Parsons & Associates
specialist groundwater consultants cc
CK 96/27895/23

Report
180/INF-D2

Geohydrological Assessment of the Planned Development at Erf 134, Infanta

report prepared for

Jarjin Investments cc

Ref: 180/INF ***May 2006***

tel (021) 855-2480 ***PO Box 2606 Somerset West 7129*** ***fax (021) 855-2363***

EXECUTIVE SUMMARY

It is planned to develop about 80 units on a portion of Erf 134 Infanta. The north-eastern portion of the property will consist of 27 units along the coastline, while 53 units will be constructed further inland (immediately west of the present gravel road).

It is estimated some 12 400 m^3/a of groundwater will be required to meet the planned development's water demand. An estimated 30 % of the 80 units will be permanently occupied, while the remaining units will be occupied during weekends and over holiday periods. It is assumed each unit, when occupied, will require 1 m^3/d of groundwater for domestic and garden irrigation use. When fully occupied, a borehole or boreholes yielding almost 0.9 L/s over a 24 hour period will be required to meet peak daily demand (80 m^3/d).

A hydrocensus of groundwater users in the vicinity of Erf 134 Infanta was conducted on 16 November 2005, which resulted in identification of 9 boreholes. A total of 10 properties were visited, with 5 properties unoccupied during the hydrocensus. As a result, it is not known whether groundwater is used at these properties. Data from 37 boreholes identified by Toens & Partners (1999) were also obtained (boreholes CI3 to CI151, as well as borehole 'Plein'). Two boreholes existed at the proposed development (134A and 134B), while a third (134C) was drilled and tested in March and April 2006.

Boreholes 134A and 134C were tested during the course of this investigation. Interpretation of the pumping test data suggests borehole 134A can be pumped for 12 hours per day at a yield of 0.7 L/s. Borehole 134C can be pumped for 18 hours a day at a yield of 1.0 L/s. The maximum combined yield of the two boreholes is thus 95 m^3/d, which is sufficient to meet the expected peak daily demand. Proper implementation and appropriate ongoing monitoring is required to verify these yields.

Ambient groundwater quality in the vicinity of Erf 134 Infanta varies between 130 and 410 mS/m. Groundwater generally becomes poorer in a northward direction. Groundwater from the two boreholes to be used to supply water to the proposed development is less than 200 mS/m and is fit for domestic use.

The volume that can be abstracted under General Authorisation is 12 900 m^3/a. This is more than the estimated water demand of 12 400 m^3/a for the development. Consequently, the planned water use is within that generally authorised and the developer does not need to apply for a groundwater use licence.

It is planned the Lilliput sewage treatment system will be installed to manage domestic sewage generated by the development. Interpretation of available data shows the Lilliput system to be effective in terms of improving the general quality of sewage to an acceptable level. Although COD and NH_4-N concentrations of the effluent are generally above the accepted standard, the effluent should not pose a threat to the underlying groundwater resources in those areas.

CONTENTS PAGE

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION

1.1 Planned Development

Erf 134 Infanta is located between Infanta Village and Infanta Park, some 50 km south-east of Swellendam (Figure 1). The property is situated in the Overberg District. Erf 134 is about 1 km south of the Breede River mouth, and is 85.65 ha in extent. Mr Mark de Agrella of Jarjin Investments[cc] owns the property.

It is planned to develop about 80 units on a portion of the property (14.6 ha), consisting of single and double storey buildings. The north-eastern portion of Erf 134 will consist of 27 units along the coastline, while 53 units will be constructed further inland (west of the present gravel road).

It is also planned the Lilliput sewage treatment system will be installed to manage domestic sewage generated by the development. To this end, Parsons and Associates Specialist Groundwater Consultants[cc] was appointed by Mr de Agrella to assess the geohydrological potential of the property and evaluate the contamination threat posed by use of the Lilliput system.

1.2 Water Demand

Based on discussions with Mr Hendrik van der Hoven, the project landscape architect and environmental planner, Parsons and Associates estimated some 12 400 m^3/a of groundwater will be required to meet the planned development's water demand. An estimated 30 % of the 80 units will be permanently occupied, while the remaining units will be occupied during weekends and over holiday periods.

It is assumed each unit, when occupied, will require 1 m^3/d of groundwater for domestic and garden irrigation use. When fully occupied, a borehole or boreholes yielding 0.9 L/s will be required to meet the peak daily demand.

2 TERMS OF REFERENCE

A proposal to assess the geohydrological potential of the property and evaluate the contamination threat posed by use of the Lilliput sewage treatment system was submitted by Parsons and Associates to Mr van der Hoven on 18 August 2005. Mr de Agrella accepted the proposal in an email dated 26 September 2005. The following tasks were to be carried out:

- Collect as much existing geohydrological information about the area as possible (existing reports, NGDB data, etc.),
- Evaluate the performance of the Lilliput system (data, promotional material, installations, authority endorsements, etc.),
- Undertake a site visit to assess geohydrological conditions, and
- Prepare a groundwater investigation report.

During the course of the investigation, it became apparent borehole 134A would not yield sufficient water to meet expect demand. A second borehole was sited (Martin de Klerk), drilled (Amanzi Drilling) and tested (Pumpcor), the information from which was provided to Parsons & Associates.

This geohydrological report documents the results of work carried out by Parsons and Associates in the vicinity of Erf 134 Infanta. It describes geohydrological conditions and potential, groundwater quality and contamination threatsand groundwater use licensing requirements. This report is to be submitted to the relevant authorities in support of the application to develop the property as planned.

3 WORK UNDERTAKEN

3.1 Previous Geohydrological Work

Toens & Partners[cc] was appointed by the Overberg District Council to carry out an initial groundwater investigation at Cape Infanta during 1999. The objectives of that investigation were to assess the contamination status of groundwater as a result of sewage disposal methods applied at Infanta Village, determine abstraction patterns of the groundwater resources and possible saline intrusion, and determine groundwater quality in the area.

Toens & Partners (1999) concluded low levels of abstraction prevented or minimised the possibility of saline intrusion. Groundwater quality was determined to be fit for human consumption, and no groundwater contamination due to sewage disposal systems in the Village was evident. Unacceptable levels of bacterial concentrations (faecal; total) were measured in groundwater samples where Table Mountain Group rocks outcrop.

3.2 Hydrocensus

Mr Lloyd Flanagan of Parsons and Associates conducted a hydrocensus of groundwater users in the vicinity of Erf 134 Infanta on 16 November 2005. Undertaking a hydrocensus in the area was an effective and cost-efficient means of collecting geohydrological information about the area. The hydrocensus entailed collecting groundwater-related information such as borehole positions and groundwater levels. Wherever possible, groundwater samples were collected to assess the quality of the groundwater.

The November 2005 hydrocensus resulted in identification of 9 boreholes (Table 1 and Figure 2). A total of 10 properties were visited, with 5 properties unoccupied during the hydrocensus. As a result, it is not known whether groundwater is used at these properties.

