Sediments or rhyolites of the Bushveld Complex.
- sideslope on residual Karoo sediments.
- sideslope on residual rhyolites.
- alluvial zones.
- gullywash zones.
- rehabilitated areas.

The terrain units and the location of test pits used in the evaluation of profile properties, are provided on Drawing B478-02-001.

The soil properties, excavation depths and material properties have been assessed for each terrain unit.

The pipes to be used for the different pipelines will all be HDPE (PE 100P N16) pipes that will be buried at a depth of 1,5m.

For this class of pipe we have assumed that a sandy bedding and backfill (i.e. material similar to selected fill material) will be suitable.

6.1 Crestal Areas

6.1.1 Soil Profile

The crestal areas are characterised by a gentle convex topographic form. The soil profile comprises moderately thick (1,0m to 1,5m) hillwash of slightly moist, yellow-brown, silty sand overlying a ferruginised hillwash to transition horizon. This horizon grades into a moderately ferruginised transition of silty sand and ferruginised concretions that is generally present from a depth of 1,3m to reach of TLB at about 2,5m.

Seepage may be encountered at the contact of the hillwash and well cemented hillwash / transition. Depth typically in the order of 2,0m.

6.1.2 Soil Properties

The hillwash comprise a fine clayey to silty sand that exhibits low heave characteristics. Sand content is likely to range from 50% to 70% and Plasticity Indices are expected to range from 10% to 14%.

This material could be considered for selected fill material particularly for HDE piping. Properties of the material should however be reviewed by the design engineer during the detailed study.

6.1.3 Excavation

Soft excavation characteristics are expected to a depth of approximately 2m in most cases within this unit. Locally, the ferruginised transition is dense to very dense and excavation with a TLB (Case 580G or equivalent) may be slow.

6.2 Sideslope Profile

6.2.1 General

The sideslope unit is characterised by a gently sloping convex topography. This unit represents the dominant terrain unit over which the pipe routes traverse.

The underlying lithology is dominantly a shale or sandstone of the Karoo Sequence but locally diamictite of the Dwyka Formation and rhyolite of the Silons River Formation are present. The geotechnical aspects of each unit are discussed below.

6.2.2 Sideslope on Karoo Shale or Sandstone

Profile
The transported soil (hillwash) comprises a variable thickness of a slightly moist, brown to yellow-brown, silty sand that grades with depth into a ferruginised hillwash. The hillwash is typically 0,8m to 1,2m thick and grades with depth into a nodular ferruginised sand. The degree of ferruginisation is moderate resulting in a dense to very dense horizon that extends to depths of approximately 1,5m. Below this depth a well cemented and ferruginised transition is present.

Along a short section south of the MMS entrance, a diabase intrusive is present. In this section the hillwash is in excess of 2,5m thick.

Seepage / perched water table development can be expected at the interface of the hillwash and well cemented and ferruginised horizon. Depth could vary from 1,6m to 2,7m.

Soil Properties
The hillwash sand is a fine to medium grained, slightly clayey sand that exhibits a low heave potential. The properties will be similar to those discussed for the crestal unit. This material, therefore, could be considered as selected fill material with design engineer's approval.

The ferruginised hillwash and transition may comprise material in excess of 30mm diameter and should be considered for main / general fill only.

Excavation Characteristics
Soft excavation is expected to depths of 2,5m. The ferruginised hillwash and transition may however be very dense and for a confined excavation may classify as intermediate.

6.2.3 *Sideslope on Rhyolite*

Soil Profile
This terrain unit is located in two areas, namely immediately south of the MMS entrance and approximately 1 km south of N4/R575 intersection and is characterised by a rough convex boulder outcrop topography.

The profile is represented by a thin (300mm to 500mm) brown to yellow-brown silty sand with occasional gravels and boulders (hillwash and colluvium) that is underlain by an irregularly developed dense to very dense ferruginised sand with mixed gravels and boulders typically 100mm to 400mm thick. A highly weathered, closely jointed, soft rock rhyolite underlies this horizon.

Seepage is only likely within the wetter summer months and is expected to be shallow (<1,0m) on the hillwash / residual interface.

Soil Properties
The hillwash and ferruginised horizons will comprise clayey sands as a matrix to mixed gravels and boulders while the rhyolite will occur as an angular gravel that ranges in size from 50mm to 150mm within a silt matrix.

These materials exhibit low heave characteristics but due to the likely presence of oversize material, the use of this material should be limited to general / main backfill requirements for pipe works.

Excavation Characteristics
The profile to a depth of approximately 1,5m is expected to classify as soft. Below this depth, a jointed rhyolite is expected that may classify as intermediate. Hard excavation can be expected below 2,0m.

The rhyolite exhibits variable depths and degrees of weathering, consequently soft excavation could range from a depth of about 0,5m to depths of 2,5m.

6.2.4 *Sideslope on Diamictite*

Profile
Locally around the sideslopes of the dominant drainage features i.e. Boesmankransspruit and Spookspruit, diamictites of the Dwyka Formation may be encountered.

Within these areas, the profile will comprise approximately 600mm of brown silty hillwash sand that is poorly ferruginised towards the base. This horizon overlies a residual diamictite of dense to very dense sandy silt with loosely packed subrounded mixed boulders.

Very slight seepage at the residual interface is possible.

<u>Soil Properties</u>
The transported and residual soils comprise a fine sandy silt with boulders. The material is expected to be inactive with regard to heave.

The excavated material is likely only to satisfy general / main fill requirements with regard to pipe laying specifications as excessive oversize material may be encountered. Where the hillwash horizon is >300mm thick, it should be excavated onto one side of the trench and stockpiled for selected fill requirements.

<u>Excavation Characteristics</u>
The diamictite ranges from a dense to very dense residual silt and boulder material to depths of about 2,5m. Soft excavation characteristics are expected to this depth while intermediate to hard may be encountered below 2,5m.

6.2.5 *Gullywash Unit*

<u>Profile</u>
The gullywash unit defines the secondary drainage features. The gullies are typically concave in profile with poorly defined flood plains that are limited in extent. The soil profile recorded within the area is fairly typical for the whole study area.

The profile comprises a very moist dark brown organic rich clayey to silty sand (200mm to 300mm thick) overlying a very moist to wet, brown, clayey sand to sandy clay 1m to 2m thick. Below this horizon residual soils comprising clayey silty to sandy clays will be present.

Ferruginisation from about 1m is common particularly along the sideslope / gullywash interface.

Seepage is commonly encountered below 0,9m.

<u>Soil Properties</u>
The gullywash soils comprise predominantly fine and medium sands. These are non-cohesive soils and consequently sidewall instability, particularly when wet, can be expected for excavations in this terrain unit

The sands could satisfy pipe bedding and selected fill requirements but the material will need to be stockpiled and allowed to dry out.

<u>Excavation</u>
Excavations to depths of 2,5m will classify as soft. Consideration to sidewall stability will have to be given to any excavation in this unit.

Along the flanks of the gullywash areas where a well cemented and ferruginised horizon and occasional very dense residual soils are encountered, intermediate excavation can be expected.

Due to the presence of a shallow water table, saturation of trench excavations will occur and the use of a dump rock pioneer to facilitate drainage during pipe laying may need to be considered.

6.2.6 *Pan Deposits*

<u>Soil Profile</u>

The pan deposits represent wetland areas that are usually located within the crestal terrain units. They are thought to represent old erosional features that have progated downwards as erosion of the landscape occurred. The profile within the pan basin comprises a very moist to wet, grey, soft, sandy clay with roots. The horizon is about 1m thick. Moist, stiff, sandy clays residual from Karoo sediments underlie the pan clays.

Seepage, where not on surface, is present at the transported / residual interface at a depth of about 1m.

<u>Soil Properties</u>

The transported and residual soils are predominantly fine grained silts and clays and consequently are expected to exhibit a moderate to high heave potential when the degree of saturation is low. Under current conditions, these soils are very moist to wet, and therefore saturated and consequently heave is not expected.

<u>Excavation Characteristics</u>

The profile to a depth of 2,5m will classify as soft excavation. Consideration must be given to sidewall stability, as any excavation in the pan area larger than test pit length (about 2m to 2,5m), is likely to be unstable.

6.2.7 *Alluvial Terrain Unit*

<u>Soil Profile</u>

The main alluvial drainage channels comprise thick (2,5m to 3,5m) alluvium of very moist to wet, grey, soft, fissured sandy clay. This typically overlies residual shale to sandstone comprising moist, yellow-brown, firm, sandy clay.

The alluvial profile will often be characterised by surface water.

The alluvial clays will thin as the sideslope units are approached and ferruginisation of the profile may be encountered.

<u>Soil Properties</u>

The alluvial clays normally exhibit moderate to high heave potentials in a partially saturated condition. However, as the soils are likely to be saturated, low to moderate heave potentials can be expected.

The wet clayey nature of the material will result in the material only being suitable for general backfill. These properties and the degree of saturation will adversely affect compaction of the backfill and consequently backfill in thin layers (<100mm thick) and light compacting may have to be considered.

Trenches excavated within the alluvial profile are likely to be unstable and battering back the sides to stable angles will be required.

<u>Excavation Characteristics</u>

The profile to a depth of 3m will generally classify as soft excavation. Locally on the flanks of the alluvial zones, medium hard rock sandstones may be encountered. These bands are likely to classify as hard excavation and use of a rock bucket on a suitably sized excavator may facilitate excavation through these lenses.

Excavation trenches will contain surface water and use of dump rock as a pioneer layer may be necessary to act as a capillary brick and ensure relatively dry conditions during pipe laying.

6.2.8 *Rehabilitated Areas*

<u>Profile</u>
Localised areas have been identified where backfill and rehabilitation of open cast areas has occurred. Within these areas, a thin (300mm to 500mm) soil capping cover overlies an end-tipped, loosely to closely packed, angular gravel and boulder rockfill with a sandy matrix. Boulders can be up to 2m x 2m x 2m.

<u>Profile Properties</u>
Due to the nature of placing of the backfill, washout of the fine matrix and consolidation are common. Settlement of fill with time, therefore, can be quite significant and such settlements could result in damage to pipes.

Records of incidences where combustion of the fill has occurred have been recorded and the heat generated from this combustion could result in damage to the pipeline.

<u>Excavation</u>
Excavation with the backfill is likely to classify as soft but allowance for Boulder Excavation Class B should be made due to the large boulders that may be encountered.

7. DISCUSSION

The terrain evaluation and feasibility study of available data and limited field work has indicated that most of the pipelines will be located within a sideslope terrain unit. Within these units, excavation to a depth of 2m is expected to classify as soft and suitable selected pipe backfill could be obtained from the hillwash horizon during excavation.

Excavation and stockpiling of the hillwash material and ferruginised hillwash, typically to a depth of 1,2m, on one side of the excavation should be considered. The material below this depth may contain oversize material and should be stockpiled on the other side of the trench and backfilled as main backfill once the pipes have been covered with the hillwash.

The stability of the trench sidewalls must be assessed as excavation advances. Where the hillwash is about 1m thick and underlain by a ferruginised hillwash / transition near vertical excavations are possible. Where the hillwash is up to 2m to 3m thick, battering the sidewalls will have to be considered as unstable sidewalls will occur in these areas.

The gullywash and alluvial areas will contain very moist to wet soils and unstable sidewalls must be assumed for these units.

Due to the nature of the development of transported and residual soil development and the erosional cycles that have occurred, variations in horizon thicknesses will occur.

The hillwash sand could be considered for use as a selected backfill (with Engineer's approval). This material is present along most sections but over the rhyolite aeras and alluvial and gullywash importing hillwash or suitable material will be required.

Within the gullywash unit and particularly the alluvial zones the base of the excavations are likely to be wet and consequently a pioneer dump rock layer may need to be considered.

Once the routes have been finalised, a detailed geotechnical investigation may be required to evaluate:

- rock exposures.
- excavation characteristics along the route and
- the soil properties with regard to selected backfill and granular backfill.

Granular backfill may have to be imported, if required, as the soil horizons and properties along the routes are unlikely to satisfy granular bedding requirements.

BRYAN ANTROBUS
for Jones & Wagener

2 September 2008

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VOLUME 1

PRELIMINARY REPORT ON A GEOTECHNICAL INVESTIGATION OF THE MIDDELBURG RECLAMATION PROJECT (MWRP)

Project: LL1717
Date: November 2010
P.G. Hansmeyer *Pr.Sci.Nat.*

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VOLUME 1

PRELIMINARY REPORT

GEOTECHNICAL INVESTIGATION OF THE MIDDELBURG WATER RECLAMATION PROJECT, MIDDELBURG MINE SERVICES

1. INTRODUCTION

1.1 Terms of Reference

This preliminary report presents the results of a geotechnical investigation into the Middelburg Water Reclamation Project's proposed pipeline routes inclusive of infill sections on the water treatment plant (WTP) and waste disposal system (WDS) sites. The various routes and sites are indicated on the Locality Plan, Figure 1 in the beginning of the report.

The tender invitation by BHP Billiton Energy Coal South Africa Limited, dated April 2010 was conducted under their reference Enquiry Document Number MWR_4_1_1_ED_CE_001.

The scope of work for the investigation specified inter alia the following investigation procedures:-

i) Determine the site geology and the depth to well cemented pedocretes or bedrock where possible.

ii) Establish the soil, weathered rock and outcrop profiles across the site and evaluate their engineering properties and influence on the proposed pipeline routes inclusive of the structures on the WTP and WDS sites.

iii) Assess the groundwater conditions, including surface run-off, ponding and comment on the presence of perched or permanent water tables.

iv) Classify the proposed routes and the project site for 'pipeline suitability' according to geotechnical categories such as seepage, flooding, excavatability, the likely stability of the trench sidewalls, the availability of bedding material for the pipeline and the geotechnical conditions at road and stream crossings. Other aspects to be considered include ESKOM overhead power lines and servitudes, conveyor, haulage and provincial road crossings.

This report is based on information obtained from:

- Pretoria geological map, sheet 2528 to scale of 1:250 000.
- A geotechnical investigation carried out by Engeolab CC in 2009 – reference LL1617: Preliminary Report – 06 April 2009 and Final Report – 08 July 2009.
- Profiles of 174 test pits excavated along the proposed pipeline routes.
- Soil test results of a number of foundation and compaction tests of representative disturbed soil samples taken during the field investigation.
- 2m deep hand-held DCP tests carried out alongside every test pit.
- Aerial photographic data provided in digital format by Middelburg Mine Services.
- Topographical survey of the site in digital format.

The report and its appendices are contained in Volume 1 of the document while the drawings are presented as Volume 2.

1.2 Site Observations

MMS's open cast mining activities are focused on areas underlain by the coal bearing Vryheid Formation located on various portions of the farms Goedehoop 315 JS, Sterkwater 317 JS, Hartbeestfontein 339 JS and Rondeboschje 486 JS – hence the presence of rehabilitated and partially rehabilitated sections located adjacent to the proposed pipeline routes – refer to the Site Plan, Figure 2.

The Middelburg Water Reclamation Project (MWRP) is aimed at treating water from Middelburg Mine Services (MMS) to a quality fit for release into the catchment of the Olifants River. The project comprises a 15*ML/day* water treatment plant, a water collection system, water storage and distribution and waste disposal. This investigation forms part of the water collection system where an estimated 24km of 350 - 450mm diameter HDP pipeline will be required. Two routes had been considered to tie into the pipeline from the Rondeboschje earth embankment dam to Collection Dam 5 and the Goedehoop earth embankment dam – one along the boundary between Sterkwater and Goedehoop and another along the western boundary of Goedehoop – refer to the Site Plan, Figure 2.

The proposed pipeline routes traverse the following Mine Manager's areas of responsibility: - Goedehoop, Hartbeesfontein, Klipfontein and North Plant. The proposed pipelines are denoted as PK, PG1, PG2, W, WT and D - each with an alphabetical line section – e.g. AA', BB' etc., which ties in with the cross sections referred to in Paragraph 4.

On the MWRP's project site, the investigation was conducted to add additional information to the initial geotechnical investigation conducted in January 2009.

The investigation highlighted the following geotechnical constraints and other important aspects encountered along the pipeline routes and the MWR project site:-

i) seasonal flooding at pipeline crossings located within several drainage courses;
ii) seepage zones within the deeper sections of the soil and weathered profiles and pedogenic horizons;
iii) soils up to 2m thick with a loose to very loose consistency associated with unstable/collapsing side walls of excavations;
iv) scattered hardpan ferricrete, shale, sandstone and older rhyolite bedrock causing shallow refusal of the backhoe (<1.5m);
v) imported fill placed on the haulage road in the cutting on Line PG1 as well as on Line PK for a drainage crossing;
vi) two small outcrops of sandstone on Line PK;
vii) crossing of fibre-cement pipe of unknown function near Rondeboschje earth embankment dam;
viii) a provincial road crossing (the R33) on Line PK;
ix) crossing of the conveyor on Line PK;
x) presence of an extended borrow pit on Line PG1;
xi) crossing of a box cut on Line PG1;
xii) crossing of a conveyor on Line PG1;
xiii) potential rise of the water table on the WTP and WDS sites that were initially dry;
xiv) overhead power lines and ESKOM servitudes.

The preliminary geotechnical investigation's main effort was to determine the bedrock geology, the soil characteristics, excavatability, the presence of groundwater and areas susceptible to flooding, a visual assessment of stability of trench excavations along the proposed pipeline routes and the availability of bedding material. The investigation comprised test pitting, profiling, sampling, soil testing of disturbed representative samples and DCP probing adjacent to 174 test pits excavated along the proposed pipeline routes – refer to the Site Plan, Figure 2.

Soil samples were extracted at several test pit holes at various levels (maximum depth 3.8m) in the soil profile. The purpose of the soil samples was to obtain and verify soil characteristics and investigate its workability – that is excavatability, bedding material engineering characteristics and stability of trench excavations. The purpose of the hand-held DCP's was to verify the consistency of the soils and weathered overburden as well as the depth of bedrock or well cemented pedocrete.

1.3 Site Drainage and Topography

The topography of the proposed pipeline routes is controlled by the bedrock geology. The sediments of the Vryheid Formation form a local watershed and trend more or less parallel to the tarred R33 from Middelburg to Bethal. Along this alignment the site dips eastwards towards the upper reaches of the Vaalbankspruit and westwards towards the perennial Spookspruit. The two drainage courses are initially confined to fairly narrow and shallow valleys, gradually deepening and widening northwards.

The Goedehoop earth embankment dam, Dam 6 and several smaller earth embankment dams are located near the proposed pipeline routes PG1 and PG2 on Goedehoop 315 JS – refer to the Site Plan, Figure 2. The Rondeboschje earth embankment dam is located in the upper reaches of Vaalbankspruit on the farm Rondeboschje 468 JS close to the southern extreme of Line PK. A third collection dam, Dam 5, is located at the western extreme of Line PK.

Seepage and surface run off are also collected in two shallow pans separated by the tarred R33 located adjacent and in close proximity to Line PK on the farm Sterkwater 317JS.

2. METHODS OF INVESTIGATION

2.1 Test Pitting and Profiling

Using a Komatsu WB 93E tractor-loader-backhoe (TLB) provided by Nu Way Plant Hire of Witbank and a test pit interval of approximately 200m, one hundred and seventy four (174) test pits were ultimately selected and excavated along the proposed pipeline routes, the WTP and WDS sites. The test pits were excavated to either refusal on well cemented pedocrete, decomposed rock, or where difficult excavation was encountered in less weathered rock. A summary of the proposed pipeline route lengths and amount of test pits excavated is indicated below.

TABLE 2.1 Summary of Proposed Pipeline Route Lengths & Amount of Test pits Excavated

Route Name	Approximate Length (m)	Number of Test Pits	Comments
PK	13 000	65	-
PG1	8 900	42	Includes spillway & floodplain of Goedehoop earth embankment dam
PG2	5 800	29	-
W	400	20	-
WT	200	10	-
D	360	8	Fill-in test pits downstream of earth embankment dam E6
Total	28 660	174	Total distance covered to be confirmed

Due to safety regulations, the test pit excavations were inspected from above and the excavation progress was monitored to estimate the consistency of the soil/bedrock profile. The profile assessments were done by a qualified, registered practitioner and the materials were described in terms of moisture, colour, consistency, structure, soil type and origin in accordance with the methods of Jennings et al (Reference 1 in the Bibliography).

The soil profiles are included in Appendix A and the positions of the test pits are indicated on the Site Plan, Figure 2.

2.2 Sampling and Laboratory Testing

Small, disturbed indicator samples and bulk CBR samples were selected during the profiling to confirm the in-field assessments of the engineering properties of the various representative soil horizons. The disturbed and bulk soil samples were submitted to Messrs. Loma Lab CC in Witbank, for grading, classification and compaction tests, as detailed below. Copies of the laboratory test results are attached in Appendix B and are presented as summaries by Tables A1 to A5 for convenience.

The following tests were carried out on the samples: -

i) One hundred and forty (140) foundation Indicator tests comprising particle size distribution analysis (sieve and hydrometer gradings) and Atterberg Limit tests.

These tests permit a basic classification of the soils and group them according to typical engineering properties.

ii) Twenty seven (27) compaction tests comprising Modified AASHTO moisture/density relationships and California Bearing Ratio Values.

These tests evaluate the compaction characteristics of the site soils and permit an evaluation of their suitability for use as construction materials.

Simplified graphic summaries of the site soils and geology inclusive of the seepage levels and pavement construction material classes are presented as Profiles, Figures 3A to 3F.

2.3 Dynamic Penetration Tests

One hundred and seventy four (174), 2m deep hand-held dynamic penetration tests (DCP's) were done adjacent to the test pits.