Table 1. Summary of information obtained during the November 2005 hydrocensus

Borehole no.	Property name	Latitude (WGS84)	Longitude (WGS84)	Groundwater level (mbgl)	EC level (mS/m)	Use
BH01	Unknown	-34.40755	20.82572	60.00		Domestic
BH02	Grasrug Winkel	-34.41983	20.81331	7.96		Stock watering
BH03	Grasrug Winkel	-34.41957	20.81245			Stock watering
BH04	Grasrug Winkel	-34.41971	20.81146	10.76	250	Domestic
BH05	Infanta Park	-34.42007	20.84872	9.21	196	Domestic
BH06	Infanta Park	-34.42009	20.84882			Domestic
BH07	Unknown	-34.41586	20.82241	20.22	333	Stock watering
134A	Erf 134	-34.42110	20.84920		199	Domestic
134B	Erf 134	-34.42130	20.84890			Not used - capped
	San Sebastian Reserve					
	Breësig					
	Bailey					
	Sedgwick					
	Property directly west of Infanta park					

A search of the National Groundwater Data Base by Ms Rooseda Peters of the Department of Water Affairs and Forestry (DWAF) in Bellville yielded data for 3 boreholes in the vicinity of Erf 134 Infanta (3420BD00015 to 3420BD00017). Data from 37 boreholes identified by Toens & Partners (1999) were also obtained (boreholes CI3 to CI151, as well as borehole 'Plein') (Appendix A).

Two boreholes existed at the proposed development, namely boreholes 134A and 134B. Borehole 134A is currently used for domestic purposes during holiday periods, while 134B is capped and unused. It was reported that this borehole is blocked at a depth of 8 m, and is hence no longer usable. All collected data were added to a database developed during the project, and used to compile this report.

3.3 Groundwater Development

During the course of the investigation it became apparent that the existing borehole would not be sufficient to meet the expected water demand of the planned development. Martin de Klerk was appointed by the developer to undertake a geophysical traverse using the Lund resistivity imaging system. Based on the outcome of the survey, borehole 134C was drilled some 420 m west of boreholes 134A and 134B. The borehole was drilled by Amanzi Drilling to a depth of 80 m and had a blow yield of 3.5 L/s. Pumpcor undertook a step drawdown and a 45 hr constant discharge and recovery test. On completion of pumping a sample was taken and submitted to Bemlab for analysis. The client provided information from this exploration to Parsons and Associates.

4 BACKGROUND INFORMATION

Erf 134 Infanta is located in the Breede Water Management Area and in quaternary catchment H70K. The divide between G50K and H70K is located directly south of the property.

4.1 Climate

The area experienced a mild climate and mean annual precipitation (MAP) of 470 mm/a. Rainfall occurs throughout the year, but with wetter months between May and September. Due to orographic effects, the MAP on the higher lying parts south of Erf 134 Infanta may reach 700 mm/a. Mean annual evaporation (MAE) is in the order of 1 300 mm/a.

4.2 Topography

The topography of Erf 134 Infanta is relatively flat with a gentle eastward slope towards the ocean. The approximate topographical gradient across the property from west to east is 0.02, with a maximum elevation of 62 mamsl along the western boundary. The property extends to the coastline and hence has an elevation of 0 mamsl along the eastern boundary.

Erf 134 Infanta is situated on the northern slopes of the Potberg Mountain range. These mountains attain a maximum elevation of 242 mamsl at Kadiekop, located some 1.6 km south-west of the property.

4.3 Geology

The existing published geological map (Hill and Viljoen, 1990) was interpreted to determine the geology underlying Erf 134 Infanta. The geology at surface is made up of light grey to pale red sandy Quaternary soil (Figure 4). The thickness of these sediments is not known.

The bedrock underlying the southern portions of the property comprises light-grey feldspathic sandstone and thin siltstone and shale beds of the Rietvlei Formation, as well as massive light-grey quartzitic sandstone of the Skurweberg Formation (Figure 5). Both these formations form part of the Nardouw Supgroup, which in turn is part of the Table Mountain Group (TMG). Rocks of this Subgroup generally weather to a brownish colour. The Rietvlei Formation is recognised by finer grain size, a higher feldspar content and more dense vegetation cover that is visible on aerial photographs as darker tones of grey (de Beer, 2002). Sedimentary rocks of the TMG form part of the Cape Supergroup sequence of rocks. Sediments of the Cape Supergroup were deposited from early Ordovician to early Carboniferous times, approximately between 500 and 340 Ma ago (de Beer, 2002b). Maximum thickness of the Cape Supergroup amounts to 5 300 m (SACS, 1980). These sediments were deposited in shallow marine environments under tidal, wave and storm influences, as well as in non-marine, braided-fluvial environments (de Beer, 2002b). The TMG sediments were deposited in a shallow, but extensive, intra-cratonic basin on a fairly stable continental shelf (Visser, 1989).

High yielding boreholes in the TMG aquifers are generally associated with post-depositional structural features such as faults and fractures. These features should hence be targeted as locations for boreholes, particularly in those areas where faults intersect each other. Aquifers of the TMG – and particularly those associated with significant faulting, folding and fracturing – are obvious targets for groundwater development and have proved reliable sources of water. Due to its overall thickness and massive thick-bedded zones, the Skurweberg Formation can support large-scale groundwater abstraction (Hartnady and Hay, 2002).

The Wankoe Formation forms part of the Bredasdorp Group. This formation consists of calcarenite (a clastic limestone) and calcrete lenses. As these rocks occur north of Erf 134 Infanta, they are not discussed further in this report.

5 GEOHYDROLOGICAL DESCRIPTION

5.1 Aquifer Type

The area surrounding Erf 134 Infanta consists of the fractured secondary TMG aquifer. These aquifers are classified as major aquifers (Parsons, 1995). Parsons and Conrad (1998) classified major aquifers as highly permeable formations with known or probable presence of significant fracturing. Such aquifers may be highly productive and able to support large groundwater abstraction.

5.2 Groundwater Levels and Direction of Groundwater Flow

Measurement of groundwater levels in the vicinity of Erf 134 Infanta indicated groundwater levels are in the order of 2 to 11 m below ground level. As expected, groundwater levels are shallower along the coastline (Figure 6). Groundwater levels measured at BH01 and BH07 were pumping water levels, and the data only provides an indication that groundwater levels can be measured at these boreholes. No information is available regarding the seasonal variation of groundwater levels in the area.

Using data collected during the hydrocensus and that measured on the property, a groundwater level contour map was compiled (Figure 7). From this, it was interpreted groundwater flows in a north-easterly direction across the property. The average hydraulic gradient across the property is 0.05.

5.3 Groundwater Quality

Ambient groundwater quality in the vicinity of Erf 134 Infanta varies between 130 and 410 mS/m (Figure 8). Groundwater generally becomes poorer in a northward direction. Sampled boreholes have all been drilled in the Rietvlei Formation, which consist of occasional siltstone and shale beds. Meyer (1999) reported that less potable groundwater is procured from boreholes drilled into these interbedded shale layers.