The DCP or dynamic cone penetrometer in which a 60° cone with diameter of 20mm is driven into the soil by a 7.815kg weight dropped through 575mm. The results are expressed as millimetres penetrated per blow and refusal is achieved when 1mm penetration is recorded after 10 blows. The DCP is most useful for estimating soil conditions during the design of shallow footings or for assessing subgrade soils for road design. A crude approximation of the consistency and strength as well as the in situ inferred CBR values can also be obtained.

The DCP data files are attached to the corresponding test pit profiles in Appendix A of the report.

3. SITE SOILS AND GEOLOGY

The test pit investigations on the WTP and WDS sites and proposed pipeline routes traversing four managerial areas of responsibility confirmed the bedrock geology indicated on the 1:250 000 scale Pretoria geological sheet transferred to Figure 4, the Site and Geology Plan.

Fluvio glacial (tillite) deposits of the Dwyka Formation, older Loskop shale and deeper seated basement rhyolite (of volcanic origin) of the Selonsrivier Formation are present in the lower-lying western portion of the terrain with sediments and coal measures of the Vryheid Formation blanketing the higher-lying, central and eastern portions. Selonsrivier rhyolite is also exposed in the lower-lying easterly portion of the terrain in the upper reaches of the Vaalbankspruit in the vicinity of Rondeboschje earth embankment dam.

Weathered sandstone bedrock is exposed in the borrow area along Line PG1 (see TP's PG1-8 and PG1-9), as well as in a box cut between test pits PG1-16 and PG1-17 on the same line – refer to Figures 3D and 3E, Profiles. Sandstone outcrops were noted along Line PK at test pit position PK35 and again in the vicinity of test pit PK59 - see Figure 3C Profiles. Shale was noted in some of the test pits excavated in the haul road cutting on Line PG1 – refer to test pits PG1-34 to PG1-37, Figure 3E Profiles.

Decomposed dolerite composed of sandy clay was recorded on Line PK at a depth of 0.6m in test pit PK37 only – refer to Figure 3C Profiles. Gravel and boulder dolerite are absent and no fresh or fractured dolerite was observed.

Generally, the bedrock is overlain by residuum followed by partially to well cemented pedocrete, which is in turn blanketed by brown loose transported soils of various origins. The partially developed pedocrete and hardpan ferricrete are common superficial deposits in the area, often dominating the top 1.5m of the soil profile. The pedogenic horizon occurs either as ferricrete nodules in a partially ferruginized matrix of brown soil or as indurated and strongly cemented, usually relatively massive, rock-like horizon.

Alluvial wash is present in the drainage courses and comprises clays, silts and gravelly sand. However, some river terrace gravels were noted in Test Pit PG2-3 excavated on the western bank of Spookspruit, down-stream from Goedehoop earth embankment dam on Line PG2 – see test pit PG2-3's profile, Appendix A, the Site plan, Figure 2 and Figure 3F Profiles.

Mine discard (tabular gravels and boulders of sandstone and shale mixed with soil) was used as imported fill for a drainage crossing on Line PK in the vicinity of test pits D3 – D5 and on the haulage road on Line PG1 between test pits PG1-34 to PG1-37 – see Figure 3E Profiles.

4. GEOTECHNICAL ASPECTS

Geotechnical aspects that were considered are the workability of site materials, the availability thereof for pipe bedding, flooding, seepage and stability of excavations. Other aspects addressed along the proposed pipeline routes include overhead power lines, ESKOM servitudes, road and conveyor crossings. The various geotechnical constraints are indicated on thirteen cross sections attached as Figures 5A to 5M. The geotechnical constraints are discussed as follows:-

4.1 Workability of Site Materials

4.1.1 Excavation Characteristics

Excavation constraint is defined as difficulty in excavating to a depth of 1.5m below surface, the least favourable condition being where rock or boulders comprise more than 40% of the volume of material excavated (After Partridge, Wood & Brink, 1993). The depth to bedrock is also an important characteristic in determining excavatability along the proposed pipeline routes, the WTP site and the WDS site.

Three methods were used to assess the likely excavation conditions which will be encountered in the 2.0m deep pipeline trench, namely:-

i) a visual inspection of the pipeline routes including the identification of all rock outcrops in the nearby vicinity.

ii) the excavation of 174 test pits along the pipeline routes.

iii) carrying out of 174, two metre (2m) deep hand-held DCP's at each test pit locality.

TLB mechanical excavation operations will be adequate to excavate through the loose imported fill, top soil, residuum and very soft sediments of the Vryheid Formation, the Dwyka tillite, Loskop shale and Selonsrivier rhyolite to an average depth of 2.0m followed by intermediate or even hard excavation. Note that well compacted fill, hardpan ferricrete and less weathered sandstone, shale, tillite and rhyolite proved difficult to excavate at various localities along the proposed pipeline routes. The hardpan ferricrete is cemented to a consistency which varies between stiff soil and very hard rock which is difficult to excavate - causing shallow refusal of the backhoe on a number of occasions.

Although dolerite gravels and boulders were not encountered on site, the presence of decomposed dolerite as clayey silt observed at test pit PK37 (see Figure 3C, Profiles) prompts the provision for 'boulder excavation'.

The excavatability of the site soils and bedrock is classified according to SABS 1083 which is summarised on the overleaf. The various areas subject to shallow excavations – that is excavation refusal of a 65KW powered TLB < 1.5m are indicated on the 13 cross sections, Figures 5A to 5M.

TABLE 4.1.1 (A) Excavatability Summary

Soil/Bedrock Profile	*Origin*	*Depth Range from – to (m)*	*Excavation Class*
Loose to very loose brown-maroon colluvial silty sand; alluvium, river terrace gravels	Transported soil of Various Origins	Surface to 2.5	Soft
Fill - loose Fill – well compacted	Imported mine discard	Surface >2	Soft Intermediate
Partially developed pedocrete indurated hardpan ferricrete	Superficial deposit	0.9 – 2.0	Soft Intermediate/hard
Loose to dense brown-maroon clayey/silty residuum	Derived from in situ decomposed shale, sandstone & dolerite	~0.5 - 2.0	Soft
Gravels and boulders	Derived from in situ decomposed dolerite	0.5 – 2.0	Boulder
Shale and sandstone Dolerite*, tillite, shale & rhyolite	Sediments of the Vryheid Formation Intrusive Dwyka, Loskop & Selonsrivier Formations	> 2.0	Intermediate/ hard

*** Not observed on site but may be present**

A summary of sections along the pipeline routes where shallow excavation (<1.5m) was experienced by the 65KW powered tractor-loader-backhoe is provided below. The 'shallow excavations' ostensibly indicate zones of intermediate excavation class or where 'hard' digging will be required. Estimates of the quantities of soft (1.050m wide, 2m deep trench), intermediate (1.050m wide, 1.5m deep trench) and boulder excavation for 1.050m wide, 2m deep trench are indicated below. In our opinion, hard excavation where rock requires blasting does not occur on site.

TABLE 4.1.1 (B) Summary of Soft and Intermediate Excavation

Route Name	Length (m) of Soft Excavation Class	Estimated Volume of soft Excavation Class m^3	Length (m) of Intermediate Excavation Class	Estimated Volume of Intermediate Excavation Class m^3	Length (m) of Boulder Excavation Class	Estimated Volume of Boulder Excavation Class m^3
PK	12 500	26250	400	630	~ 100	210
PG1	7630	16023	1270	2000	N/A	N/A
PG2	3970	8337	1830	2883	N/A	N/A
W	NIL	NIL	400	630	N/A	N/A
WT	NIL	NIL	300	473	N/A	N/A
D	160	NIL	200	315	N/A	N/A

Note: **Intermediate Excavation Class presents materials in pipeline trenches where TLB excavation depth <1.5m**

4.1.2 Bedding Materials

Bedding material is required at the base of the trench beneath the pipeline and ideally should be non-active, relatively clean sand or fine gravel. The bedding is used to create an even floor level for the pipeline and to protect it from jagged edges of material caused by excavation/blasting of the trench. The 450mm diameter HDP pipe is usually placed on 100mm thick bedding material with 300mm thick filling alongside for protection from jagged trench side walls with a 150mm thick cover of similar material for protection against (coarse) backfill which extends to surface level. Thus, for a 450mm diameter pipe placed in a 1050mm wide trench, some 0.5m³/m length of bedding material will required.

Ideally, the material should be easily workable and compactable in the base of the trench and should have a plasticity index <10 and be singly graded between 19mm and 0.75mm – the minimum size below which the material is silt or clay. This grading fraction includes 'fine' gravels, coarse sand and fine sand. Site materials that do not fall into such a category and need to be blanketed by imported material include imported fill (mainly mine discard), shallow hardpan ferricrete, tillite, shallow sandstone, shale and rhyolite bedrock as summarized below.

TABLE 4.1.2 Summary of Site Materials to Be Blanketed by Imported Bedding Material***

Material Type	Depth Range (m) (from to)	Test Pits	Figure	Estimated Length (m)	Estimated Volume*** of Bedding Material Required (m³)
Imported fill	Surface to 2.4	D6 – D8 PG1, PG1-1; PG1-26 to PG1-28, PG1-30; PG1-34 to PG1-37 PK38, & PK52 – PK62A	Fig 3A; FIG 5J Fig 3D Fig 3E Fig 5G Fig 3C & 3D	300 70 1950	150 35 975
Hardpan ferricrete	0.6 – 2.2	WTP10 ; W15, W16; PK4; PK32 PG2-5,7,8,14, 25,28	Fig 3A Fig 3B Fig 3C Fig 3F Fig 3G	700	350
Vryheid Sandstone	0.6 – 1.5	W6 & W7 PG1-19; PG1-33;PG1-39	Fig 3G FIG 3E	250 300	125 150
Vryheid shale	0.3 – 1.8	PG1-34 to PG1 -37	Fig 3E	Taken into account with imported fill	N/A
Dwyka tillite	0.2 – 2.2	PG2-22; PG1-3 & 4	Fig 3D	300	150
Rhyolite	0.9 – 2.2	PK1 & PK2	Fig 3B	450	225

Note: * indicates = 0.5m³/meter length of trench**

The various sources of bedding material along the proposed pipeline routes are indicated as Blocks A to G on Figure 6, Bedding Material. Generally, the bedding material comprises cover soils with a typical brownish colour, is silty or clayey sand with a loose consistency and soft excavatable to at least 1.0m below surface. The general engineering characteristics conform to the operation limits of G7 class pavement construction materials with a plasticity index <10 and a grading modulus >0.6<1.5. These cover soils are present over most of the site, except in drainage courses, box cuts, borrow areas or road cuttings where imported mine discard has been placed as a wearing course or as fill. The various sources mentioned above had been selected on the basis of extensive deposits, normally thicker than 1m with a fairly large spatial distribution. The material is non - to low active, easily workable and compactable and can be loaded and hauled over fairly short distances.

4.1.3 Compactability of Site Materials

Samples representing a range of soil types identified along the various routes - that is mainly sandy cover soils, coarse and fine alluvium, ferruginous gravels and gravelly residuum were sampled and submitted for compaction tests, together with the grading characteristics – refer to the laboratory test results in Appendix B. The abovementioned materials comply with the operational limits of the various pavement material classes summarized below. Generally, the brown-khaki coloured cover soils classify as G7 and the gravelly materials – that is predominantly ferruginised residuum, residual rhyolite tillite, shale and sandstone conform to the operational limits of G6 - G7 class materials, displaying adequate compaction characteristics for fills and sub-grade.

TABLE 4.1.3 Summary of Pavement Material Classes

Origin	Material Type	Depth Range (m)	G Class
Colluvium	Silty, clayey sand	Surface to 2.0	G7
Alluvium	Sandy clay	Surface to 1.6	G8 – G10*
Imported fill (mine discard)	Gravel	Surface to >2m	
Pedocrete	Silty, gravelly sand	0.5 – 2.0	G6 – G9
Vryheid Formation Sandstone	Gravelly sand	0.5 – 2.0	G5
Vryheid Formation shale	Clayey gravel	0.5 – 2,0	G8 – G10*
Dwyka tillite	Clayey sand	0.4 – 2.2	G7
Loskop shale	Silty sand	0.4 – 1.0	G9, G10*
Selonsrivier rhyolite	Gravelly sand	1.0 – 2.0	G6, G7*

Where: - * = inferred

4.1.4 Stability of Excavations

The stability of the test pit excavations was assessed by simple field tests such as:-

i) the resistance to penetration of the 2m deep hand-held dynamic penetrometer;
ii) the ease of excavation by the backhoe and;
iii) slumping/ravelling of the test pit side walls occurring within 15 minutes from time of excavation – especially when the soil is wet.

Note that the interpretation of the excavation stability is based on experience – hence the downgrading of some dense/stiff soil consistencies to loose/soft over considerable lengths of the proposed 2m deep pipeline trenches – refer to the cross sections Figures 5A to 5M where potentially unstable zones are indicated .

Where the 2m deep test pit excavations had either collapsed or the visual stability assessment had confirmed imminent collapse, the results of the DCP tests were correlated to the loose or very loose consistency of sandy materials or the very soft to soft consistency of clayey materials (after Terzaghi & Peck, 1967).

However most of the sandy/clayey/silty cover soils were dry enough and had sufficient silt/clay in the matrix to provide adequate strength against collapse of the test pit side walls with sufficient stand-up time – refer to Table 4.1.4 (A) below. Slumping/ravelling of the test pit side walls only occurred whilst excavating in areas blanketed by thick cover soils (up to 2m) with high moisture contents, where point seepage occurred or where considerable inflows were recorded – refer to Line PK, test pits PK17 to K19, Appendix A, Soil Profiles.

Clayey cover soils were encountered in areas underlain by Loskop shale down stream from the Goedehoop earth embankment dam. Yet again, the excavations stood up well as the stability was controlled by the fairly low moisture content of the clayey material. If seepage is present or an elevated moisture content is eminent, even trenches shallower than 1.5m should be regarded as dangerous and stand-up time could be measured in minutes – refer to Table 4.1.4 (A) below.

Table 4.1.4 (A) Estimated Stand-up Time for Trench Excavations

Soil Type	Depth (m)	Dry	Moist	Saturated
Brown loose cover soils	<1 1 – 1.5 >1.5	months weeks days	weeks days hours	days/hrs hours minutes
Clayey residuum	<1 1 – 1.5 >1.5	months weeks days	weeks days hours	days/hrs hours minutes
Weathered rock, hardpan ferricrete	<1 1 – 1.5 >1.5	years months months	months weeks weeks	weeks days days/hours
Imported fill (mine discard)	<1 1 – 1.5 >1.5	years months months	months weeks weeks	weeks days days/hours

The stability of trench excavations in the lower ferruginised residuum will be similarly controlled by moisture and should also be regarded as unstable where high moisture conditions exist or could exist during high rainfall periods – i.e. down stream from storage dams and seasonal drainage features.

Typical material types with unstable excavations or potentially unstable excavations are as follows:

i) brown to light brown, khaki coloured cover soils with a tendency to collapse when wet are associated with the colluvial soil cover of >1m;

ii) light grey, ivory to dark brown clays associated with decomposed Loskop shale >1m in the drainage channel down stream from Goedehoop earth embankment dam;

iii) clayey dolerite exposed in test pit PK37;

iv) imported mine discard placed loosely in a wet environment as rockfill for a stream crossing.

These sections of trenches referred to as *'unstable'* on the cross section drawings, Figures 5A to 5M need to be either shored, or flattened to less than 60° from horizontal; alternatively the trenches should not exceed 1.5m in depth. Furthermore, spoil from the trench excavations should not be placed closer than the equivalent depth of the trench to avoid unnecessary loading of the sidewalls, especially under moist to saturated conditions.

A summary of the proposed pipeline routes with potentially 'unstable' excavation with expected limited stand-up time is indicated below.

TABLE 4.1.4 (B) Summary of Potentially 'Unstable' Excavations under Moist to Saturated Conditions with stand-up time measured in minutes to hours

Route Name	Length (m)
PK	3610
PG1	2260
PG2	<100
W	~500
WT	<100
D	Whole length, with ave. thickness 1m, ranging between 0.7m and 1.3m

Trenches excavated in the decomposed to completely weathered rock, or well cemented pedocretes will be substantially more stable than the overlying sandy cover soils with a loose consistency or soft clayey residuum. Indeed, stability problems are not anticipated in these materials and stand-up time is expected to be measured in months. Sections of pipeline route excavations perceived to be safe are also indicated on the cross sections. These include well compacted fill, partially cemented pedocretes, very soft rock and areas devoid of seepage and flooding as well as areas with a thin soil cover i.e. the borrow area covered by test pits PG1-8 and PG1-9 and the box cut at test pit PG1-17 – refer to Cross Sections Figures 5F and 5G.

4.1.5 Seepage

Poor subsurface drainage conditions along the proposed pipeline routes were often reflected by the natural vegetation e.g. tubular grasses and other hydrophilic plants. Local agricultural practices along proposed pipeline route Line PG2 were also useful indicators of ground which is not freely draining and was made over to pastures rather than to cultivation. Other practices included free draining, shallow open furrows.

Groundwater seeps noted during the test pitting phase of this investigation vary from slightly moist to very moist profiles, point seepage to excessive inflows – refer to Line PK, test pit PK19 with an estimated inflow of 500*l/h*.

Another indicator used to define potential seepage zones is the presence of hardpan ferricrete which, although often recorded as being moist, is closely associated with a seasonal water table. Hardpan ferricrete, together with recorded test pit seepage data were thus mapped and defined as 'seepage zones' along the proposed pipeline routes and are indicated on the thirteen cross sections, Figures 5A to 5M and summarized below.

TABLE 4.1.5 Summary of Seepage Zones

Route Name	Length (m)
PK	4070
PG1	990
PG2	2640
W	See note below
WT	See note below
D	Whole length

Note: The water treatment plant (WTP) and disposal site (WDS) were investigated in March 2009. At the time of the investigation, no seepage was recorded in any of the 2m deep test pits excavated on the terrain and the 3 - 5m deep borrow was also dry. Other indicators of an eminent perched water table were the presence of well developed pedocrete. However, percussion boreholes drilled during the investigation recorded an average water table of 9m below surface. Additional test pits had subsequently been excavated (August, September 2010) only to discover that most of the site is subject to a perched water table - refer to Water Treatment Plant Seepage Zones, Figure 7.

4.1.6 Areas Susceptible to Flooding

The proposed pipeline routes pass downstream from the Goedehoop earth embankment dam, Dam 6 and Rondeboschje, the third earth embankment dam. These sections of the proposed pipeline routes are thus subject to seasonal flooding. The various zones susceptible to flooding are indicated on the thirteen cross sections, Figures 5A to 5M and summarized below.

TABLE 4.1.6 Summary of Flood Zones

Route Name	Length (m)
PK	1380
PG1	830
PG2	750
W	n/a
WT	n/a
D	Whole length

4.2 Other Aspects

These include conveyor and road crossings, overhead ESKOM power lines and ESKOM servitudes, fibre-cement pipelines of unknown function and origin. The various constraints are summarized as follows:-

TABLE 4.2 Summary of Other Constraints

Route Name	Length (m)
PK	fibre-cement pipe & crossing of conveyor PK1 - PK3; crossing of tarred R33 between PK24 – PK25;crossing haulage road PK62 – PK63;
PG1	Conveyor crossing at PG1-40;close to haulage road for 2100m from PG1-29 PG1-40; edge of box cut at PG1-17;
PG2	N/A
W	ESKOM overhead powerline
WT	N/A
D	N/A

5. CONCLUSIONS and RECOMMENDATIONS

This section of the report briefly summarizes the significant geotechnical and other findings relevant to the proposed pipeline routes that were investigated.

i) approximately 82% or 24 620m of the proposed pipeline routes recorded soft excavatable soils comprising loose cover soils, partially cemented pedocretes, residual gravelly sandstone, shale, tillite and rhyolite.

ii) some 18% or 4400m of the proposed pipeline routes to be intermediate excavatable < 1.5m; limited boulder excavation is expected.

iii) groundwater seepage is expected along some 7700m of proposed pipeline routes (inclusive of areas underlain by hardpan ferricrete).

iv) some 6570m of trench is expected to have low stand-up times and shoring is required.

v) sufficient sources of good quality bedding material are available within relatively short haulage distances; the bedding materials are generally soft excavatable, silty, clayey colluvial soils and extend to 1.0m (and more) below surface.

vi) ESKOM overhead power lines, road and stream crossings occur along the proposed pipeline routes.

6. GENERAL

Every effort was made during the site investigation to ensure that generally accepted practices of our profession were used in the sub-surface evaluation of the site, and that the sampling and testing was representative of the soil/rock conditions observed on-site. However it is impossible under the constraints of a restricted investigation of this nature to guarantee that zones of poorer geological materials were not identified that could have a significant bearing on the outcomes of this investigation. The investigation has therefore attempted, through interpolation and extrapolation at known test locations, to identify problem issues of a geotechnical nature on which this report is based. Variances in soil and rock quality and quantity from those predicted may be encountered during construction and these should be recorded, however no warranty against these variations is expressed or implied, due to the geological changes that can occur over time due to natural processes, or human activity.