Groundwater quality in the Skurweberg Formation is expected to be less than 100 mS/m, as this formation is composed of inert quartzitic rocks resistant to weathering. As a result, boreholes drilled into this formation should yield fresher groundwater than that from the Rietvlei formation. No boreholes drilled into the Skurweberg Formation were identified during the hydrocensus. The quality of the groundwater from this formation could therefore not be determined.

Groundwater sampled by Toens & Partners during September 1999 and by Pumpcor during the testing of borehole 134A (June 2005) and 134C (April 2006), were analysed for major cations and anions. All groundwater tends towards a Na-Cl character (Figure 9). In the Infanta area, EC is in the order of 170 to 220 mS/m. Groundwater sampled from the two boreholes on Erf 134 is fit for direct human consumption (Appendix B).

5.4 Groundwater Contamination

Toens & Partners (1999) reported groundwater at Infanta Village was fit for human consumption and negligible / no contamination of groundwater had occurred due to existing sewage disposal infrastructure. This conclusion is based on very low concentrations of potassium (K) and total nitrogen (N) measured in groundwater samples (Appendix B). These parameters are good indicators of anthropogenic contamination. This was due to low and seasonal sewage volumes generated on the Village properties, as well as presence of very low permeability shale, which prevents infiltration of contaminants into the underlying groundwater resources.

Toens & Partners (1999) however indicated that unacceptable levels of bacteria found in some groundwater samples were limited to areas where TMG rocks outcrop. It was concluded risk of contamination due to anthropogenic activities increased where TMG rocks occurred, predominantly as quartzites have higher permeability than shale allowing easy and quicker migration of contaminants.

Due to the proximity of the Village to the ocean, the threat of saline intrusion exists. However, due to limited groundwater abstraction in the area, there is currently no indication of contamination due to saline intrusion (Toens & Partners, 1999).

5.5 Groundwater Use

Infanta Village is predominantly a holiday destination, and about five people permanently reside in the Village (Toens & Partners, 1999). All homes are supplied with water from rainwater collected from the rooftops and stored in tanks, as well as from boreholes. There are 37 boreholes drilled on the approximate 110 ervens in Infanta Village. Toens & Partners (1999) estimated some 3 300 m^3/a of groundwater is abstracted at the Village.

No groundwater abstraction data is available for the areas west of Infanta Village. No information could be obtained during the hydrocensus, as homeowners were generally not present. However, as groundwater is used for stock watering and some domestic use, it is expected some 12 000 m^3/a of groundwater is abstracted west of Infanta Village, with about 7 000 m^3/a of groundwater abstracted at Infanta Park.

There are no known groundwater users south of Erf 134 Infanta, and except for Infanta Park, there are also no users directly north of the property. An estimated 15 300 m^3/a of groundwater is abstracted within a radius of 2 km around the property.

5.6 Borehole Yields

Previous work by Toens & Partners (1999) indicated borehole yields at Infanta Village ranged from 0.6 L/s to over 12 L/s. Boreholes drilled in the Skurweberg Formation in the Ceres region yielded between 3 and 20 L/s, with the main high yielding fractures encountered at depths between 80 and 150 m below ground level (Rosewarne, 2002). Low yielding fracture zones were encountered between 20 and 60 m.

Pumpcor tested borehole 134A during May 2005. The pumping test was conducted at a rate of 1 L/s for 48 hours, with a final drawdown of 2.74 m (Figure 10). Recovery of groundwater levels was measured subsequent to cessation of pumping. Groundwater levels recovered to 0.50 m after 24 hours, a recovery of 82 %. Based on the pumping test data, Pumpcor recommended a pumping regime of 20 hours per day, with 4 hour recovery. This pumping regime would result in 72 m^3/d of groundwater being abstracted from borehole 134A.

Pumpcor provided the pumping test data to Parsons and Associates on 22 November 2005 (Figure 10). Reanalysis of the data by Parsons and Associates showed that borehole 134A is not capable of being pumped at a rate of 1 L/s over the long term. The shape of the graphs of both the step drawdown and constant discharge tests are indicative of a failing borehole. Because of this, it is expected the borehole will require more time to recovery than recommended by Pumpcor. It was interpreted that borehole 134A could yield 0.7 L/s and should be pumped for no more than 12 hrs each day.

Borehole 134C was also tested by Pumpcor during April 2006. Pumping the borehole at 0.8 L/s induced a drawdown of 23.91 m. A drawdown of 0.06 m was observed in borehole 134A some 420 m to the west. Analysis of the constant discharge test data (Figure 11) indicated typical fractured aquifer conditions where the upper fractures were being dewatered. However, on cessation of pumping, the groundwater level rapidly recovers and was within 3.5 % of the static water level after 24 hrs. It is interpreted that borehole 134C can be pumped at a rate of 1 L/s for 18 hours each day.

It is of interest to note G North and Sons previously undertook 72 hour pumping tests on boreholes 134A and 134B (August 1976). They reported a pump depth of 55.5 m in borehole 134A and 44.5 m in borehole 134B. G North and Sons reported the sustainable borehole yield to be 18 KL/hr (5 L/s) at each borehole. This assessment is not supported by the results of the tests undertaken by Pumpcor.

From the pumping test data it is interpreted the two boreholes can sustainably yield 95 m^3/d. This is sufficient to meet the peak daily demand of the planned development. Appropriate groundwater monitoring is to be implemented so the validity of this interpretation can be confirmed based on the long-term response of the aquifer to abstraction.

5.7 Recharge

No site-specific information is available concerning recharge in the area. Based on work by Fortuin *et al*. (2004), recharge in the vicinity of Erf 134 Infanta amounts to some 5.3 % of MAP. This is considered reasonable, as recharge from the GRA Phase II project for quaternary catchment H70K was set at 6.8 % of MAP.

5.8 Harvest Potential

Fortuin *et al*. (2004) identified the area in the vicinity of Erf 134 Infanta as having a moderate groundwater development potential. DWAF estimated the harvest potential of the study area to be 56 600 $m^3/km^2/a$ (Baron *et al*., 1998). The harvest potential is a measure of the maximum volume of groundwater that can be abstracted per square kilometre per annum, without depleting the aquifer (Baron *et al*., 1998). Using the national dataset, harvest potential was determined on the basis of groundwater recharge and groundwater storage. As Erf 134 Infanta cover an area of 0.86 km^2, approximately 48 700 m^3/a of groundwater could therefore be abstracted.

6 THE LILLIPUT SEWAGE TREATMENT SYSTEM

6.1 Preamble

It is planned a Lilliput sewage treatment system will be installed at Erf 134 Infanta (model SBC72000). According to the manufacturer, Lilliput Treatment Technologies International (previously Africa Water and Waste), 72 m^3/d of domestic sewage can be treated using the SBC72000 system. It is estimated about 60 m^3/d of sewage will be generated at the property (Ross *pers. comm.*, 2005). It is expected all treated effluent will be used for garden irrigation, while sludge will be harvested in a drying bed for composting and garden use.