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P.G. Hansmeyer ***Pr. Sci. Nat.***

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APPENDIX A

Test Pit Profiles
Laboratory Test Data

LINE PG1

APPENDIX B

Test Pit Profiles –
Laboratory Test Data

LINE PG2

APPENDIX C

Test Pit Profiles –
Laboratory Test Data

LINE PK

APPENDIX E

Test Pit Profiles –
Laboratory Test Data

LINE D

APPENDIX D

Test Pit Profiles –
Laboratory Test Data

LINE W

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VOLUME 1

PRELIMINARY REPORT
ON
ACCESS ROAD CENTRE LINE SOIL SURVEY, PUMP STATION FOUNDATIONS, R33 ROAD CROSSING, WASTE WATER DAM & HOLDING DAM FOUNDATIONS
OF THE
MIDDELBURG WATER RECLAMATION PROJECT
(MWRP)

Project: LL1717P2
Date: December 2010
P.G. Hansmeyer ***Pr.Sci.Nat.***

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VOLUME 1

PRELIMINARY REPORT

ACCESS ROAD CENTRE LINE SOIL SURVEY, PUMP STATION FOUNDATIONS, R33 ROAD CROSSING, WASTE WATER DAM & HOLDING DAM FOUNDATIONS OF THE MIDDELBURG WATER RECLAMATION PROJECT (MWRP)

1. INTRODUCTION

1.1 Terms of Reference

This preliminary report presents the results of the access road centre line soil survey and geotechnical investigations into the Middelburg Water Reclamation Project's (MWRP) proposed pump station foundations, a road crossing beneath the tarred R33 provincial road inclusive of infill sections on the waste water dam, holding dam and water treatment plant site (WTP). The various sites are indicated on the Locality Plan, Figure 1 in the beginning of the report.

The investigations were done under the auspices of Aurecon Consulting Engineers, Lead Consultant on the Middelburg Water Reclamation Project for BHP Billiton Energy Coal South Africa Limited.

The scope of work included some of the following investigation procedures:-

i) Determine the geology and the depth to well cemented pedocretes or bedrock where possible.

ii) Establish the soil, weathered rock and outcrop profiles across the various sites and evaluate their engineering properties and influence on the proposed plant access road, pump station foundations, the R33 tarred road crossing, various dams and the Water Treatment Plant (WTP) foundations.

iii) Assess the groundwater conditions, including surface run-off, ponding and comment on the presence of perched or permanent water tables.

iv) Classify the various sites for development suitability according to geotechnical categories such as seepage, flooding, excavatability and engineering characteristics of the site soils.

This report is based on information obtained from:

- Pretoria geological map, sheet 2528 to scale of 1:250 000.
- A preliminary geotechnical investigation carried out by Loma Lab CC in November 2010 – reference LL1717.
- Profiles of 26 test pits excavated along the centre line of the access road, pump station foundations, R33 road crossing, waste water - and holding dams and Water Treatment Plant (WTP) foundations.
- Soil test results of a number of road and foundation indicators and compaction tests of representative disturbed soil samples taken during the field investigation.
- Aerial photographic data provided in digital format by Middelburg Mine Services.
- Topographical survey of the site in digital format.

The report and its appendices are contained in Volume 1 of the document and the drawings are presented as Volume 2.

2. MWRP ACCESS ROAD

2.1 Site Assumptions and Observations

The access road from the tarred R575 to the MWRP site extends eastwards from the slip way opposite Naledi Village for 1.050km along the 400KVA ESKOM overhead power line – refer to Figure 2, the Site Plan.

A 200m broad drainage course emanating from several groundwater seeps close to the coal fines dam some 600m to the south extends northwards, forming a natural catchment for the western part (some 750m) of the MWRP terrain and hence a convenient discharge zone for surface-run off from the proposed access road.

Except for the moist to very moist conditions observed within the drainage course, the route was fairly dry with poor to average drainage conditions.

The fibrous root systems of the vegetated access route from the R575 eastwards towards the WTP are fairly shallow – usually 0.15m but the tap root systems of the wattle and Eucalyptus trees from TPPP12 towards TPPP13 (Chainage 900 to Chainage 1025) are much deeper (average 1.2m) and more prolific.

A subsurface water pipeline of unknown diameter and subsurface telephone cabling were noticed within the R575 road reserve. The waterborne and telecommunication services cross the tarred road to Naledi Village.

2.2 Investigation Methodology

2.2.1 Test Pitting

Using an approximate 200m interval spacing, the fourteen (14) pre-selected test pits were excavated along the proposed access road's centre line. Two test pits (TPPP01A and TPPP01B) were excavated on the R575 road shoulder opposite the Naledi Village entrance. The test pits were excavated by a Daewoo Solar 220 excavator provided by Remotech Plant Hire of Witbank. The test pits were either excavated to the required 1.5m depth or shallower (TPPP04) where slow penetration occurred at 1.2m in less weathered material.

Due to safety regulations, the test pit excavations were inspected from above and the excavation progress was monitored to estimate the consistency of the soil/bedrock profile. The profile assessments were done by a qualified, registered practitioner and the materials were described in terms of moisture, colour, consistency, structure, soil type and origin in accordance with the methods of Jennings et al (Reference 1 in the Bibliography).

The soil profiles are included in Appendix A1 and the positions of the test pits are indicated on the Site Plan, Figure 2.

2.2.2 Sampling and Laboratory Testing

A number of road indicator samples and bulk CBR samples were selected during the profiling to confirm the in-field assessments of the engineering properties of the various representative soil horizons. The disturbed and bulk soil samples were submitted to Messrs. Loma Lab CC in Witbank, for grading, classification and compaction tests, as detailed below. Copies of the laboratory test results are attached in Appendix B1 and presented as a summary by Table A1 for convenience.

The following tests were carried out on the samples: -

i) Twenty seven road indicator tests comprising particle size distribution analysis (sieve gradings up to 75micron metre) and Atterberg limit tests.

These tests permit a basic classification of the soils and group them according to typical engineering properties.

ii) Twenty six (26) compaction tests comprising Modified AASHTO moisture/density relationships and California Bearing Ratio Values.

These tests evaluate the compaction characteristics of the site soils and permit an evaluation of their suitability for use as construction materials.

Simplified graphic summaries of the site soils and geology inclusive of the seepage levels and pavement construction material classes are presented as Profiles, Figure 3.

2.2.3 Dynamic Penetration Tests

Twenty 1.5m deep hand-held dynamic penetration tests (DCP's) were done on an approximate 100m interval spacing along the access road centre line – that is adjacent and halfway between the test pits – refer to the Site Plan, Figure 2. The DCP data files are attached as Appendix C1 to the report.

The DCP or dynamic cone penetrometer in which a 60° cone with diameter of 20mm is driven into the soil by a 7.815kg weight dropped through 575mm. The results are expressed as millimetres penetrated per blow and refusal is achieved when 1mm penetration is recorded after 10 blows. The DCP is most useful for estimating soil conditions during the design of shallow footings or for assessing subgrade soils for road design. A crude approximation of the consistency and strength (after Terzaghi & Peck, 1967) as well as the in situ inferred CBR values can also be obtained.

2.2.4 Photographic Records

Digital photographs taken of the test pits excavated along the access road centre line are displayed on Figure 4, Cross Section AA'.

2.3 Site Soils and Geology

The bedrock geology observed during the test pitting phase of the access road differs from the 1:250 000 scale Pretoria geological sheet in that the area towards the R575 tarred road from the drainage course comprises tillite of the Dwyka Formation and not younger sedimentary bedrock of the Vryheid Formation as indicated. The drainage course appears to follow a concealed geological contact between the older Dwyka tillite and the sediments of the Vryheid Formation which dominate the easterly portion of the access road and the MWRP site – refer to Figure 4, Cross Section AA'.

Generally, the decomposed to highly weathered bedrock is sequentially overlain by residuum blanketed by a scattered but well developed pebble marker and brown, loose transported soils (colluvium) of various origins some 0.8m thick but varying between 0.5m and 1.1m. Dark brown very loose to loose alluvial wash comprising silty sand occurs within the drainage course and attains a maximum thickness of 1.3m.

The partially developed pedocrete is a common superficial deposit on the eastern portion of the terrain, generally dominating the 0.5m to 1.5m section of the soil profile. The pedogenic horizon occurs as ferricrete nodules in a ferruginised matrix of brown-maroon sandy soil which is a partially to well cemented and usually relatively massive.

The well compacted base and sub base layers with a combined thickness of 0.5m exposed within the tarred R575 road shoulder comprise ferricrete nodules and ferruginous concretions in a sandy matrix. The pavement construction material was imported en masse from elsewhere and placed in two layers upon gravelly subgrade derived from in situ decomposed Dwyka tillite.

2.4 Road Centre Line Material Qualities

The geotechnical aspects addressed along the proposed access road include workability of site materials, flooding, seepage as well as the road bed and subgrade layer's engineering characteristics. These aspects are discussed in more detail as follows:-

2.4.1 Workability of Site Materials

2.4.1.1 Excavation Characteristics

Excavation constraint is defined as difficulty in excavating to a depth of 1.5m below surface, the least favourable condition being where rock or boulders comprise more than 40% of the volume of material excavated (After Partridge, Wood & Brink, 1993). The depth to bedrock is also an important characteristic in determining excavatability along the access road.

Excavator or TLB mechanical excavation operations will be adequate to excavate through the compacted imported fill, top soil, alluvium, residuum and very soft sediments of the Vryheid Formation, the gravelly Dwyka tillite deposits and partially cemented pedocrete to an average depth of 1.5m followed by intermediate excavation. Exception to the rule is the shallow excavation in TPPP04 within well cemented, dense tillite where the excavator experienced slow penetration from 1.2m. Scattered boulders with diameters ranging from 0.2m to 0.3m, were encountered in the tillite residuum on occasion. Note that no provision has been made for possible 'boulder' excavation.

The excavatability of the site soils, pedocretes and residuum is classified according to SABS 1083 summarised below. The excavation depths are indicated on Figure 4, Cross Section AA'.

TABLE 2.4.1.1: Excavatability Summary

SOIL/BEDROCK PROFILE	ORIGIN	DEPTH RANGE FROM – TO (M)	EXCAVATION CLASS
Brown-maroon, loose colluvial silty sand; alluvium & pebble marker	Transported soil of Various Origins	Surface to 1.6	Soft
Well compacted base and sub base	Imported	Surface 0.5	Soft
Partially developed pedocrete	Superficial deposit	0.5 – 1.6	Soft
Gravels and soils of residual tillite*	Derived from in situ decomposed Dwyka tillite	0.5 – 1.6	Soft

Note: - boulder tillite may occur

2.4.1.2 Compaction Characteristics

Samples representing a range of soil types identified along the road centre line - that is mainly imported pavement layers on the tarred R575's road shoulder, sandy cover soils, silty sandy alluvium, ferricrete and ferruginous gravels associated with the pedogenic horizon and gravelly residuum derived from in situ decomposed Dwyka tillite were sampled and submitted for compaction tests, together with the grading characteristics – refer to the laboratory test results in Appendix B1.

The abovementioned materials comply with the operational limits of the various pavement material classes summarized below. Generally, the road bed materials classify as G7 class and the deeper gravelly subgrade materials conform to the operational limits of G5 to G7 class pavement construction materials (with G10 of TPPP12 an exception), both types displaying adequate compaction characteristics for road bed materials, fills and subgrade. The relevant test pits, chainages, pavement layers, material types and G-class of the materials encountered along the access road centre line are summarized as Table 2.4.1.2 below.

TABLE 2.4.1.2 Summary of Pavement Material Classes

TEST PIT	APPROXIMATE CHAINAGE	PAVEMENT LAYER	DEPTH RANGE (m)	MATERIAL TYPE	ORIGIN	G-CLASS
PP01A & PP01B	0	Base & subbase	Surface to 0.5	Ferricrete & ferruginous concretions	Imported	G6, G7
		Subgrade	0.5 to 1.5	Gravelly residuum	In situ decomposed tillite	G5, G6
PP02 & PP03	2 - 220	Road bed	Surface to 0.4	Sity sandy Colluvium	Transported	G7
		Subgrade	0.4 to 1.5	Gravelly residuum	In situ decomposed tillite	G5 to G8
PP04 to PP06	220 - 400	Road bed	Surface to 1.3	Silty sandy Alluvium	Transported	G7
		Subgrade	0.4 to 1.6	Gravelly residuum	In situ decomposed tillite	G8
PP06 to PP13	400 - 1050	Road bed	Surface to 1.1	Silty sandy Colluvium	Transported	G7
		Subgrade	0.7 to 1.5	Gravelly residuum	Pedocrete	G5 to G10

The twenty 1.5m deep DCP probing tests carried out along the access road centre line recorded very loose to loose sandy road bed soils (colluvium and alluvium) some 0.25m to 1.5m thick grading into denser gravelly subgrade. The transition from the loose road bed materials to denser subgrade follows an undulating pattern as indicated on Figure 4B, Cross Section AA'.

The results of the probing tests on the roadbed and subgrade layers respectively equate to *inferred in situ* CBR values of 5 and 20.

2.5 Seepage

Poor subsurface drainage conditions encountered along the drainage course to be crossed by the access road were reflected by the natural vegetation e.g. tubular grasses and other hydrophilic plants with shallow (0.15m) fibrous root systems.

Moisture conditions recorded during the test pitting phase of this investigation vary from slightly moist to very moist profiles with point seepage recorded in test pits TPPP06 and TPPP07 at 1.8m below surface. Although no free water was observed, it is assumed that seasonal ponding will occur in the deeper sections of the drainage course.

Another indicator used to define potential seepage zones is the presence of a pedogenic horizon which, although recorded as being only moist on site, is closely associated with a temporary seasonal water table. As mentioned, from TPPP08 to TPPP13 (roughly from Chainage 580 to Chainage 1050), the access road's subgrade material comprises partially cemented pedocrete ranging from 0.7m to 1.5m below surface and as a rule of thumb, should be regarded as a seepage zone.

2.6 Areas Susceptible to Flooding

Although the drainage course was very moist, it was easily crossed by foot, excavator and LDV and no free water was observed. However, provision will have to be made to accommodate surface and storm water run-off. If coarse filling is considered, mine discard or slag imported from Middelburg Alloys may be considered.

2.7 Borrow Materials

A visual inspection of the borrow pit sidewalls confirmed an extensive superficial deposit of good quality ferruginised material present from 0.5m to 1.5m below surface. It is expected that this specific horizon will at least comply with the operational limits of G5 to G7 class pavement construction materials. The pedogenic horizon covers most of the eastern portion of the MWRP site, is soft to intermediate excavatable with an extensive reserve estimated to be in excess of 10 000m^3.

2.8 Conclusions and Recommendations

The access road's centre line soil survey investigation highlighted the following geotechnical aspects:-

i) Seasonal ponding with possible flooding within the 200m wide drainage course;

ii) Seepage zones within the deeper sections of the weathered profiles and pedogenic horizons in an isolated zone along central and eastern section of the drainage course;
iii) Road bed soils up to 1m thick and more with a loose consistency are associated with collapse settlement;
iv) Road bed soils recorded a low *in situ* inferred CBR value (≤ 5);
v) Road bed soils generally comply with the operational limits of G7class pavement construction materials;
vi) Subgrade soils generally have a medium dense consistency with an inferred in situ CBR value of 20;
vii) Subgrade soils generally classify as G5 to G7 class pavement construction materials;
viii) With the exception of an isolated zone, road bed and subgrade materials are generally soft excavatable to 1.5m;
ix) Deep tap root systems associated with wattle and Eucalyptus trees occur on the WTP site with shallower fibrous root systems on most of the access road;
x) Soft to intermediate excavatable borrow materials with sufficient reserves and generally of G5 to G7 class pavement construction material are available on site;
xi) Mine discard or slag can be imported as fill for the drainage crossing;
xii) Imported base and sub base materials on R575 road shoulder comply with the operational limits of G6 and G7 class pavement construction materials;
xiii) Care must be taken not to damage the subsurface waterborne and telecommunication services to Naledi Village.

3. PUMP STATION FOUNDATIONS, R33 ROAD CROSSING, WASTE WATER & HOLDING DAM , WTP PLANT FOUNDATIONS

The three pump station sites, tarred provincial road (R33) crossing, the waste disposal and holding dams and plant site foundations which are indicated on the Site Plan, Figure 5 were investigated with the objectives of determining the following:-

i) Site soils and geology
ii) Engineering characteristics of the site ;
iii) Depth of intermediate/hard excavatable bedrock;
iv) Standing time of the test pit sidewalls at the R33 crossing;
v) Seepage and groundwater conditions, if possible.

The investigation methodology comprised the excavation of at least one test pit at each site with a Daewoo Solar 220 excavator which was required to be transported with a lowbed from site to site. The test pits were excavated, profiled and sampled at each of the above sites, and a number of foundation indicator samples and bulk samples were selected during the profiling to confirm the in-field assessments of the engineering properties of the various representative soil horizons.

The disturbed and bulk soil samples were submitted to Messrs. Loma Lab CC in Witbank, for grading, classification and compaction tests, as detailed

TABLE 3.1 Sumarry of Relevant Geotechnical Aspects

TEST PITS	SITE	TYPE BEDROCK	EXCAVATION CLASS	SEEP. DEPTH (M)	GEOTECHNICAL CONSTRAINTS	RECOM. FOUND. DEPHT (m)	ESTIMATED BEARING CAPACITY (kPA)	RECOMMENDATIONS
AUR 06	Dam 5 Pump Station	Imported mine discard	Intermediate to 2.3m	N/A	Imported fill difficult to excavate > 2.3m; possible seepage > 2.3m; within flood plain	2.3	500	Normal construction with good site drainage applies
AUR 07	R33 Road Crossing	Brown colluvium grading into decomposed shale	Soft to 5m	4.8	Very short stand-up time of test pit sidewalls; seepage from 4.8m; loose compressible profile to 5m; pipe jacketing operations will be partially submerged	5	350	Extensive shoring required for safe working environment; continuous pumping to keep working place relatively dry
AUR 10 & 11	Goedehoop Dam Pump Station	Loskop shale	Intermediate to hard from 2.8m	2.8	Shale slakes rapidly; clayey residuum highly compressible; close to flood plain; below water table from time to time	1.5 – 2.9	500	Found on sound bedrock; normal construction with good drainage applies; exposed foundations to be blinded with concrete without delay to prevent slaking
AUR13	Suiker-boschje Dam Pump Station	Selonsrivier rhyolite	Intermed. to hard > 2.1	1.5	Cover soils highly compressible; close to flood plain; founding depth below water table	2.1	800	Foundation submerged; provide cut-off drains & excavate to 1.5m, backfill & compact imported rock fill to 1.0m; normal construction & good drainage applies
AURDD1-DD3	Waste Disposal Dam	Vryheid formation sediments	Intermed to hard > 4.3	3.2 & 4.2	Cover soils have low PI and cohesion; expected internal friction angle ~ 35° ; dam basin to found on intermediate/hard excavatable sandstone/gritstone or shale	4.3	600	Founding depth of 4.2m on intermediate/hard sedimentary bedrock; drain site towards east
HO1/4/2010	Holding Dam	Vryheid Formation sediments	Intermed to hard > 1.6 – 4.3	2.5	Cover soils have low PI and cohesion; expected internal friction angle ~ 35° ; dam basin to found on intermediate/hard sandstone/gritstone or shale	4.3	600	As above; site almost level & subsurface drainage complex
AUR Plant 1 & 2	WTP	Vryheid Formation sediments	Intermed. to hard> 3.5 – 4.0	3.6	Cover soils have low PI and cohesion; expected internal friction angle ~ 35° ; dam basin to found on intermediate/hard sandstone/gritstone or shale	4	600	

below. Copies of the laboratory test results are attached in Appendix B2 and presented as a summary by Table A2 for convenience.

The following tests were carried out on the samples: -

i) Sixteen foundation indicator tests comprising particle size distribution analysis (sieve gradings and hydrometer readings) and Atterberg limit tests.

These tests permit a basic classification of the soils and group them according to typical engineering properties.

ii) Three (3) compaction tests comprising Modified AASHTO moisture/density relationships and California Bearing Ratio Values.

These tests evaluate the compaction characteristics of the site soils and permit an evaluation of their suitability for use as construction materials.

iii) Four compaction tests comprising Proctor moisture/density relationships.

These tests evaluate the compaction characteristics of the site soils.

Simplified graphic summaries of the site soils and geology inclusive of the seepage levels are presented as Profiles, Figures 6A and 6B.

The site's bedrock geology inclusive of the relevant geotechnical aspects have been summarised and are attached to the opposite page.

4. GENERAL

Every effort was made during the site investigation to ensure that generally accepted practices of our profession were used in the sub-surface evaluation of the site, and that the sampling and testing was representative of the soil/rock conditions observed on-site. However it is impossible under the constraints of a restricted investigation of this nature to guarantee that zones of poorer geological materials were not identified that could have a significant bearing on the outcomes of this investigation.

The investigation has therefore attempted, through interpolation and extrapolation at known test locations, to identify problem issues of a geotechnical nature on which this report is based. Variances in soil and rock quality and quantity from those predicted may be encountered during construction and these should be recorded, however no warranty against these variations is expressed or implied, due to the geological changes that can occur over time due to natural processes, or human activity.

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P.G. Hansmeyer ***Pr Sci Nat.***

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APPENDIX A1

SOIL PROFILES:

- Road Centre Line

APPENDIX A2

SOIL PROFILES:

- Pump Station Foundation
- R33 Road Crossing
- Waste Disposal Dam
- Holding Dam
- Plant Site

APPENDIX B1

SOIL TEST DATA:

- Road Centre Line

APPENDIX B2

SOIL TEST DATA:

- Pump Station Foundation
- R33 Road Crossing
- Waste Disposal Dam
- Holding Dam
- Plant Site

APPENDIX C1

DCP DATA

D.7 Groundwater Assessment

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS UV

Hydrogeological Report for Middelburg Coal Mine

Middelburg Water Reclamation Project

April 2011

by

F de Lange and D Vermeulen

Report number: 2011/16/PDV

April 2011

IGS

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EXECUTIVE SUMMARY

Me. Beth Candy of Jones & Wagner Consulting Engineers (J&W) requested the Institute for Groundwater Studies (IGS), to assist an additional groundwater assessment and specialist study for the Proposed Middelburg Mine Water Treatment Plant at Middelburg Coal Mine in Mpumalanga, South Africa.

Initially the A (deep – 30 m) and B (shallow – 10 m) boreholes were drilled at each location and the lithology recorded. To allow for packer tests to be performed, only the starter casings were left inside each borehole. Due to delays with the packer testing, the boreholes collapsed and had to be re-drilled to allow for further investigation (packer tests) with regard to formation characteristics in terms of hydraulic conductivity. C, D, and E locations were drilled at a later date to facilitate the packer testing and were then properly constructed to enable long term monitoring of ground water at the site.

The entire area is largely blanketed by sand between 3 m and 7 m thick which overlies a decomposed shale/clay layer situated on top of sandstone of the Vryheid Formation. In areas another shale layer is present below the sandstone at depths ranging between 17 mbgl and 25 mbgl.

Hydraulic characteristics of the ground water regime are low to moderate with borehole yields expected to range between less than 0.1 l/s and 2.0 l/s with a distribution of 60 % yielding less than 0.1 l/s, 30 % yielding between 0.1 l/s and 1.0 l/s and only 10 % yielding more than 1.0 l/s.

Possible affected hydrogeological regimes can be delimited, based on geological (and hydrogeological characteristics of the rock strata) and topographical (local and regional drainage patterns) settings and water resources monitoring, and should be relatively small in extent and in close proximity to mining infrastructure.

Aquifers across the area within zones impacted upon by mining and related infrastructure are fractured with a secondary porosity derived from cracks and fractures in the rock mass. Consequently, hydraulic parameters, viz. storage and transmissivity, vary between low and moderate:

- Permeability or hydraulic conductivity (k) varies between 4 X 10-2 m/d (semi-impervious) and 4.8 X 10-3 m/d (impervious). Whilst the permeability of the rock mass is zero, the permeability of fractures and fault zones and therefore preferential flow paths, could vary between 0.1 m/d (low) and 1.0 m/d (high), averaging less than 0.2 m/d.

- Transmissivities (T = KD) are generally low and fall in the range between 1 m2/d (most f the area) and 10 m2/d (small-scale fracturing and/or faulting and in the contact zones between different rock types).
- Storativity, based on physical descriptors and limited test data, fall in the range between 10-1 and 10-3 (between 0.1 and 0.001 m3 of ground water per m3 of rock mass; averaging 0.01 m3).
- Porosity is estimated at 1 % or less.

The aquifer across the area may be classified as a minor aquifer system where insignificant weathering and fracturing prevails. These systems occur across the whole of area.

The rating for the Aquifer System Management Classification is 2 (Minor Aquifer System). Ratings for the Ground Water Quality Management Classification System vary between 2 and 4. The Aquifer Vulnerability Classification is low yielding a Ground Water Quality Management Index less than 1, indicating that low level ground water protection may be required

From groundwater quality plot positions of boreholes around the area on the expanded Durov diagram in, it follows that most water qualities plot in field 3 of the diagram which represents fresh, clean, relatively young groundwater that has undergone Na ion exchange. This plot position indicates that the site specific groundwater qualities are relatively unaffected by mining activities. The remaining groundwater qualities are scattered all over the diagram and can be as a result of varying impacts including existing mining operations.

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1 INTRODUCTION

Me. Beth Candy of Jones & Wagner Consulting Engineers (J&W) requested the Institute for Groundwater Studies (IGS), to assist an additional groundwater assessment and specialist study for the Proposed Middelburg Mine Water Treatment Plant at Middelburg Coal Mine in Mpumalanga, South Africa.

This report documents data and information gathered during supervision of monitoring borehole drilling and testing activities by IGS as well as provided by J&W and BHP Billiton (BHP) during various investigations and assessments pertaining to the Middelburg Water Reclamation Project (MWRP) and present an assessment of the current groundwater regime in the area.

2 SCOPE OF INVESTIGATION

The scope of work consists of the following:

- Geophysics;
- Borehole drilling, groundwater well installation, well head establishment;
- Marking (GPS points for each borehole and mapping);
- Sampling;
- Analysis of samples; and
- Interpretation of results and recommendations.

A report will be prepared and issued (in combination with Report no: 2008/33/PDV, first in draft form [in electronic form] and, after client comments, in final form [two hard copies and also in electronic format.

3 LOCALITY

Figure 1 indicates the location of the investigation area on a regional scale, while Figure 2 indicates the site specific layout and borehole locations.

Initially the A (deep – 30 m) and B (shallow – 10 m) boreholes were drilled at each location and the lithology recorded. To allow for packer tests to be performed, only the starter casings were left inside each borehole. Due to delays with the packer testing, the boreholes collapsed and had to be re-drilled to allow for further investigation (packer tests) with regard to formation characteristics in terms of hydraulic conductivity. C, D, and E locations were drilled at a later date to facilitate the packer testing and were then properly constructed to enable long term monitoring of ground water at the site.

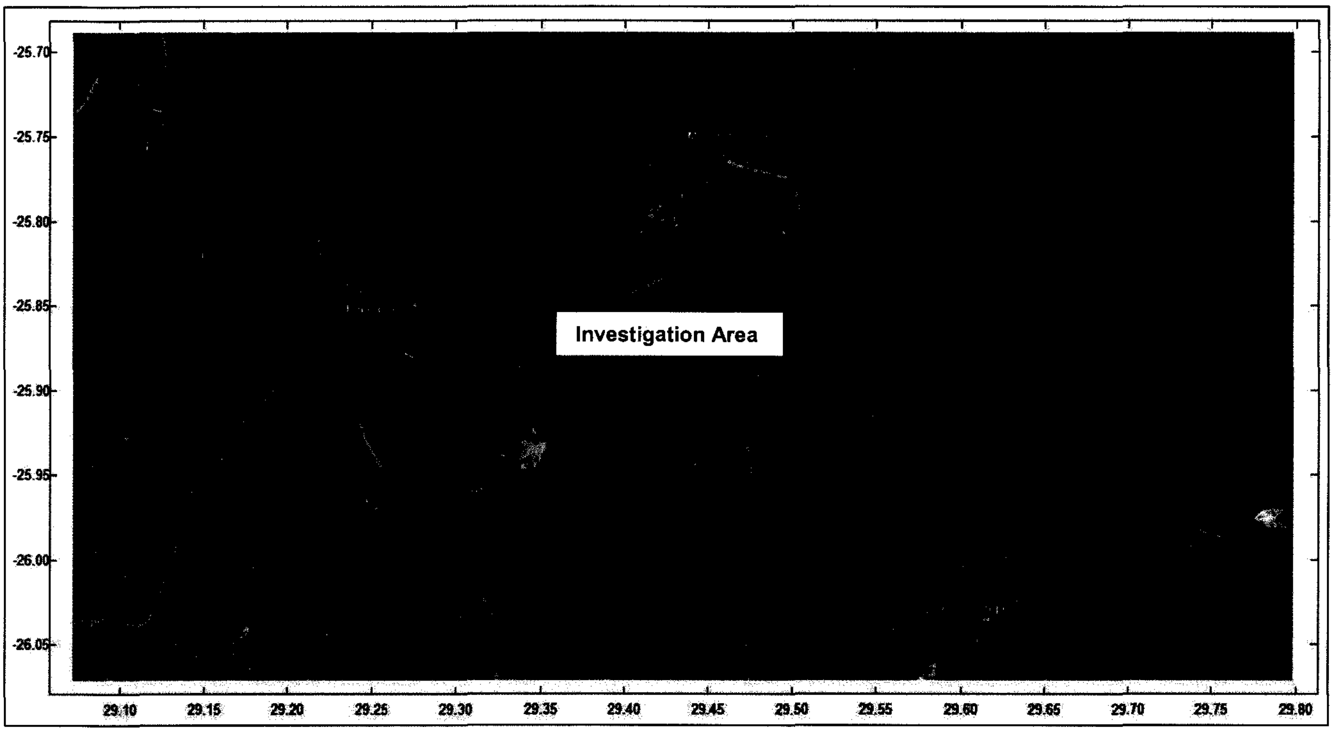


Figure 1: Regional layout plan (Courtesy of Google Earth).

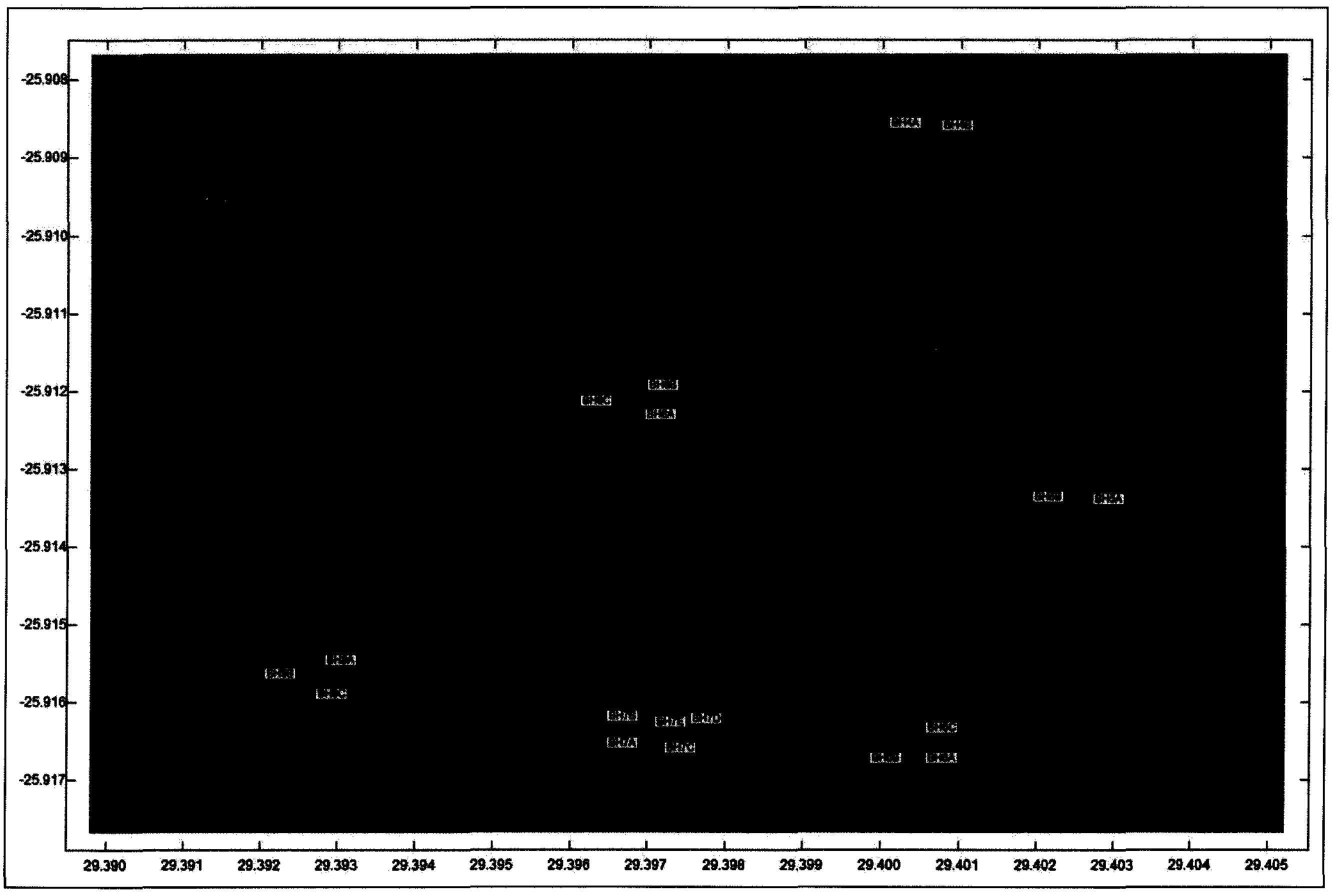


Figure 2: Layout plan indicating borehole locations (Courtesy of Google Earth).

4 HYDROGEOLOGICAL ASSESSMENT

4.1 Location 4

Two boreholes BH4A (deep) and BH4B (shallow) were drilled at this location. It is the most northern location and topographically the lowest lying. Lithological profiles (APPENDIX A – Figure 1 and APPENDIX A – Figure 2) indicate a top layer of sand on top of a clay layer situated between 3 m and 4 m. Below 4 m the formation consists of sandstone of the Vryheid Formation to the end of hole at 50 m. No water strikes were observed during drilling and the boreholes were classified as dry with no measurable blow yield at the end of the drilling phase.

Static ground water levels are at 5.8 meters below collar height (mbch) in BH4A and 5.6 mbch in BH4B. The consistency in static ground water levels between the shallow and deep boreholes indicates unconfined conditions.

Packer testing of the boreholes indicated a section of higher hydraulic conductivity (K) (6.93 X 10-2 meters per day (m/d)) situated between 7.5 meters below ground level (mbgl) and 11.5 mbgl (APPENDIX C - Figure 1). No further sections were observed at depth and K-values were recorded as 0 m/d. Electrical conductivity (EC) profiling of BH4A indicated an increase in EC at a depth of approximately 7 mbgl (APPENDIX A – Figure 1).

4.2 Location 5

BH5A and BH5B were drilled to a depth of 48 mbgl and 10 mbgl respectively (APPENDIX A – Figure 3 and APPENDIX A – Figure 4). Situated towards the most eastern location on the area, their lithology differs from location 4 with shale layers that were observed at 1 mbgl as well as 27 mbgl to 40 mbgl. Sandstone of the Vryheid Formation completes the rest of the profile for BH5A, which is the deep borehole.

A water strike of 0.1 litres per second (l/s) was recorded at a depth of 15 mbgl and another water strike of 0.3 l/s at 35 mbgl.

Static ground water levels of 7.2 mbch in BH5A and 9.5 mbch in BH5B were recorded. The difference between the two static ground water levels of 2.3 m was not visually evident when comparing local topography and collar heights above ground level, therefore it can be assumed that the level measured in BH5A is a piezometric level, indicating semi-confined to confined conditions, which can be attributed to the presence of the shale layers.

Packer tests were only conducted to a depth of 30 mbgl. Table 1 overleaf summarises the results.

Table 1: Summary of packer testing in BH5A.

Section interval (mbgl)	Hydraulic Conductivity (K) (m/d)
17.0 - 21.5	1.79×10^{-2}
21.5 - 26.0	1.65×10^{-2}
26.0 – 30.0	4.81×10^{-2}

From the above it is evident that the sections with higher K occur at depth. An inconsistency exists between the depth of the first water strike (15 mbgl) and the top of the first section where an actual K-value were observed (17 mbgl). Considering the lithology descriptions, the 17 mbgl could be a more accurate observation. The marginally increased K-value in the section that includes the sandstone just above the shale layer could be attributed to the contact zone and the concomitant fractured nature of the shale.

The slight increase in EC with depth observed during the EC profiling (APPENDIX A – Figure 3) does not indicate the water strikes observed during drilling and further profiling where a tracer such as sodium chloride (NaCl – table salt) is introduced into the system can be considered but the possible impact on long term monitoring should be kept in mind.

4.3 Location 6

Two boreholes were drilled initially at this location BH6A and BH6B. Borehole BH6C was drilled at a later date to facilitate the packer testing due to cave in of BH6A. The location is situated at the eastern side of the area of investigation and in close proximity just north of a discard dump.

Lithological descriptions and other borehole parameters are depicted in APPENDIX A – Figure 5, APPENDIX A – Figure 6 and APPENDIX A – Figure 7. The sandstone of the Vryheid Formation was encountered at a depth of approximately 8 mbgl. All three boreholes drilled at this location indicate a clay layer occurring between 3 mbgl and 8 mbgl overlying the aforementioned sandstone. Drilling information indicate seepage occurring at the contact between the clay layer and sandstone.

In BH6A a static ground water level was measured at 5.2 mbch and in BH6B a static ground water level of 4.9 mbch. The observed seepage at the contact between the clay layer and sandstone layer (approximately 8 mbgl) as the first water encountered and the static ground water levels measured at a shallower depth might be indicative of the clay being competent and therefore a confining layer, which could minimise the effect of seepage from possible contamination at surface.

Packer testing of the boreholes did not indicate any sections/zones with a measurable K and was recorded as 0 m/d.

Both boreholes exhibit an increase in EC below the clay layer. In BH6A the sharp increase in the sandstone section that exhibits fracturing (17 mbgl to 20 mbgl), although not excessive, might indicate a zone of flow where dilution occurs. This is however not supported by information from the packer tests.

4.4 Location 7

A total of five boreholes were drilled at this location situated close to a discard dump towards the southern boundary of the area of investigation. Although the lithology (APPENDIX A – Figure 8 to APPENDIX A – Figure 12) is generally the same as at the other locations, BH7E does not indicate the shallow clay/decomposed shale layer.

Only during the drilling of BH7E was seepage observed at 10 mbgl, in a sandy layer. All the other boreholes at this location were recorded as dry.

During December 2010, static ground water levels in BH7A and BH7B were 4.9 mbgl and 4.8 mbgl respectively. Once again static ground water levels are measured shallower than encountered depth recordings, substantiating the concept of confined conditions.

A slight increase in EC with depth is inconclusive with regard to zones of higher K due to the collapse of the boreholes during time before packer tests could be performed. K-values were observed ranging between 4.4 X 10^{-3} m/d and 4.0 X 10^{-2} m/d at depths between 3 mbgl and 12 mbgl.

4.5 Location 8

Situated centrally in the area of investigation, three boreholes were drilled. Although in close proximity to each other the later drilling log for BH8C recorded a shale layer while it was described as a clay layer in BH8A. This can be attributed to different individuals supervising the drilling and the clay has been described as decomposed shale. In general the lithology (APPENDIX A – Figure 13 to APPENDIX A – Figure 15) represents the same formations as at all the other locations being sand overlying a clay layer which in turn is situated on top of sandstone from the Vryheid Formation with a final shale layer at 22 mbgl to end of hole (EOH).

Very low yielding water strikes were recorded during the drilling of BH8A of approximately 0.1 l/s at 20 mbgl and 0.35 l/s at 25 mbgl. Seepage was observed in both BH8A and BH8C at 4 mbgl and 5 mbgl respectively.

Static water levels of 3.8 mbch in BH8A and 4.1 mbch in BH8B were measured during December 2010.

Due to collapsing of BH8A at the time, no conclusive data could be gathered with regard to EC when the boreholes were profiled. Packer testing of BH9B and BH9C did not encounter any sections with a recordable K and was recorded as 0 m/d.

4.6 Location 9

Situated approximately 450 m west of location 7, another cluster of three boreholes were drilled. Initially only BH9A and BH9B were drilled and later on BH9C were drilled to allow for packer testing due to the collapse of BH9A.

Considering the lithology observed at location 9 (APPENDIX A – Figure 16 to APPENDIX A – Figure 18), it more or less mirrored the formation sequence encountered across the area. The shallow decomposed shale layer (3 mbgl to 8 mbgl) was once again observed situated above the sandstone formation of the Vryheid Formation. Some seepage – yield unknown – were observed at 6 mbgl during the drilling of BH9C.

Static ground water levels were 4.0 mbch (BH9A) and 2.6 mbch (BH9B) during December 2010. No quantifiable K could be determined during packer testing in BH9B and BH9C.

4.7 Ground Water Compartment

4.7.1 Physical Composition of the Aquifers - Geology and Structure

The entire area is largely blanketed by sand between 3 m and 7 m thick which overlies a decomposed shale/clay layer situated on top of sandstone of the Vryheid Formation. In areas another shale layer is present below the sandstone at depths ranging between 17 mbgl and 25 mbgl.

Although ground water flow takes place through the entire soil profile in both the horizontal and vertical (albeit significantly less) directions, local zones of more rapid flows occur in coarser (more sandier) zones in shallow soils, deep and extensive zones of weathering and/or fracturing, and geological contact zones i.e. zones between different layers of rock and/or intrusions such as dykes of dolerite.

The hydraulic characteristics of the ground water regime are low to moderate with borehole yields expected to range between less than 0.1 l/s and 2.0 l/s with a distribution of 60 % yielding less than 0.1 l/s, 30 % yielding between 0.1 l/s and 1.0 l/s and only 10 % yielding more than 1.0 l/s.

4.7.2 Lateral Extent and Thickness of the Hydrogeological Regime

Ground water generally occurs and moves through planes along the layering, joints, fractures and cracks in the absence of large-scale fracturing/faulting (preferential flow paths). Theoretically, the lateral extent of aquifers is infinite. Physical-structural geological phenomena (fracture systems which are not interconnected and intrusions such as dykes of dolerite) occur frequently, causing differences in hydraulic characteristics which sub-divide aquifers into smaller compartments. The lateral extent of the hydrogeological regime may also be determined along hydraulic lines based on topographic and ground water level information. Possible affected hydrogeological regimes can be delimited, based on geological (and hydrogeological characteristics of the rock strata) and topographical (local and regional drainage patterns) settings and water resources monitoring, and should be relatively small in extent and in close proximity to mining infrastructure.