6.2 Operation

Sewage is collected under gravity and undergoes pre-treatment in an anaerobic, pre-digestion environment, i.e. in a septic tank (Figure 3). Once the sewage enters the digester, biological activity takes place, and microbes convert complex organic compounds to simple (but toxic) soluble organic compounds. The digester provides a hydraulic residence period of 12 hrs to 2 days, allowing the degradation of organic solids to be achieved.

Effluent is then transferred to the base of the aerobic upflow Lilliput bio-reactor. The bio-reactor is designed for specific hydraulic residence and COD loading. It contains a porous membrane air diffuser for oxygen supply. Air is introduced and aerobic bacteria oxidise harmful, malodourous chemicals, converting it to clean smelling liquid. Any excess effluent is returned to the septic tank to ensure complete treatment. Carbonaceous degradation and nitrification are achieved through the controlled input of dissolved oxygen.

The Lilliput bio-reactor is made up of 'random-packed' media and serves as the main anchor for bacterial population. The beds of random-packed media create a three-dimensional environment that facilitates contact between the biomass and carbonaceous material. The high surface area to volume ratio of the bio-reactor media promotes a higher biomass per unit volume than most other processes (including activated sludge systems) (Africa Water and Waste, 2005). This is critical as the rate at which COD and ammonia are removed is a function of the active biomass available for substrate conversion.

Once the effluent has passed through the bio-reactor, it is sent for final cleaning and disinfection in the chlorine contact tank (Figure 3). Disinfection destroys harmful bacteria. Fine particles of humus can also be removed in a Clarifier before final disinfection in the chlorine tank. If effluent that is discharged is used for anything other than to irrigate, the clarifier must be used to extract the excess solids, and return them to the septic tank.

6.3 Previous Impact Assessments

During October 2003, it was decided by Africa Water and Waste and DWAF among others, that the possible impacts of effluent generated from Lilliput systems on water resources be assessed (Joubert, 2003). This decision had transpired due to consistently high ammonia concentrations in effluent from the systems. Five Lilliput installations were assessed.

NH_4-N and COD concentrations in the final effluent samples collected were consistently elevated (above 5 mg/L and 50 mg/L, respectively), but the general quality of the water was good with no *E.coli* present (Joubert, 2003). The chemical analysis results of this investigation are presented in Table 2. The results of that study showed that all five installations did not appear to have significant effect on water resources, human health or the environment. However, it must be noted between 12 and 24 m^3/d of effluent were discharged from the investigated systems, making it less likely that any detrimental impacts would occur should there be periodic fluctuations in NH_4-N and COD concentrations.

Table 2. Comparison of the quality of untreated sewage and treated effluent (Joubert, 2003)

Parameter		Nitrochem		Kearsney College		Kloof Rest Home		General standard
		Raw sewage **	Final effluent	Raw sewage	Final Effluent	Raw sewage	Final effluent	
E.Coli	/100ml		0				0	0
pH		7.3	7.3	7.5	7.3	6.8	7.6	5.5 - 9.5
EC	mS/m	131	101	139	150	224	89	-
Suspended solids	mg/L	96	27	956	16		32	-
COD	mg/L	196	80	1 180	76	13 939	80	75 max
NH_4-N	mg/L	6.1	6.1	42.5	5.6	504.4	5.1	10 max
PO_4	mg/L	11.2	10.9	10.5	12.1		6.1	-
NO_x-N	mg/L	< 0.3	28.6	2.7	< 0.3	< 0.3	< 0.3	-
T.Alk	mg/L	302	54	188	402	358	202	-
Parameter		**Dalmat**		**Chartwell**				**General standard**
		Raw sewage	**Final effluent**	**Raw sewage ****	**Final effluent**			
E.Coli	/100ml		0		0			0
pH		7.1	7.4	7.0	6.8			5.5 - 9.5
EC	mS/m	180	140	121	96			-
Suspended solids	mg/L	2 800	26	62	< 10			-
COD	mg/L	488	116	187	52			75 max
NH_4-N	mg/L	532.1	7.2	77	40.7			10 max
PO_4	mg/L	10.5	9.3	11	11			-
NO_x-N	mg/L	< 0.3	< 0.3	< 0.05	37			-
T.Alk	mg/L	378	304	328	62			-

** sample taken from septic tank

6.4 Assessment of the Lilliput System

Quality of untreated sewage and that of treated effluent after being discharged from the Lilliput system were compared using chemistry data from the Joubert (2003) investigation (Table 2) as well as that from a 72 m^3/d treatment system located in Oranjemund (Table 3).

Table 3. Comparison of the quality of untreated sewage and treated effluent (treatment system located in Oranjemund)

Parameter		Raw sewage	Final effluent	General standard
pH		7.30	7.17	5.5 - 9.5
EC	mS/m	134.0	111.0	-
Coliform	/100ml	-	0	0
COD	mg/L	102.0	40.3	75.0 (max)
NH_4-N	mg/L	36.60	1.40	10.00 (max)

Interpretation of available data shows the Lilliput system to be effective in terms of improving the general quality of sewage to an acceptable level. Although COD and NH_4-N concentrations of the effluent are generally above the accepted standard, the effluent should not pose a threat to the underlying groundwater resources in those areas.

In certain instances, NO_x-N and T.Alk concentrations are higher after raw sewage has been treated (Table 2). At Nitrochem, NO_x-N concentrations increased from < 0.3 mg/L to 28.6 mg/L, while at Chartwell, it increased from < 0.05 mg/L to 37 mg/L. At Kearsney College, T.Alk concentrations increased from 188 mg/L to 402 mg/L. It is not understood why these concentrations increased after the treatment process.

As holidaymakers will predominantly own the units of the planned development, it is expected low loads of sewage will be generated. It is also expected the Lilliput system will be infrequently used do to limited permanent occupation. Further, infiltration of untreated sewage into the subsurface should only result should incorrect and unprofessional installation and maintenance occur. Lilliput Treatment Technologies International provides operations contracts with clients to ensure responsible running of the plant. It is recommended this be considered for operation of the system at Erf 134 Infanta, to prevent any possibility of contamination.

During the hydrocensus, no groundwater users were identified north of Infanta Village and Infanta Park. As the planned units at Erf 134 Infanta will be situated between the Village and Infanta Park, it is recommended the Lilliput system be erected along the far north-eastern section of the development. Groundwater flows in a north-easterly direction, away from any existing groundwater users (see Figure 2 and Figure 7). Hence, positioning the treatment system in that area will eliminate any possibility of use of the system affecting surrounding groundwater users, should contamination occur.

6.5 Use of Soak-Away Systems

Both Infanta Village and Infanta Park currently rely on soak-away systems for sewage disposal. If correctly designed and installed, these systems are a highly effective means of wastewater treatment and disposal (Wright, 1999a). Contamination resulting from these systems is only related to poor location, poor design and lack of maintenance. Wright (1999a) concluded that such systems remain the most cost effective means of sewage disposal, and use of these systems should continue and be actively promoted. Several authors have promoted use of these systems and presented guidelines on proper siting, design and maintenance procedures, to prevent contamination of groundwater resources (EPA, 1987; Wright, 1994; 1995; 1999b).