4.7.3 Hydraulic-Physical Description of the Aquifers

Insignificant (less than 0.1 l/s) to moderate (2.0 l/s) ground water occurrences and movement are confined to open planes along layered rocks, joints, fractures and cracks in weathered and fractured strata. Insignificant (more common) to significant fracturing prevails in most geological formations and contact zones whilst bedding plane openings and fractures vary between small and moderate, limited to large in extent, irregularly to frequently distributed and often not interconnected. Sustainable borehole yields are often limited by negligible recharge inhibited by the layer of clay at the surface.

Ground water levels generally rose to levels higher than those at which water was encountered. This would indicate that ground water occurs and moves in a semi-confined to confined flow regime.

Aquifers across the area within zones impacted upon by mining and related infrastructure are fractured with a secondary porosity derived from cracks and fractures in the rock mass. Consequently, hydraulic parameters, viz. storage and transmissivity, vary between low and moderate:

- Permeability or hydraulic conductivity (k) varies between 4 X 10^{-2} m/d (semi-impervious) and 4.8 X 10^{-3} m/d (impervious). Whilst the permeability of the rock mass is zero, the permeability of fractures and fault zones and therefore preferential flow paths, could vary between 0.1 m/d (low) and 1.0 m/d (high), averaging less than 0.2 m/d.
- Transmissivities (T = KD) are generally low and fall in the range between 1 m^2/d (most f the area) and 10 m^2/d (small-scale fracturing and/or faulting and in the contact zones between different rock types).
- Storativity, based on physical descriptors and limited test data, fall in the range between 10^{-1} and 10^{-3} (between 0.1 and 0.001 m^3 of ground water per m^3 of rock mass; averaging 0.01 m^3).
- Porosity is estimated at 1 % or less.

Ground water moves slowly and receives limited recharge through the clay which suggests that the long-term fluctuation in ground water levels would not exceed 3.0 m between annual lows and highs, thus a variation of 1.5 m around the average.

By employing the estimates for permeability, ground water level gradient and porosity, the average seepage velocity is estimated at between 0.10 m/a and 10 m/a, which implies that ground water may not migrate far as subsurface flow. Taking due cognisance of all of these, recharge to the ground water regime is estimated at around 3 % of MAP across most of the area.

4.8 Aquifer Classification

The aquifer(s) underlying the power station could not be classified in accordance with: ***A South African Aquifer System Management Classification, December 1995***, prepared for the Water Research Commission and the Department of Water Affairs and Forestry by Roger Parsons, Groundwater Programme, Watertek, CSIR.

Once enough information with regard to the ground water environment has been gathered, the classification should be done in accordance with the definitions for Aquifer System Management Classes:

Sole Aquifer System: An aquifer which is used to supply 50 per cent or more of domestic water for a given area, and for which there are no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.

Major Aquifer System: Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (less than 150 mS/m - Electrical Conductivity).

Minor Aquifer System: These can be fractured or potentially fractured rocks, which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important both for local supplies and in supplying base flow for rivers.

Non-Aquifer System: These are formations with negligible permeability that are generally regarded as not containing ground water in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, ground water flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

In terms of the above definitions, the aquifer across the area may be classified as a minor aquifer system where insignificant weathering and fracturing prevails. These systems occur across the whole of area.

The rating for the Aquifer System Management Classification is 2 (Minor Aquifer System). Ratings for the Ground Water Quality Management Classification System vary between 2 and 4. The Aquifer Vulnerability Classification is low yielding a Ground Water Quality Management Index less than 1, indicating that low level ground water protection may be required.

5 GROUND WATER QUALITY

APPENDIX B - Table 1 depicts the laboratory results of samples collected during December 2010.

From the groundwater quality plot positions of boreholes around the area on the expanded Durov diagram in APPENDIX B - Figure 1, it follows that most water qualities plot in field 3 of the diagram which represents fresh, clean, relatively young groundwater that has undergone Na ion exchange. This plot position indicates that the site specific groundwater qualities are relatively unaffected by mining activities. The remaining groundwater qualities are scattered all over the diagram and can be as a result of varying impacts including existing mining operations.

6 CONCLUSIONS

The hydraulic characteristics of the ground water regime are low to moderate with borehole yields expected to range between less than 0.1 l/s and 2.0 l/s with a distribution of 60 % yielding less than 0.1 l/s, 30 % yielding between 0.1 l/s and 1.0 l/s and only 10 % yielding more than 1.0 l/s.

Aquifers across the area within zones impacted upon by mining and related infrastructure are fractured with a secondary porosity derived from cracks and fractures in the rock mass. Consequently, hydraulic parameters, viz. storage and transmissivity, vary between low and moderate:

- Permeability or hydraulic conductivity (k) varies between 4 X 10^{-2} m/d (semi-impervious) and 4.8 X 10^{-3} m/d (impervious). Whilst the permeability of the rock mass is zero, the permeability of fractures and fault zones and therefore preferential flow paths, could vary between 0.1 m/d (low) and 1.0 m/d (high), averaging less than 0.2 m/d.
- Transmissivities (T = KD) are generally low and fall in the range between 1 m^2/d (most f the area) and 10 m^2/d (small-scale fracturing and/or faulting and in the contact zones between different rock types).
- Storativity, based on physical descriptors and limited test data, fall in the range between 10-1 and 10-3 (between 0.1 and 0.001 m^3 of ground water per m^3 of rock mass; averaging 0.01 m^3).
- Porosity is estimated at 1 % or less.

The aquifers across the area may be classified as minor aquifer systems where insignificant weathering and fracturing prevails. These systems occur across the whole of area.

The rating for the Aquifer System Management Classification is 2 (Minor Aquifer System). Ratings for the Ground Water Quality Management Classification System vary between 2 and 4. The Aquifer Vulnerability Classification is low yielding a Ground Water Quality Management Index less than 1, indicating that low level ground water protection may be required.

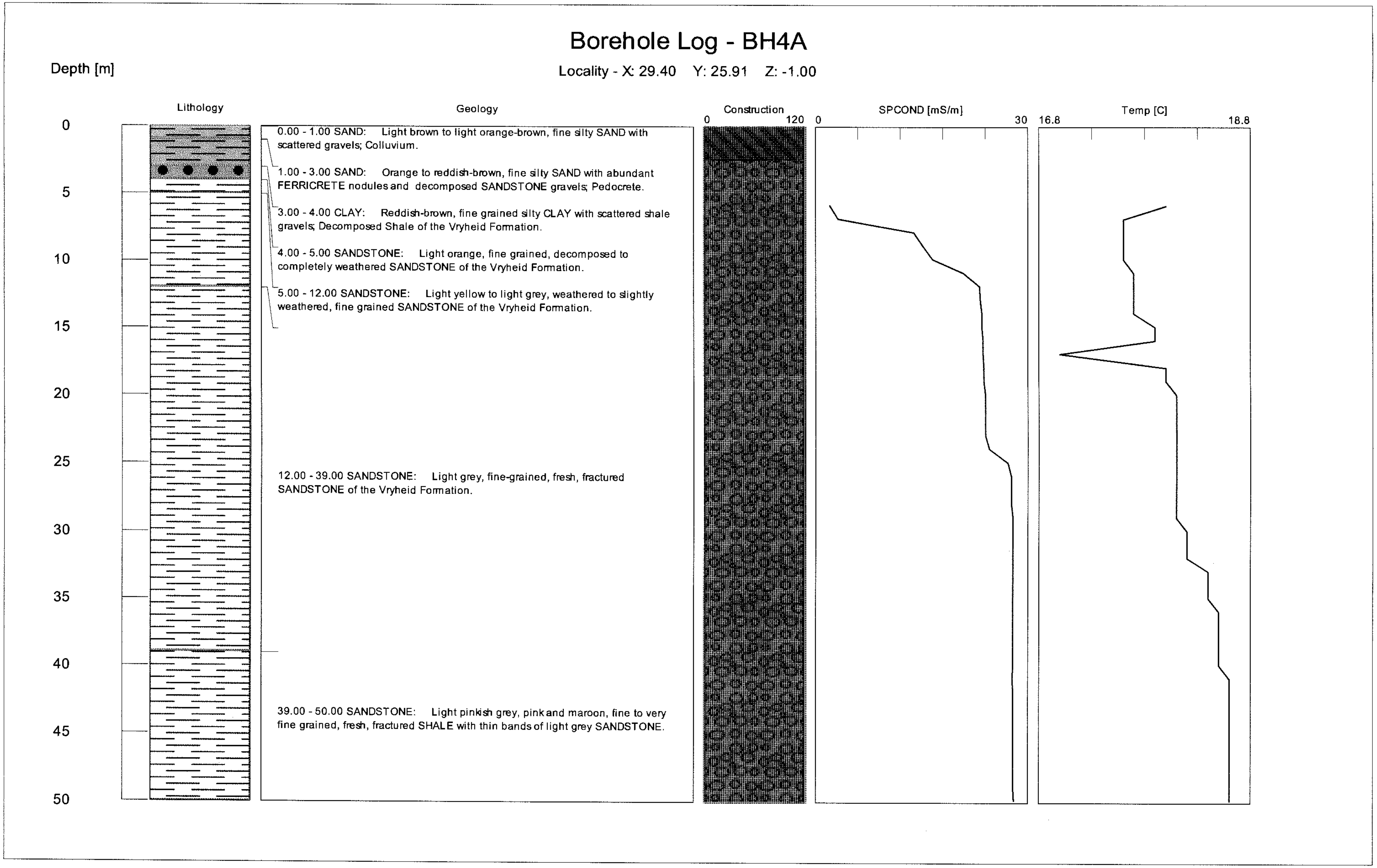
Chemical diagrams indicate that the majority of the site specific groundwater qualities are relatively unaffected by mining activities. The remaining groundwater qualities are scattered all over the diagram and can be as a result of varying impacts including existing mining operations.

7 RECOMMENDATIONS

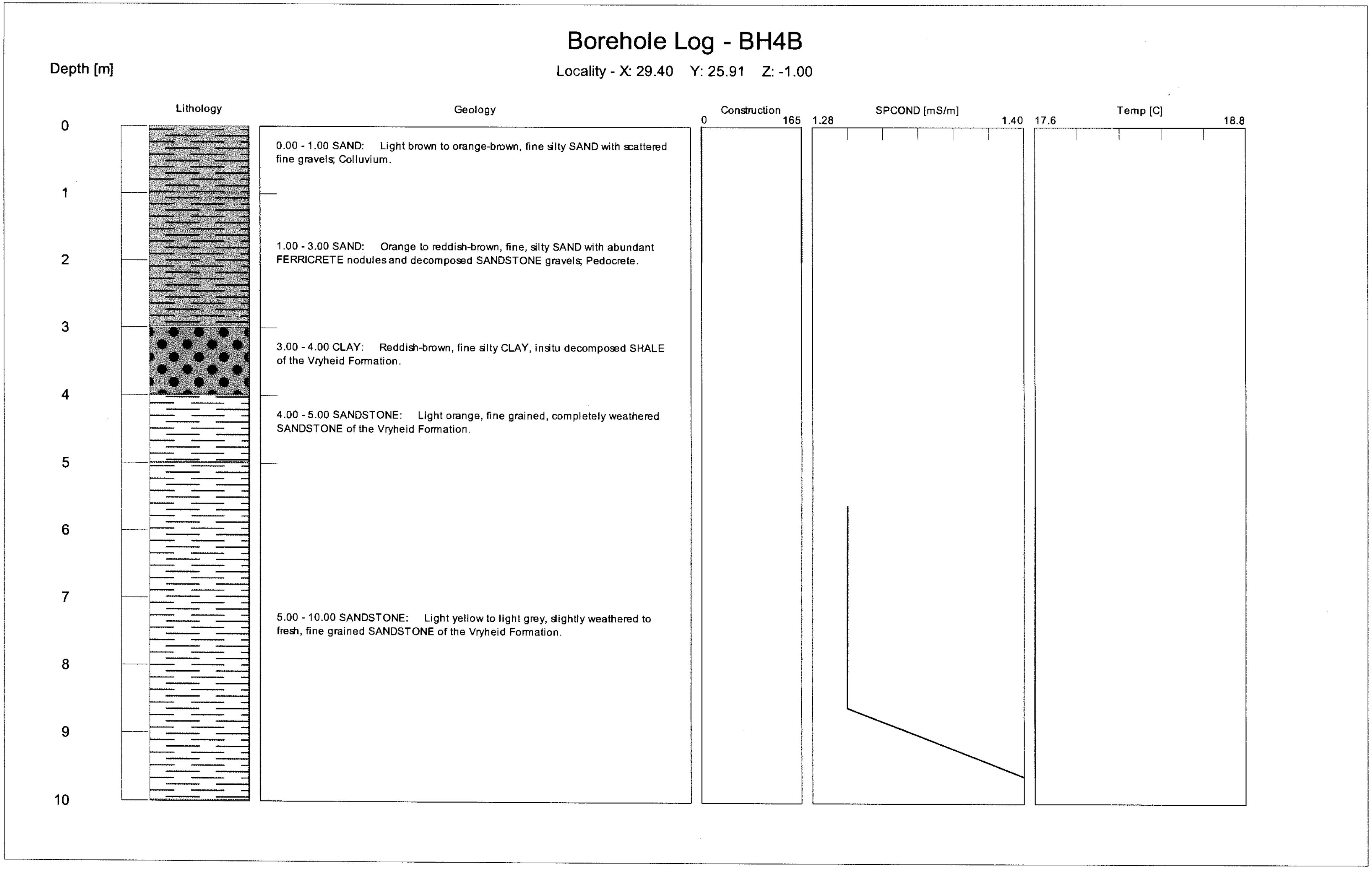
- Borehole elevations should be surveyed by a qualified surveyor to determine ground water gradients and flow directions;
- The boreholes should be incorporated in the mine's monitoring network;
- Another set of samples should be taken after boreholes have been purged;
- EC profiling – The slight increase in EC with depth observed during the EC profiling does not indicate the water strikes observed during drilling and further profiling where a tracer such as sodium chloride (NaCl – table salt) is introduced into the system can be considered but the possible impact on long term monitoring should be kept in mind; and
- Constructing a numerical ground water model, which can be updated on a yearly basis with new monitoring data, in order to assist in managing the impacts associated with mining on the underground water resources.

APPENDIX A

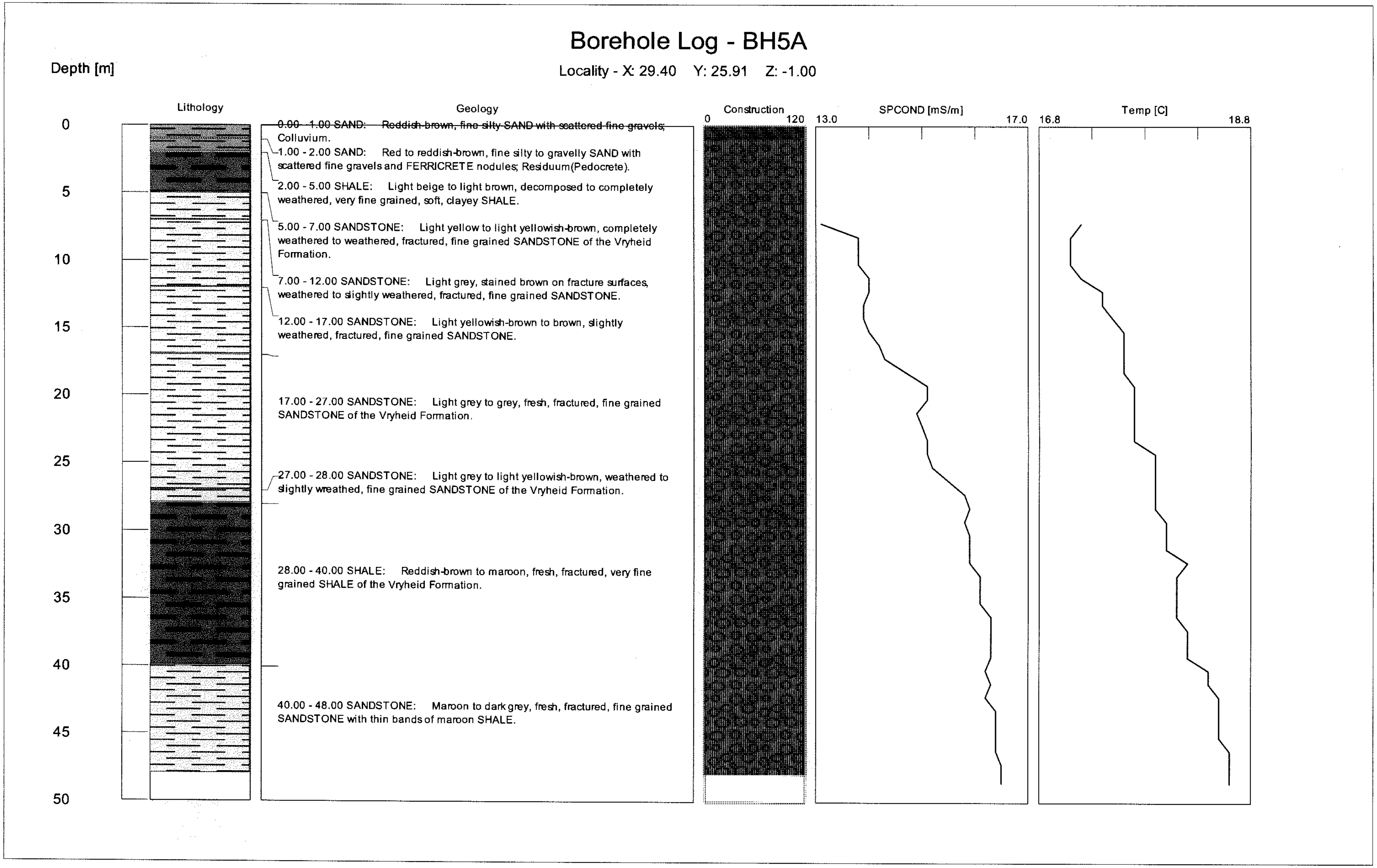
Borehole Logs and Parameters



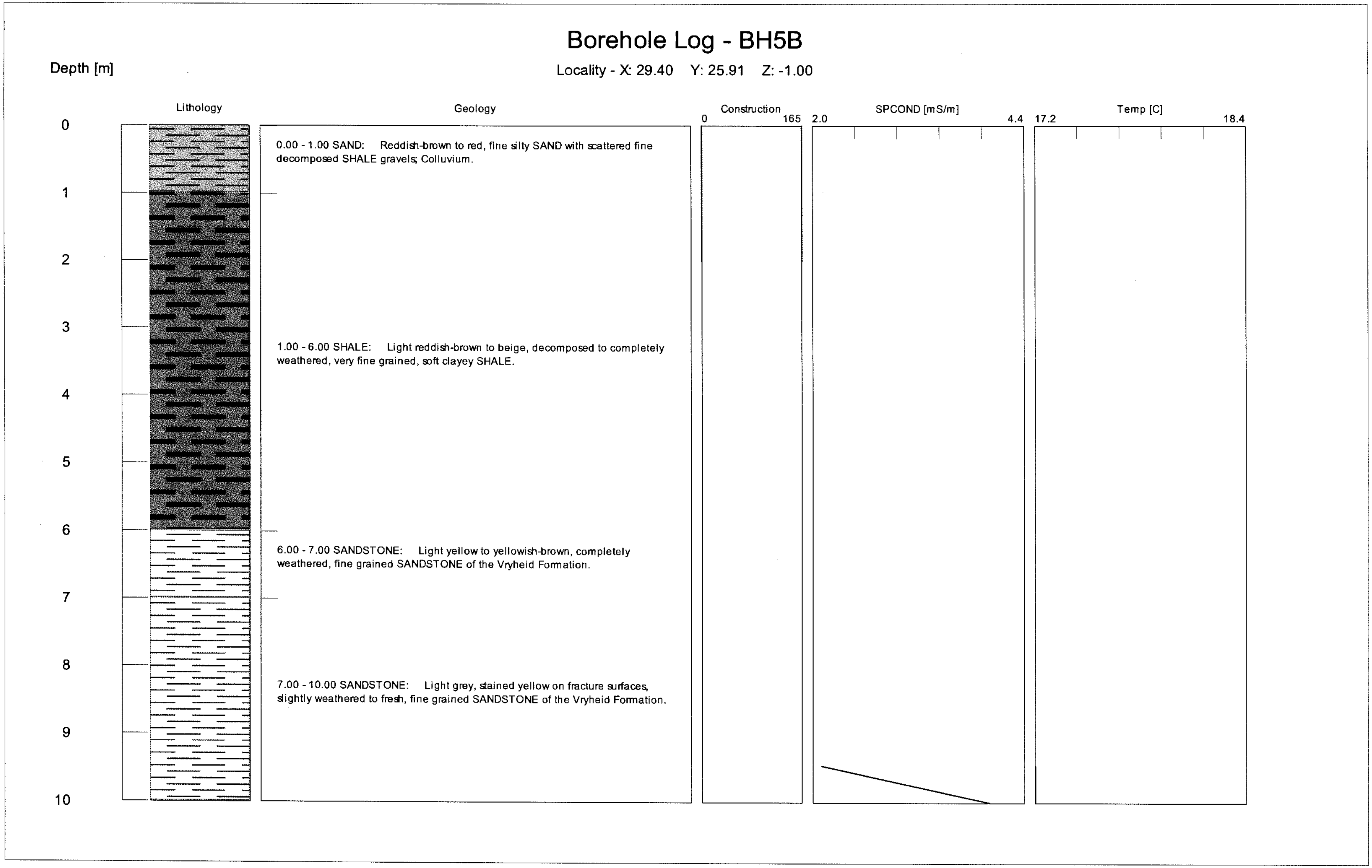
APPENDIX A – Figure 1: Borehole parameters BH4A



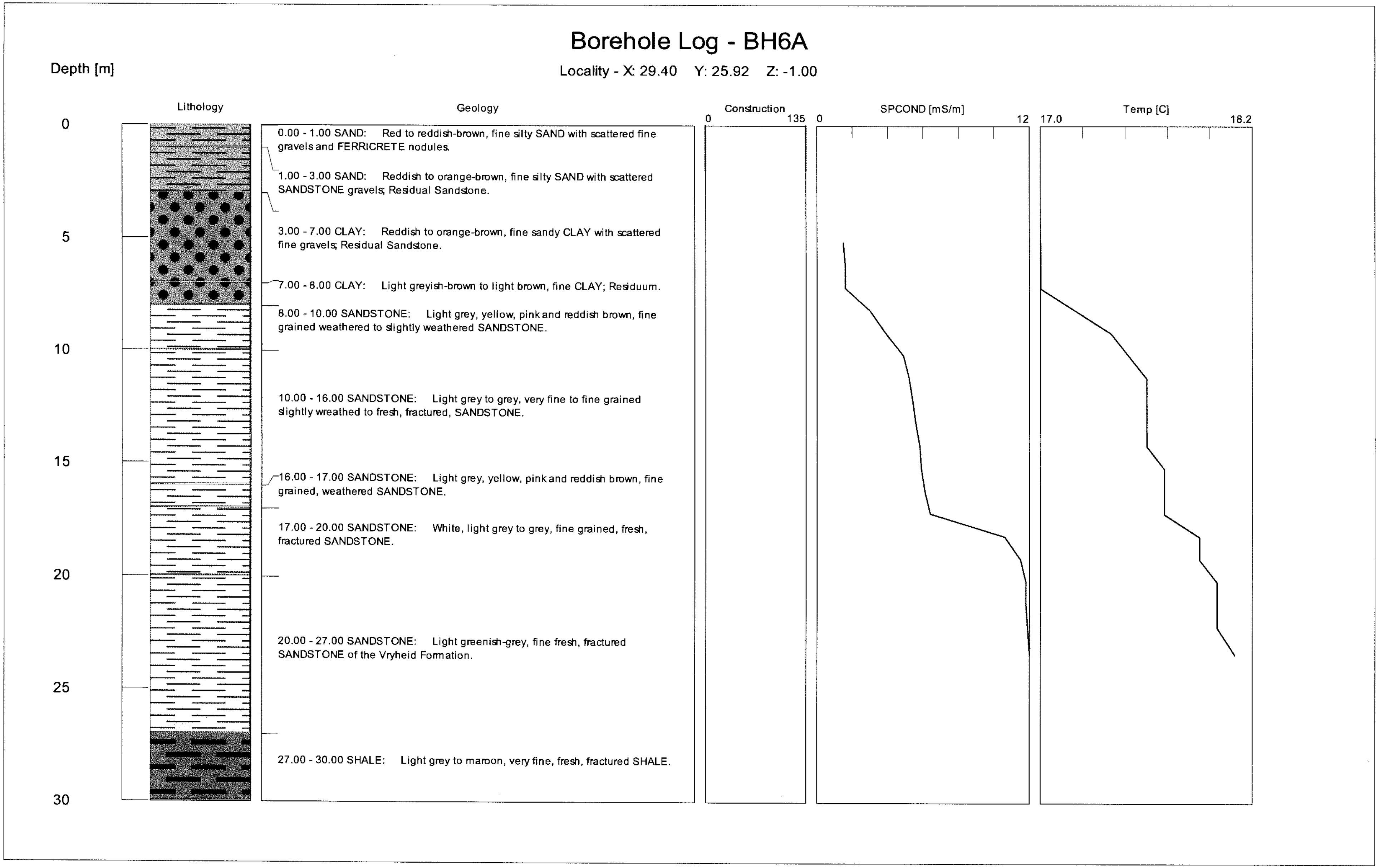
APPENDIX A – Figure 2: Borehole parameters BH4B



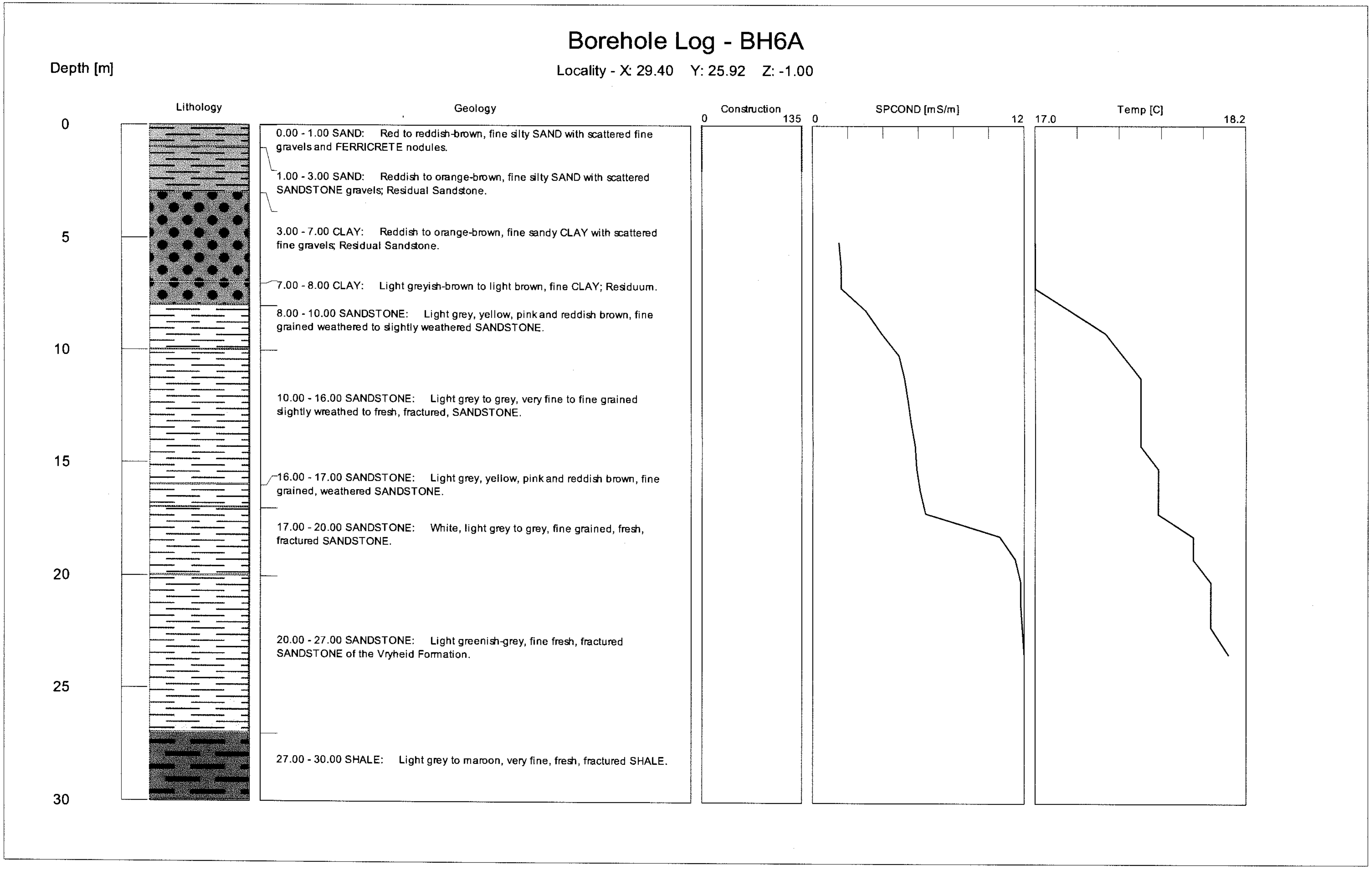
APPENDIX A – Figure 3: Borehole parameters BH5A



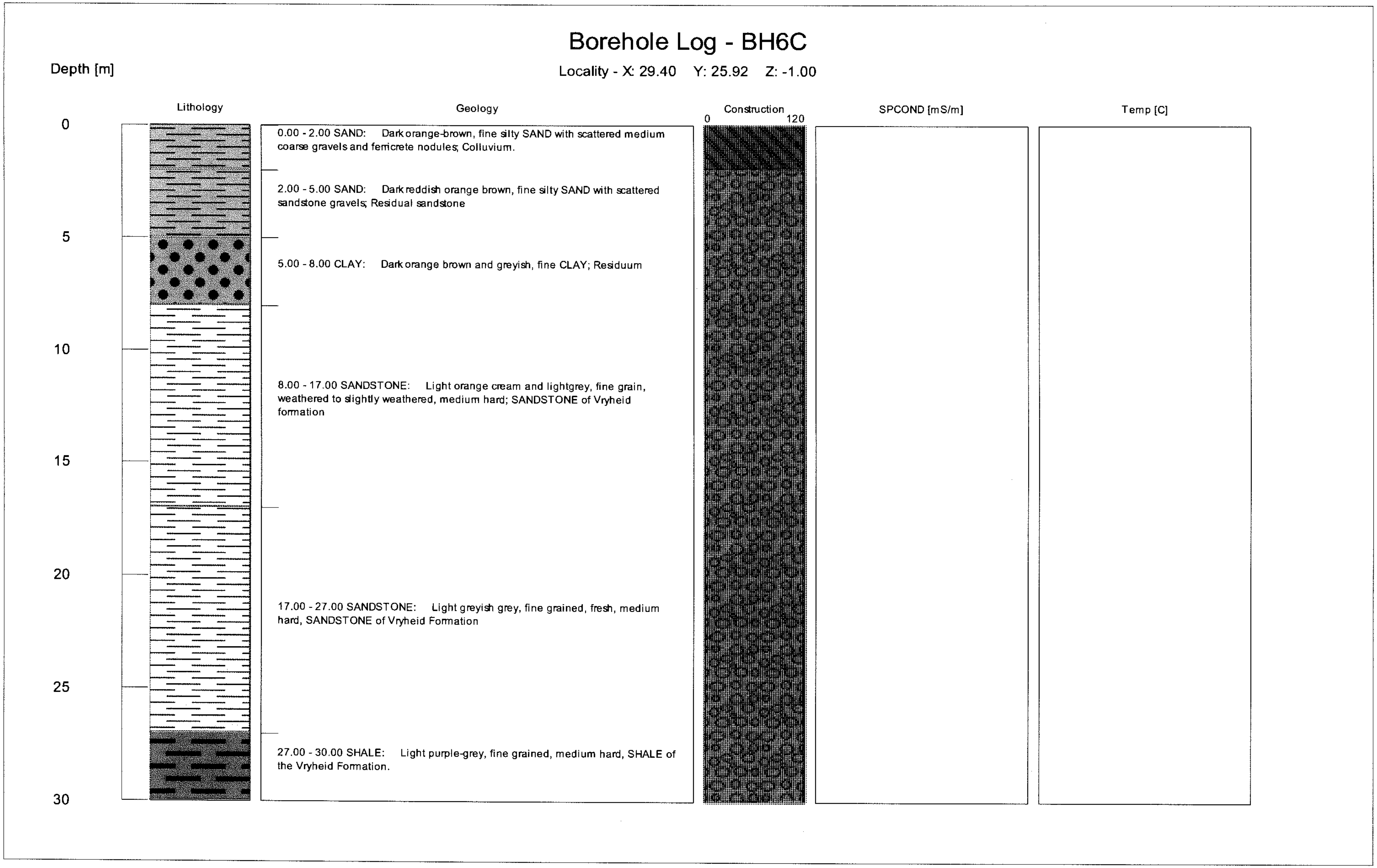
APPENDIX A – Figure 4: Borehole parameters BH5B



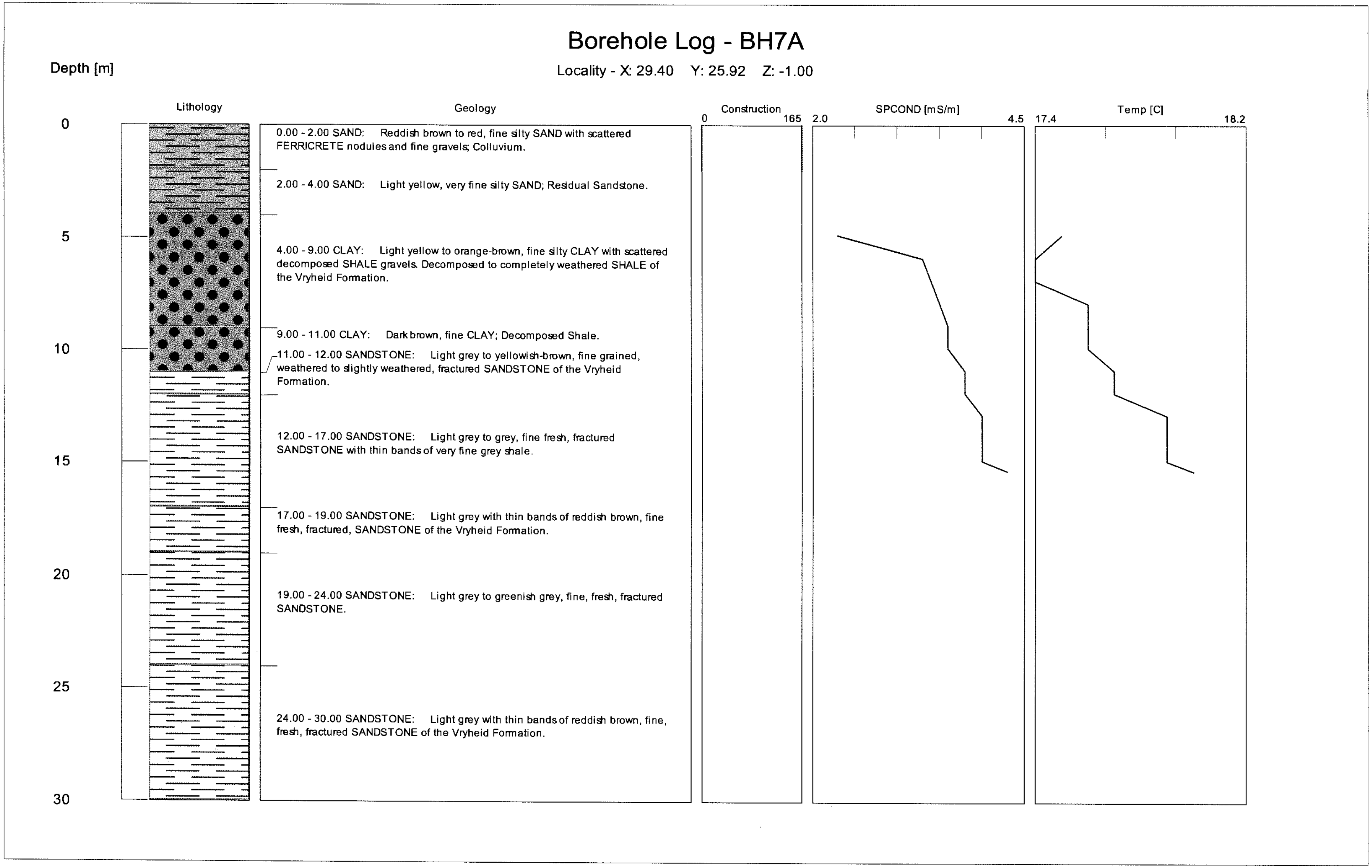
APPENDIX A – Figure 5: Borehole parameters BH6A



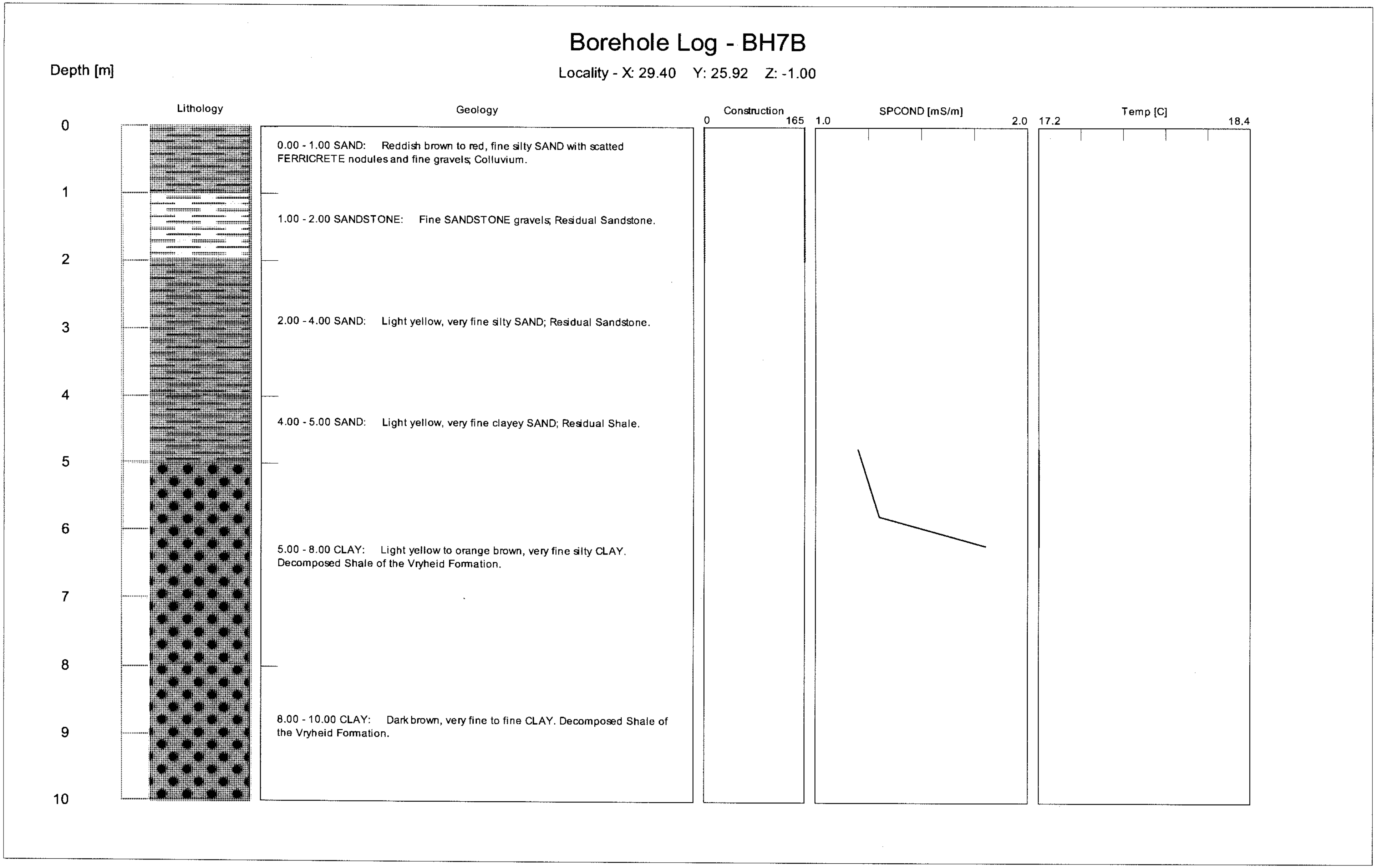
APPENDIX A – Figure 6: Borehole parameters BH6B



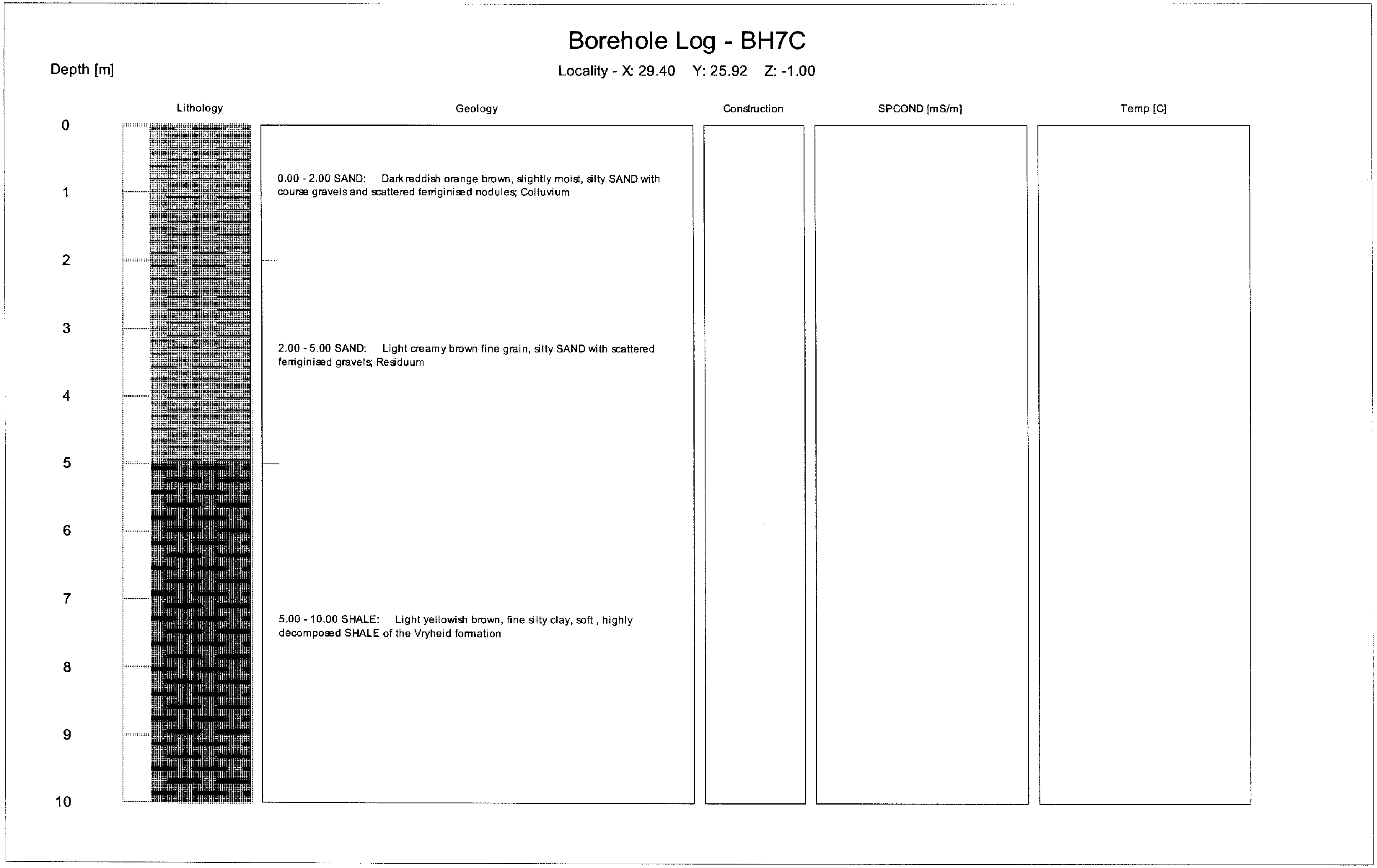
APPENDIX A – Figure 7: Borehole parameters BH6C