For these reasons, use of soak-away systems may be considered as an alternative to the Lilliput system. Although use of the Lilliput system results in discharged effluent being reusable for irrigation and possibly for water features, conventional soak-away systems can also provide a reliable method of sewage disposal.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

It is planned to develop 80 units on a portion of Erf 134 Infanta. The north-eastern portion of the property will consist of 27 units along the coastline, while 53 units will be constructed further inland (immediately west of the present gravel road).

It is estimated some 12 400 m^3/a of groundwater will be required to meet the planned development's water demand. An estimated 30 % of the 80 units will be permanently occupied, while the remaining units will be occupied during weekends and over holiday periods. It is assumed each unit, when occupied, will require 1 m^3/d of groundwater for domestic and garden irrigation use. When fully occupied, a borehole yielding 0.9 L/s over a 24 hour period (77.8 m^3/d) will be required to meet the daily demand.

Based on the interpretation of pumping test data provided to Parsons & Associates, the two boreholes are capable of yielding 95 m^3/d over the long-term. This is sufficient to meet the peak daily water demand of the planned development. Borehole 134A should be pumped for no more than 12 hours a day; while borehole 134C can be pumped for 18 hours a day.

A hydrocensus of groundwater users in the vicinity of Erf 134 Infanta was conducted on 16 November 2005, which resulted in identification of 9 boreholes. A total of 10 properties were visited, with 5 properties unoccupied during the hydrocensus. As a result, it is not known whether groundwater is used at these properties. Data from 37 boreholes identified by Toens & Partners (1999) were also obtained (boreholes CI3 to CI151, as well as borehole 'Plein'). None of these boreholes are threatened by abstraction from the two boreholes on Erf 134.

Ambient groundwater quality in the vicinity of Erf 134 Infanta varies between 130 and 410 mS/m. Groundwater generally becomes poorer in a northward direction. Sampled boreholes have all been drilled in the Rietvlei Formation, which consist of occasional siltstone and shale beds. Groundwater quality in the Skurweberg Formation is expected to be less than 100 mS/m, as this formation is composed of inert quartzitic rocks resistant to weathering. The two boreholes on Erf 134 yield groundwater with an EC in the order of 175 – 200 mS/m and is fit for domestic use.

The volume of groundwater that can be abstracted under General Authorisation is 12 900 m^3/a. As the expected annual demand is less than this, the developer need not apply to the Department of Water Affairs and Forestry for a groundwater use license.

It is planned the Lilliput sewage treatment system will be installed to manage domestic sewage generated by the development. Interpretation of available data shows the Lilliput system to be effective in terms of improving the general quality of sewage to an acceptable level. Although COD and NH_4-N concentrations of the effluent are generally above the accepted standard, the effluent should not pose a threat to the underlying groundwater resources in those areas.

7.2 Recommendations

It is recommended that appropriate monitoring be implemented so that the interpreted borehole yields can be verified based on aquifer response to abstraction. Groundwater monitoring must form an integral part of the future management of the planned development. Monitoring should include:

- the rate at which groundwater is abstracted from the two boreholes
- weekly volume of groundwater abstracted
- weekly measurement of groundwater levels (static and pumping levels) in boreholes 134A and 134C
- monthly measurement of the quality (EC) of groundwater abstracted from the boreholes
- six monthly analysis of the monitored data and reporting thereon

REFERENCES

Africa Water and Waste (2005) Information brochure – Africa Water and Waste (Pty) Ltd Lilliput™ Sewage Treatment Plants.

De Beer, CH (2002) The Stratigraphy, Lithology and Structure of the Table Mountain Group. In: K Pietersen and RP Parsons (eds.), A Synthesis of the Hydrogeology of the Table Mountain Group – Formation of a Research Strategy. Prepared for the Water Research Commission, WRC Report No. TT 158/01, January 2002, pg 9-18.

Department of Water Affairs and Forestry (1998) Quality of Domestic Water Supplies, Volume 1 – Assessment Guide. Second edition. Water Research Commission No.: TT 101/98.

EPA (1987) Septic Tank Siting to Minimize the Contamination of Ground Water by Microorganisms. U.S. Environmental Protection Agency, Office of Ground-Water Protection, Office of Water, Washington, June 1987.

Fortuin, M; Woodford, AC; Rosewarne, PN and Low, AB (2004) Identification and Prioritisation of Type Areas for Detailed Research in Terms of the Regional Variability of the Groundwater and Ecological Characteristics of the Table Mountain Group Aquifer Systems. Report to the Water Research Commission by SRK Consulting Engineers and Scientists in association with Coastec, WRC Report No. 1332/1/04, February 2004.

Hartnady, CJH and Hay, ER (2002) Fracture System and Attribute Studies in Table Mountain Group Groundwater Target Generation. In: K Pietersen and RP Parsons (eds.), A Synthesis of the Hydrogeology of the Table Mountain Group – Formation of a Research Strategy. Prepared for the Water Research Commission, WRC Report No. TT 158/01, January 2002, pg 89-94.

Hill, RS and Viljoen, JHA (1990) 1:250 000 Geological Series 3420 Riversdale.

Joubert, CSW (2003) An Assessment of the Possible Impacts of Lilliput Package Plants on Water Resources, Human Health and the Environment. Enviro Check CC, 11 November 2003.

Lilliput™ (2005) http://www.lilliputa.co.za/wla9.htm

Meyer, PS (1999) An Explanation of the 1:500 000 General Hydrogeological Map – Oudtshoorn 3320, August 1999. Department of Water Affairs and Forestry.

Parsons, RP (1995) A South African Aquifer System Management Classification. Report KV 77/95, prepared for Water Research Commission and Department of Water Affairs and Forestry, by Groundwater Programme, Watertek, CSIR, Stellenbosch, December 1995.

Parsons, RP and Conrad, J (1998) Explanatory Notes for the Aquifer Classification Map of South Africa. Prepared for the Water Research Commission, WRC Report No. KV 116/98.

Rosewarne, P (2002) Case Study: Ceres Municipality. In: K Pietersen and RP Parsons (eds.), A Synthesis of the Hydrogeology of the Table Mountain Group – Formation of a Research Strategy. Prepared for the Water Research Commission, WRC Report No. TT 158/01, January 2002, pg 160-163.

Ross, M (2005) *personal communication*

SACS (South African Committee for Stratigraphy) (1980) Stratigraphy of South Africa, Handbook 8. Part 1: Lithostratigraphy of the Republic of South Africa, South West Africa/Namibia and the Republics of Bophuthatswana, Transkei and Venda, compiled by LE Kent.

Toens & Partners (1999) Overberg District Council - Cape Infanta: Groundwater Investigation. T&P Report No. 990219, report prepared by D Visser, November 1999.