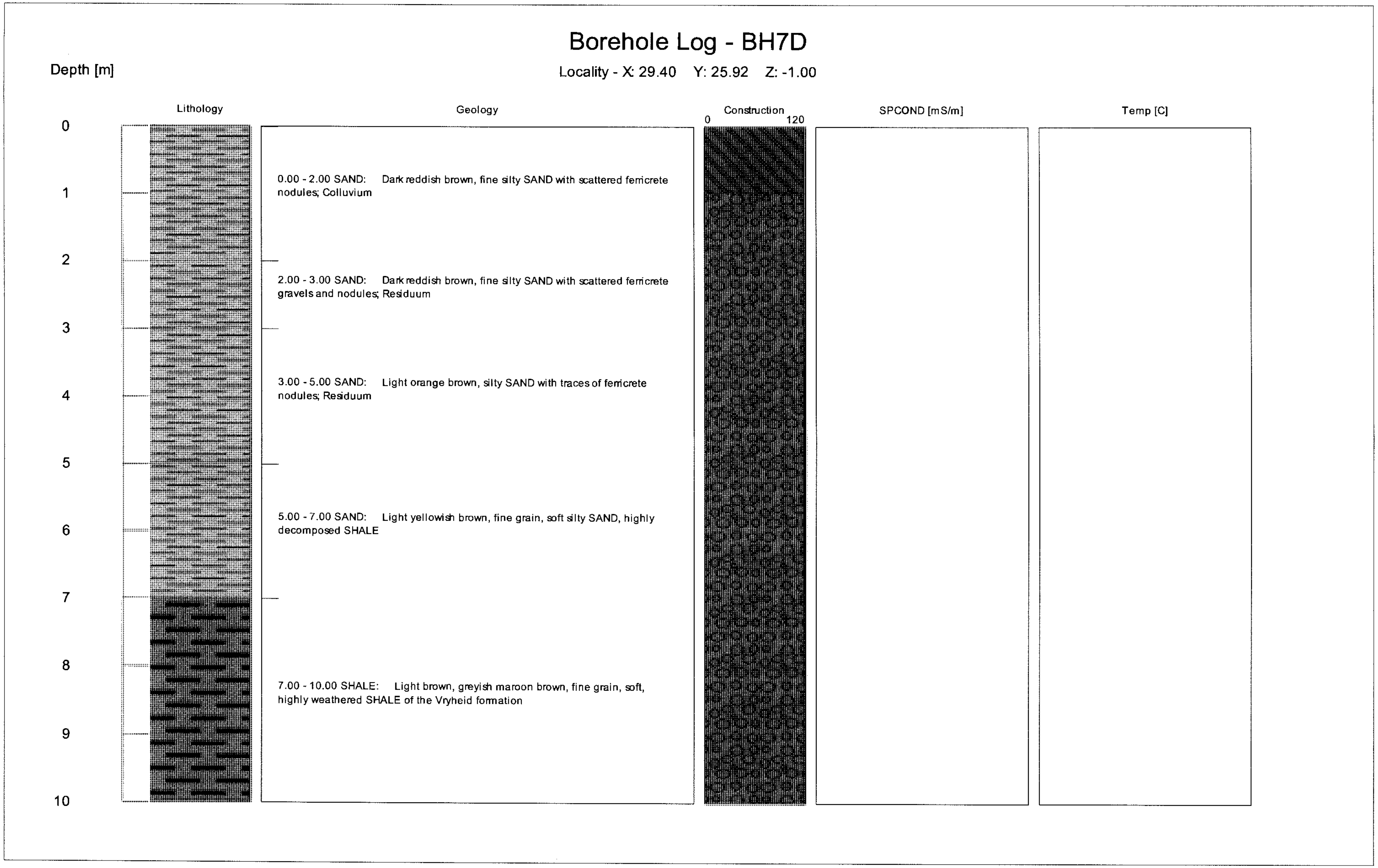
APPENDIX A – Figure 8: Borehole parameters BH7A



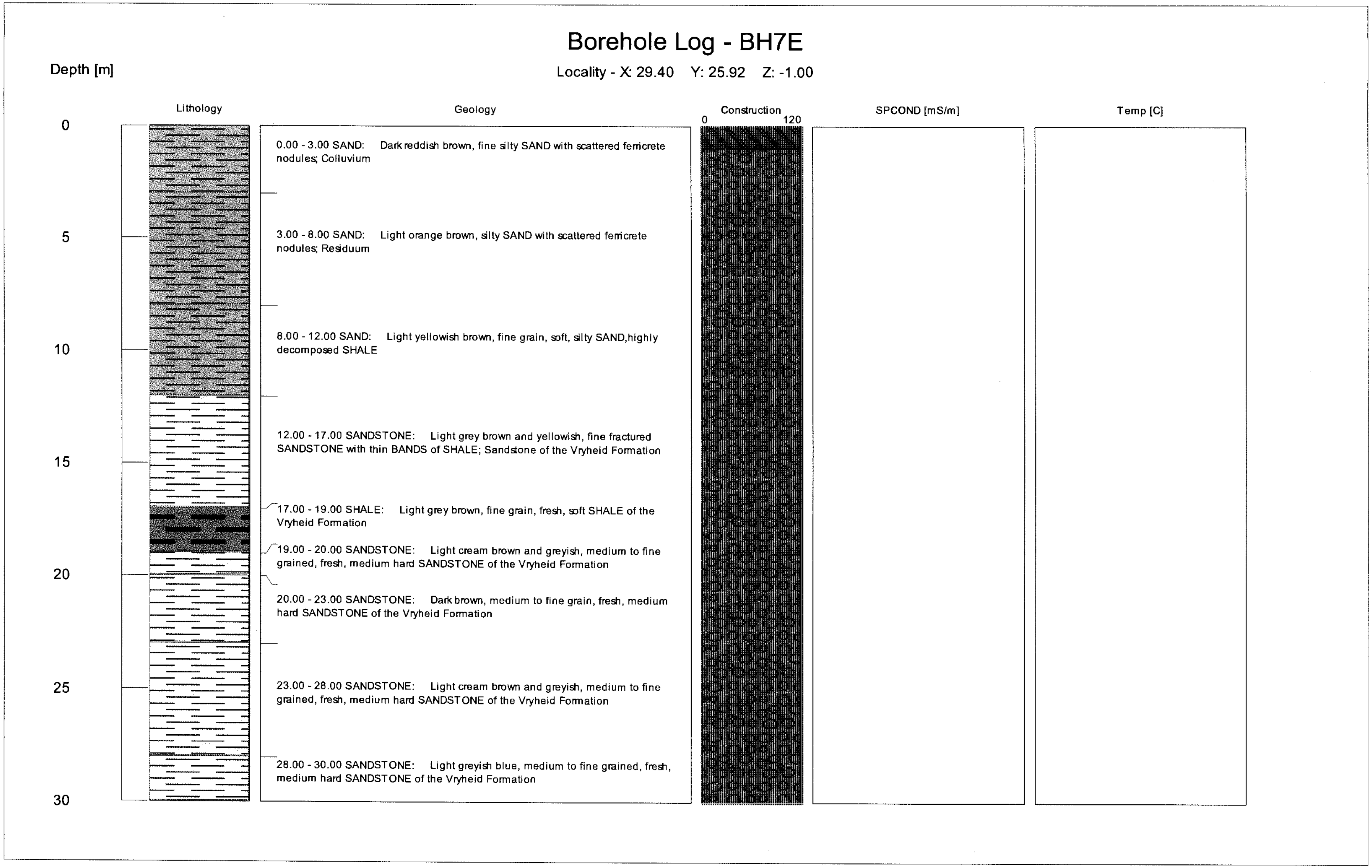
APPENDIX A – Figure 9: Borehole parameters BH7B



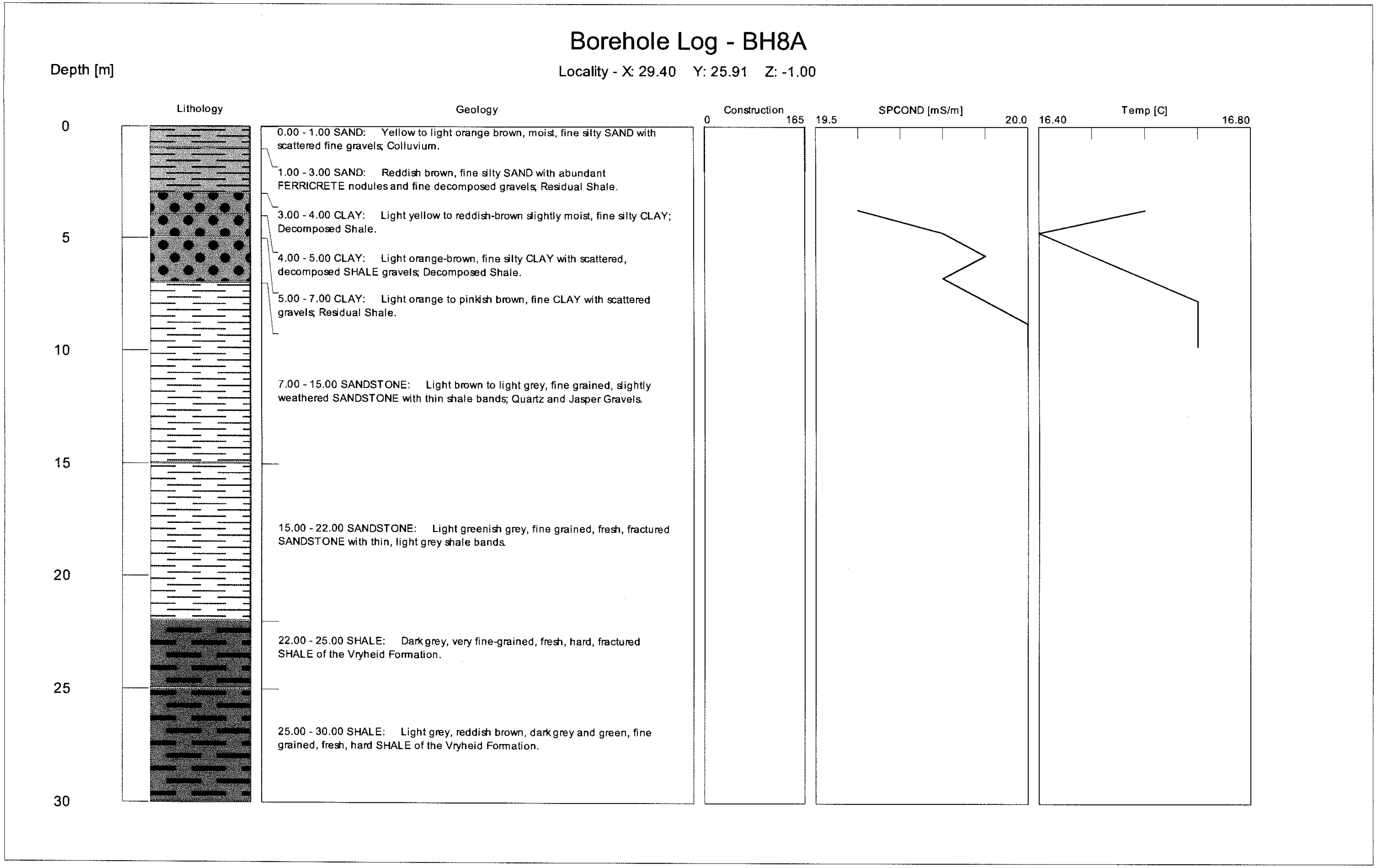
APPENDIX A – Figure 10: Borehole parameters BH7C



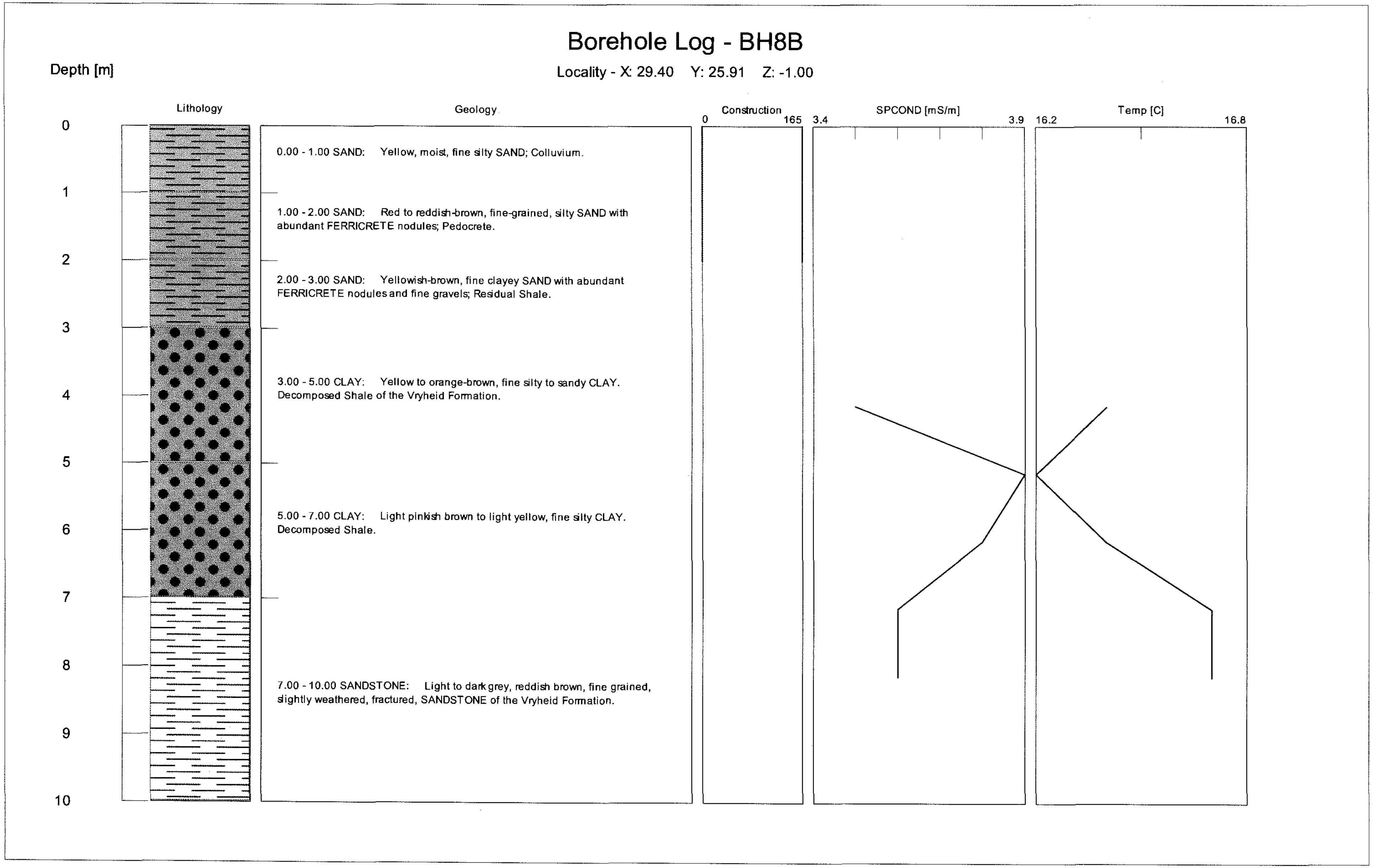
APPENDIX A – Figure 11: Borehole parameters BH7D



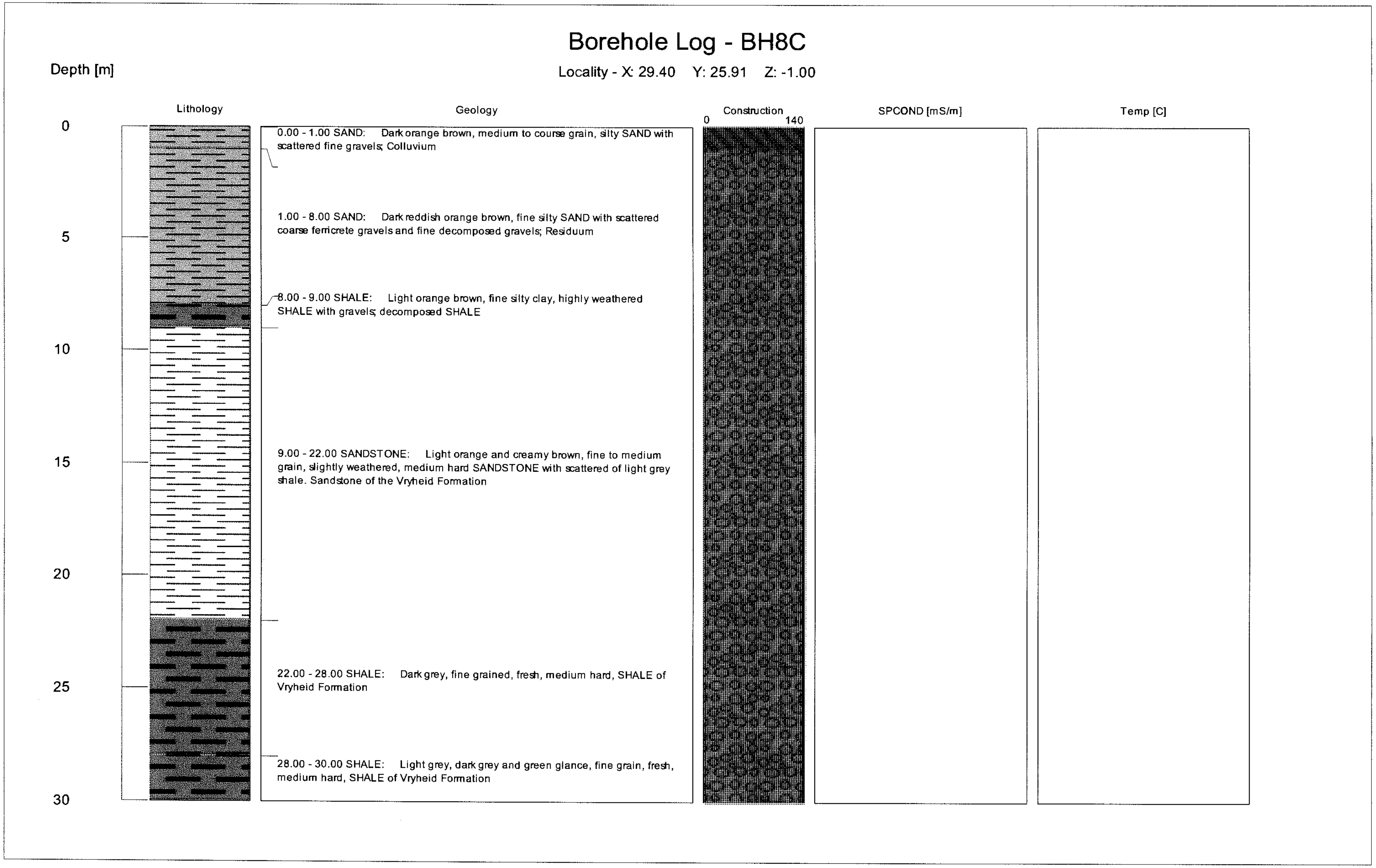
APPENDIX A – Figure 12: Borehole parameters BH7E