Visser, DJL (1989) Explanation: 1:1 000 000 Geological Map – The Geology of the Republic of South Africa, Transkei, Bophuthatswana, Venda and Ciskei and the Kingdoms of Lesotho and Swaziland. Geological Survey, Pretoria.

Wright, A (1994) Septic Tank Systems – A Source of Groundwater Contamination. A Summary Note, April 1994.

Wright, A (1995) Guidelines for the Use of Septic Tank Systems in the South African Coastal Zone. Compiled for Water Research Commission, WRC Report No. 597/2/95.

Wright, A (1999a) Septic Tank Systems in the South African Coastal Zone. Report to the Water Research Commission by the Groundwater Programme, Division of Water, Environment and Forestry Technology, CSIR, Stellenbosch. WRC Report No. 597/1/99.

Wright, A (1999b) Guidelines for the Use of Septic Tank Systems in the South African Coastal Zone. Report to the Water Research Commission by Environmentek, CSIR. WRC Report No. TT 114/99, October 1999.

FIGURES

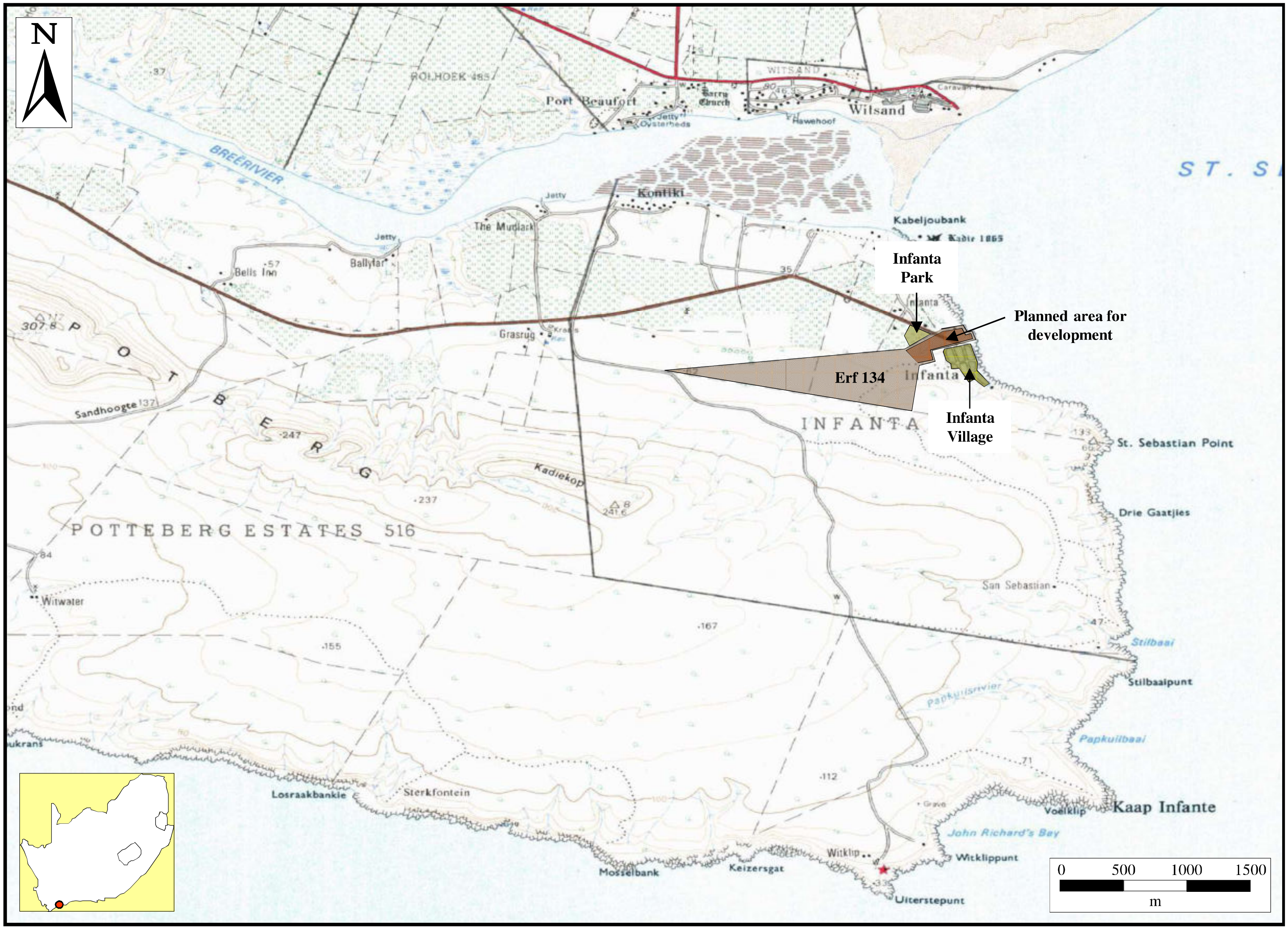

Figure 1. Locality map of Erf 134 Infanta

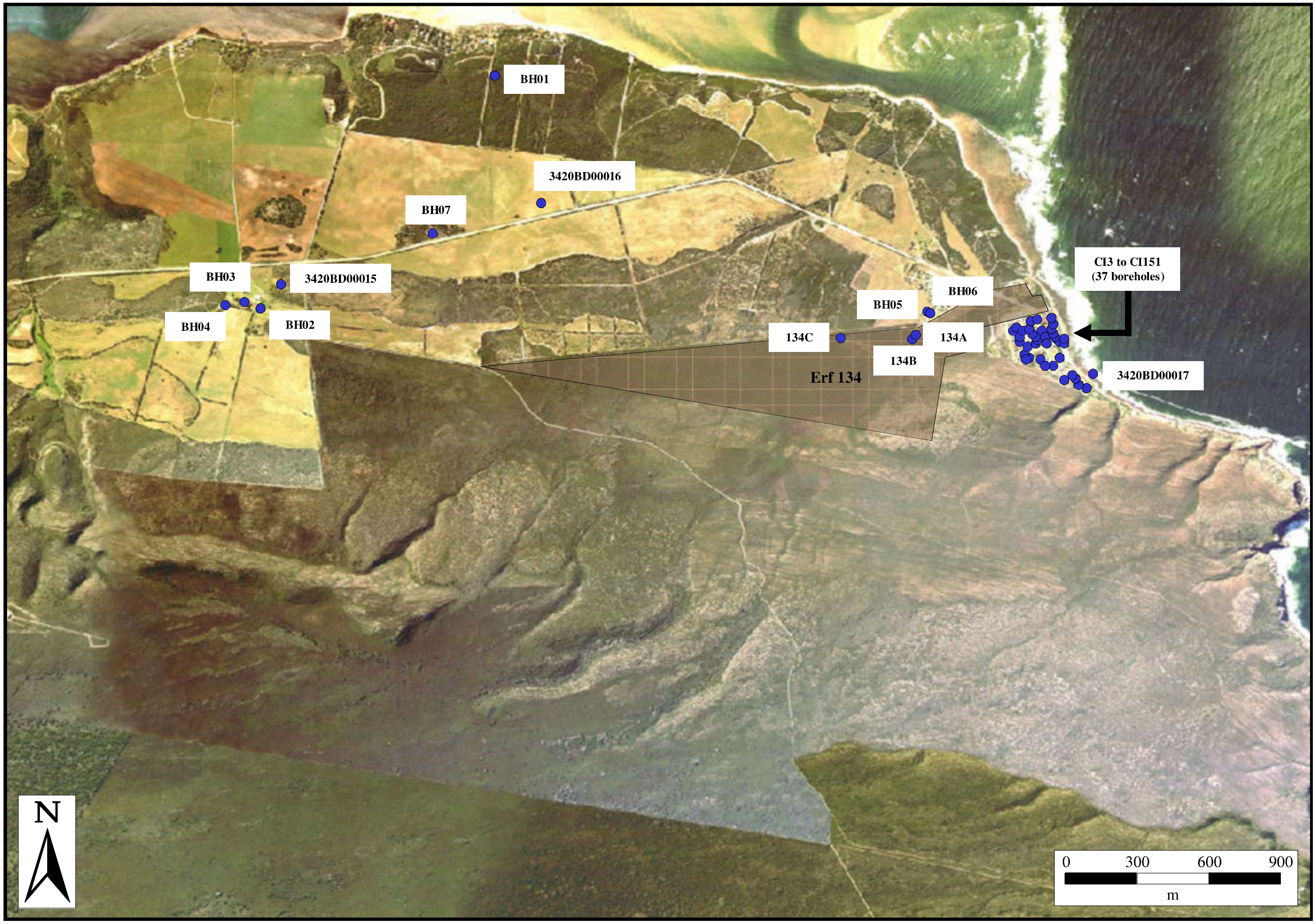

Figure 2. Boreholes identified in the vicinity of Erf 134 Infanta

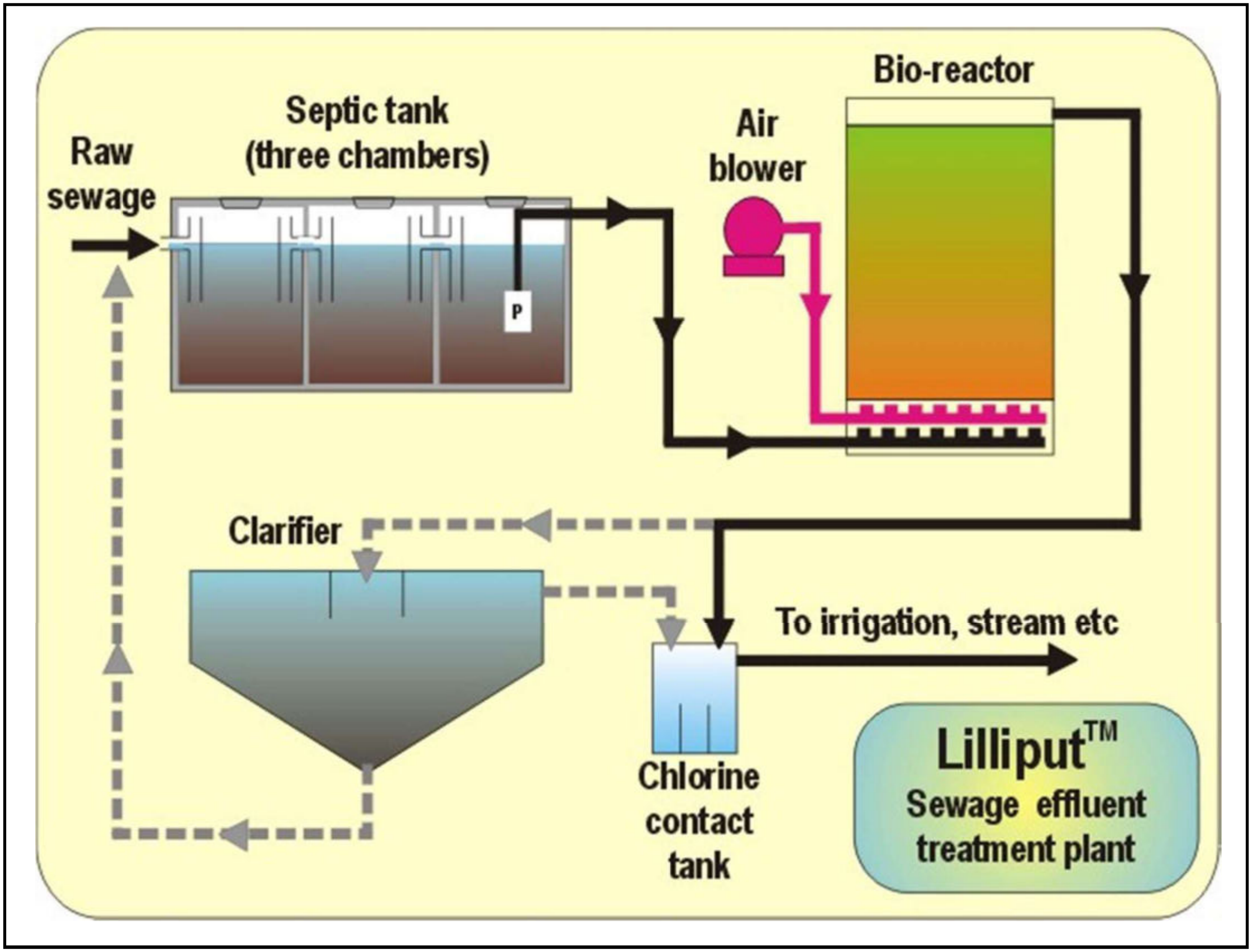

Figure 3. The Lilliput sewage-effluent treatment system process (source: Lilliput™, 2005)