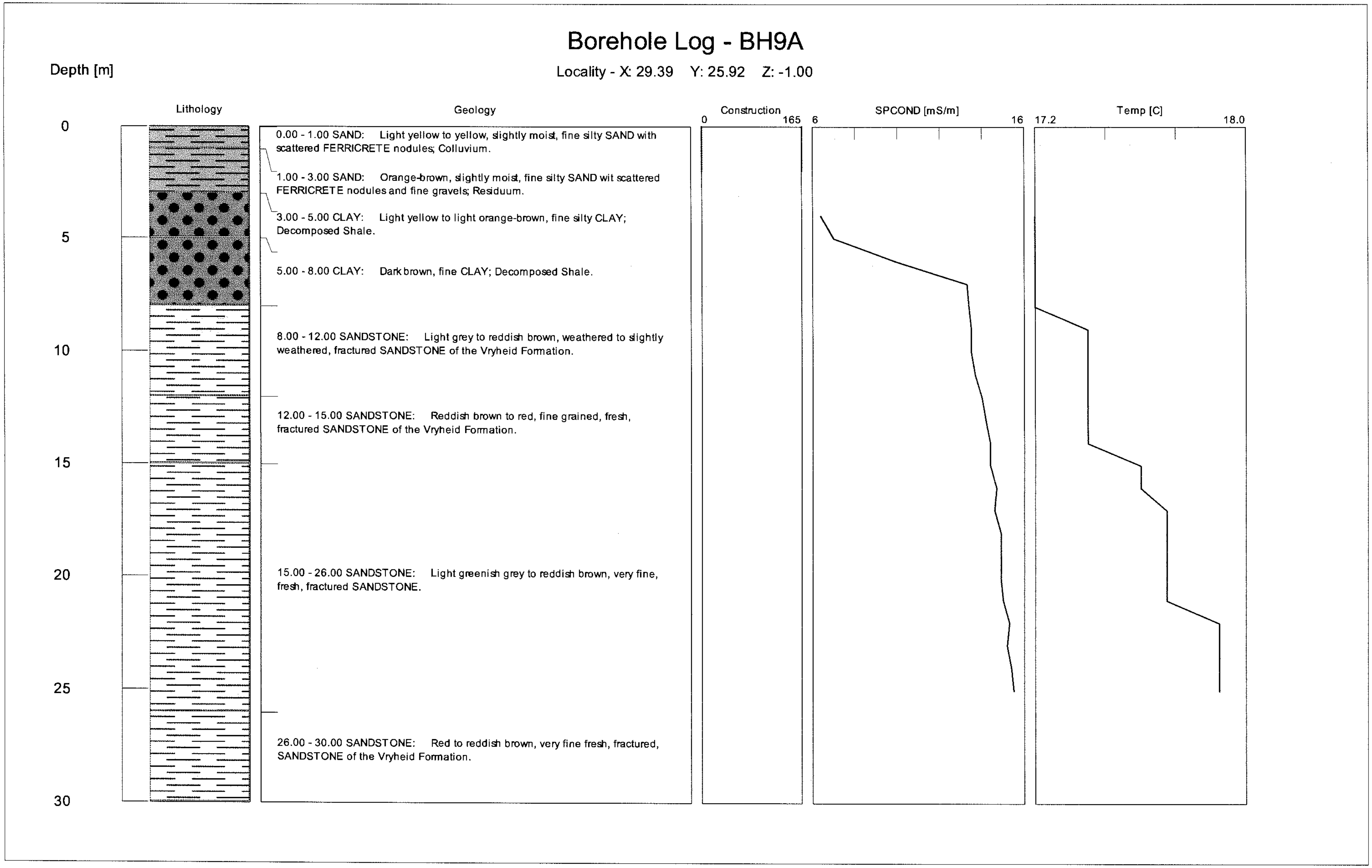
APPENDIX A – Figure 13: Borehole parameters BH8A



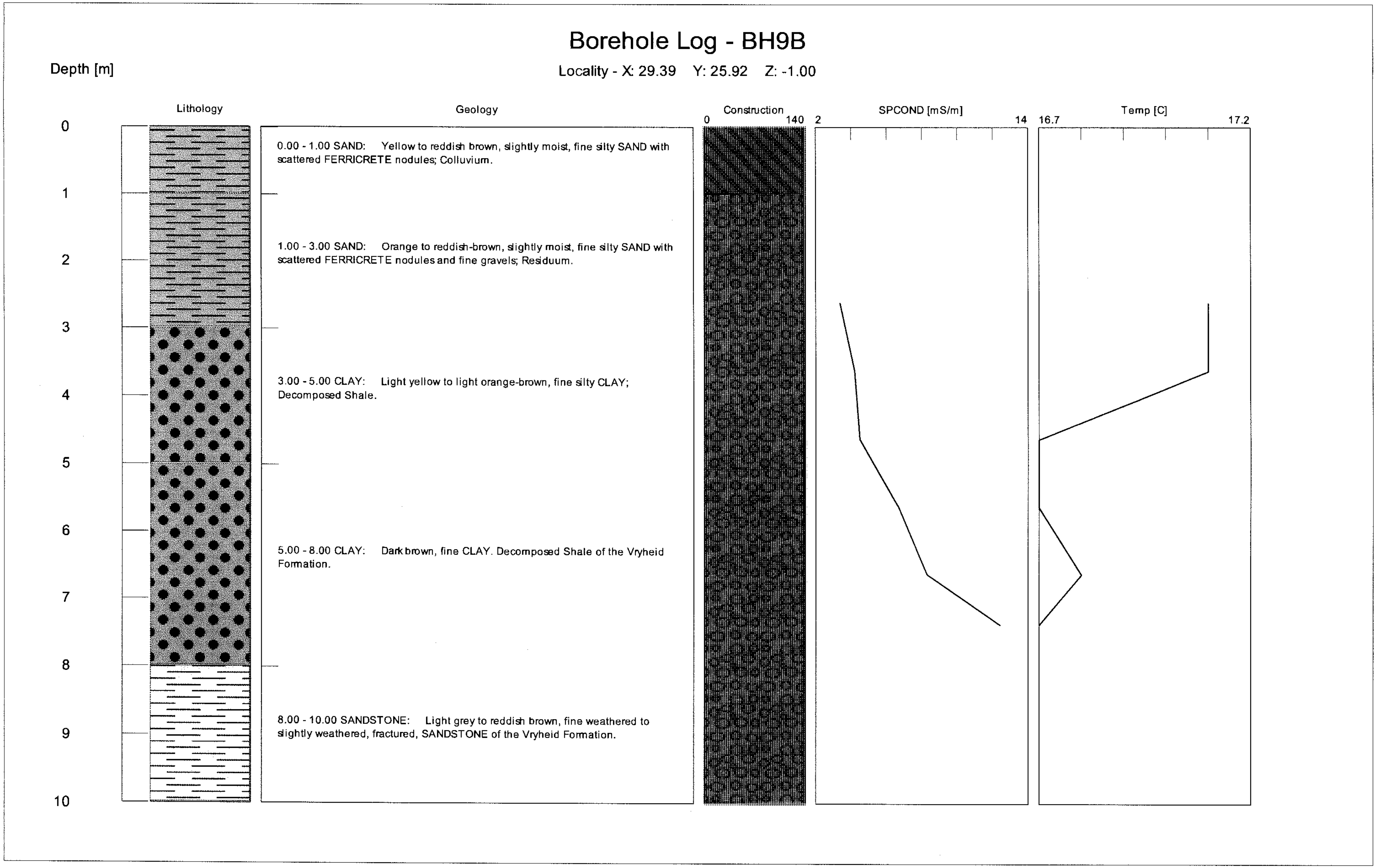
APPENDIX A – Figure 14: Borehole parameters BH8B



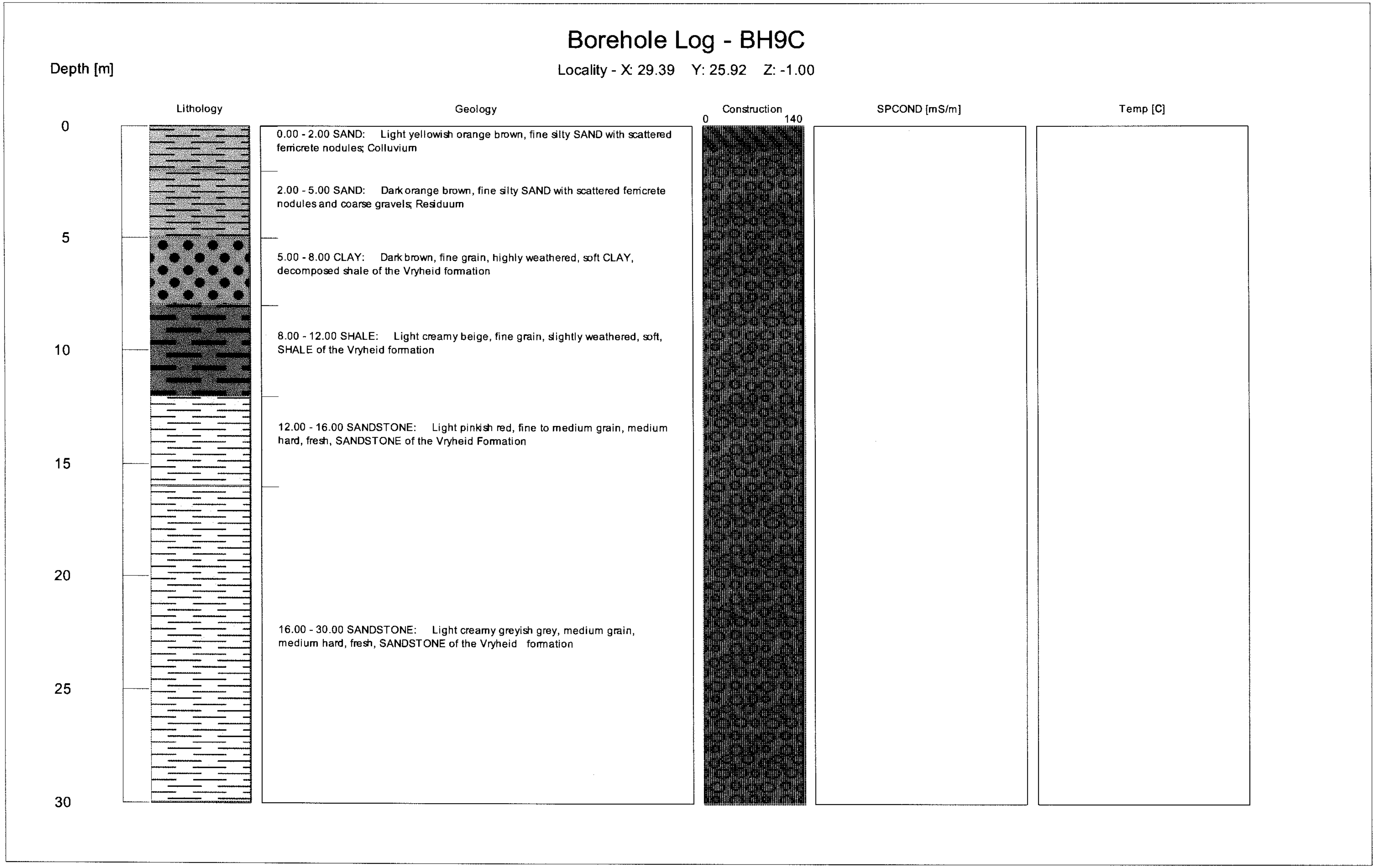
APPENDIX A – Figure 15: Borehole parameters BH8C



APPENDIX A – Figure 16: Borehole parameters BH9A



APPENDIX A – Figure 17: Borehole parameters BH9B



APPENDIX A – Figure 18: Borehole parameters BH9C

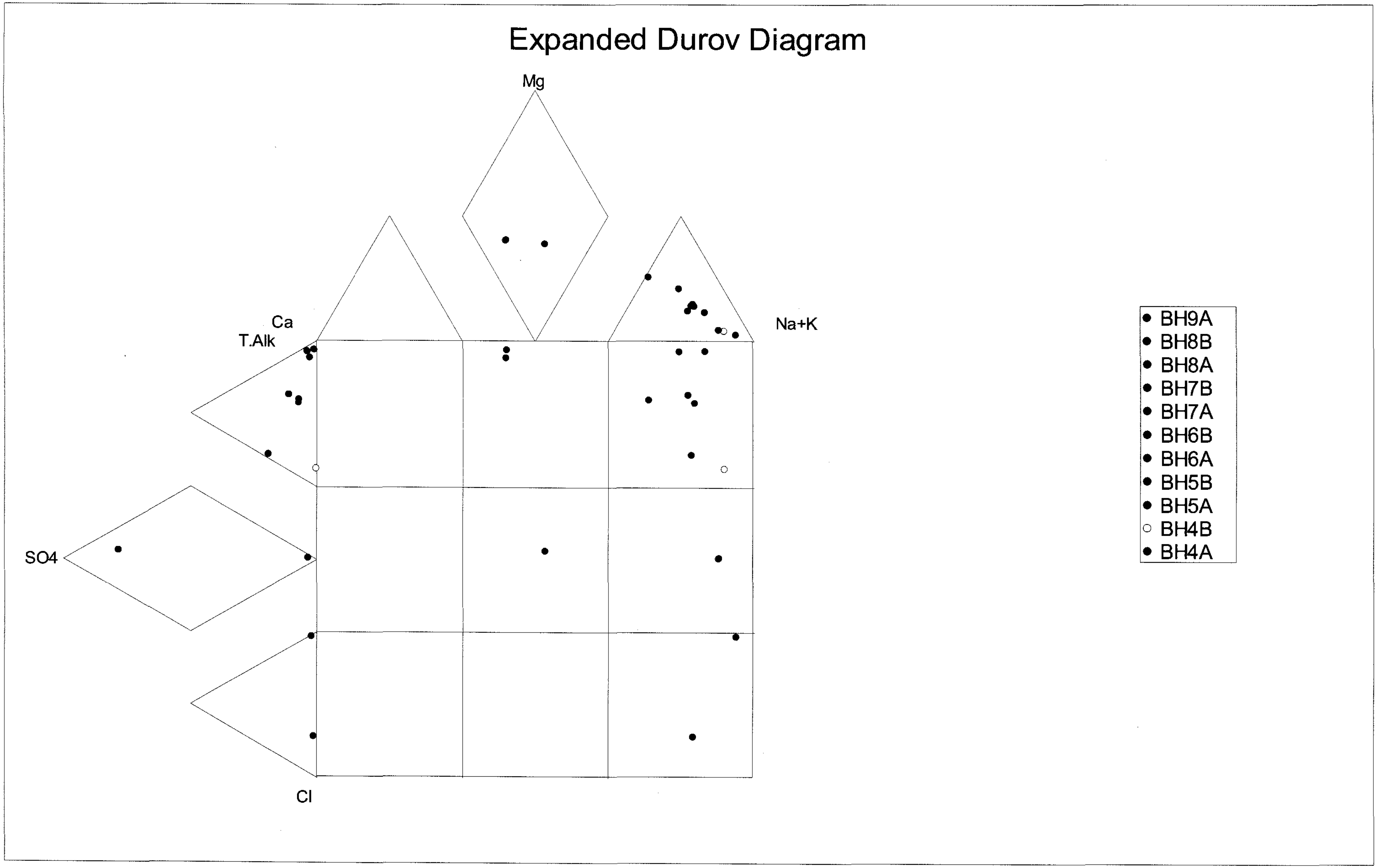
APPENDIX B

Ground Water Quality – Chemistry

APPENDIX B - Table 1: Laboratory results

Borehole ID	pH	EC	Ca	Mg	Na	K	Malk	F	Cl	$NO_2(N)$	Br	$NO_3(N)$	PO_4	SO_4	Al	Fe	Mn
Unit		mS/m*	mg/L**	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
BH4A (17M)	7.41	25.8	7.551	6.250	33.419	5.454	129	0.28	1.70	-0.01	-0.04	0.11	-0.10	4.77	0.010	0.020	0.018
BH4A (35M)	8.01	30.9	6.412	3.986	49.770	3.771	151	0.37	1.93	-0.01	-0.04	0.07	-0.10	5.65	0.020	0.017	0.010
BH4B (4M)	5.43	2.68	0.266	0.076	2.455	1.463	5.04	0.01	2.17	0.01	-0.04	0.25	-0.10	0.01	0.031	0.019	0.002
BH5A (30m)	6.69	2.5	0.920	0.542	2.887	4.108	8.3	0.00	2.06	-0.01	-0.04	0.53	-0.10	2.96	0.009	0.015	0.016
BH5B (9m)	5.7	16.9	12.772	7.858	4.872	4.420	86.4	0.03	1.43	-0.01	-0.04	0.14	-0.10	0.71	0.003	0.015	0.064
BH6A (12m)	6.01	3.81	1.670	1.105	2.867	2.330	15.3	0.02	1.52	-0.01	-0.04	0.35	-0.10	1.34	0.024	0.027	0.013
BH6A (22m)	6.58	13.8	10.385	6.308	3.827	3.689	66	0.09	1.49	-0.01	-0.04	0.34	-0.10	1.84	0.011	0.029	0.090
BH6B (6M)	5.28	1.35	0.305	0.079	2.328	1.262	3.87	0.01	1.51	-0.01	-0.04	0.47	-0.10	0.25	0.051	0.034	0.003
BH7A (13m)	7.06	3.96	0.903	0.562	4.261	2.387	14	0.01	1.88	-0.01	-0.04	0.20	-0.10	1.26	0.005	0.017	0.006
BH7B (6M)	5.67	1.64	0.158	0.046	2.470	1.664	4.08	0.00	2.48	-0.01	-0.04	0.25	-0.10	0.17	0.006	0.015	0.002
BH8A (8m)	5.62	18.6	8.604	7.430	8.852	6.177	12	0.02	2.95	-0.01	-0.04	0.83	-0.10	65.80	0.009	0.023	0.029
BH8B (6M)	5.28	2.77	0.900	0.592	3.960	2.689	2.52	0.01	2.45	-0.01	-0.04	3.57	-0.10	0.20	0.059	0.067	0.013
BH9A (20m)	6.33	9.52	4.653	2.011	20.804	3.952	50.4	0.27	5.75	-0.01	-0.04	0.19	-0.10	6.98	0.412	0.208	0.007

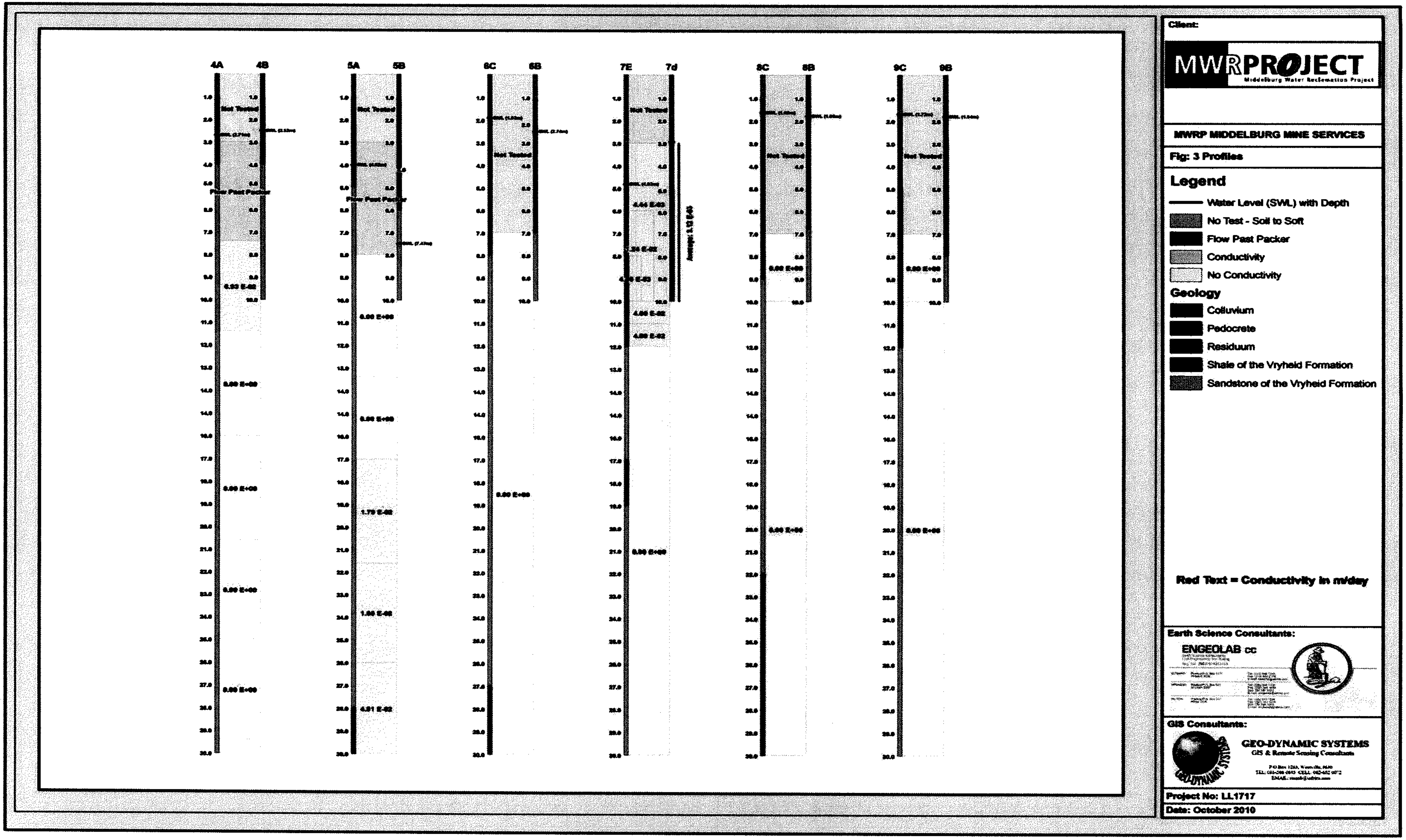
**: mg/L = milligrams per litre



APPENDIX B - Figure 1: Expanded Durov diagram of ground water samples

APPENDIX C

Packer Test Data – Hydraulic Conductivity



APPENDIX C - Figure 1: Packer testing results (as provided by BHP Billiton)