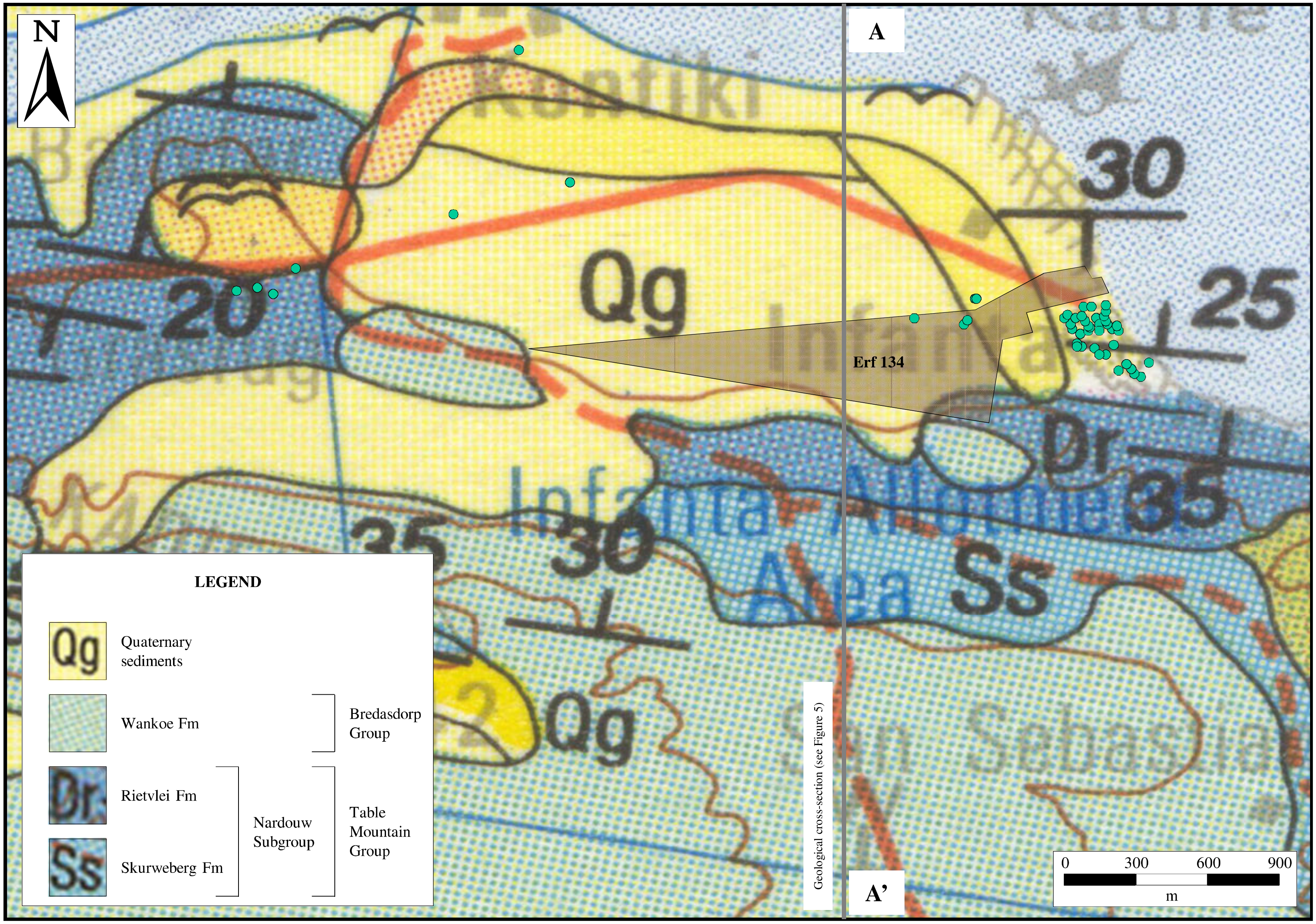

Figure 4. Published geological map of the area surrounding Erf 134 Infanta (Hill and Vijoen, 1990)

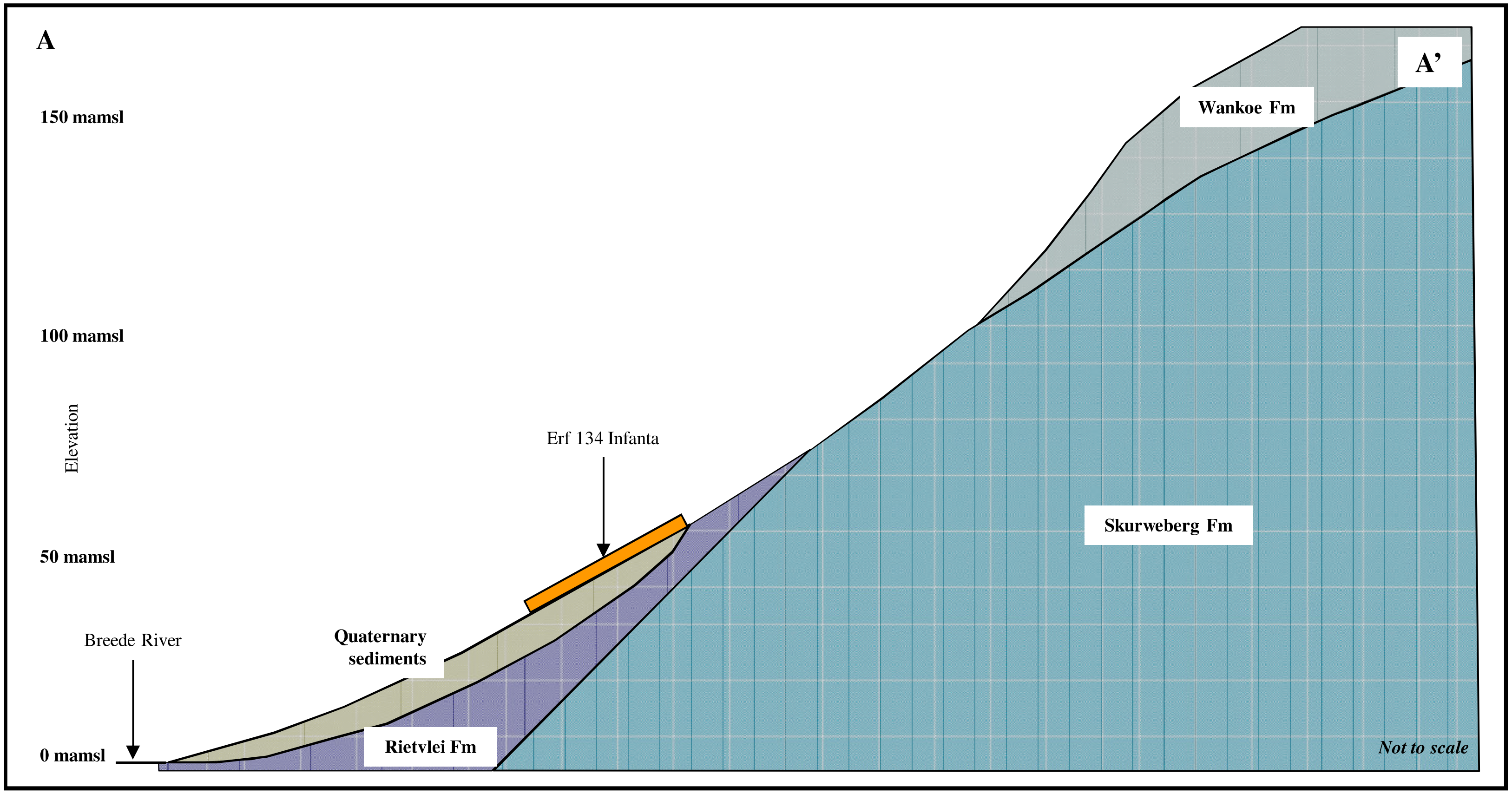

Figure 5. Schematic cross-section of the geology underlying Erf 134 Infanta and surrounding areas (see Figure 4 for section line)

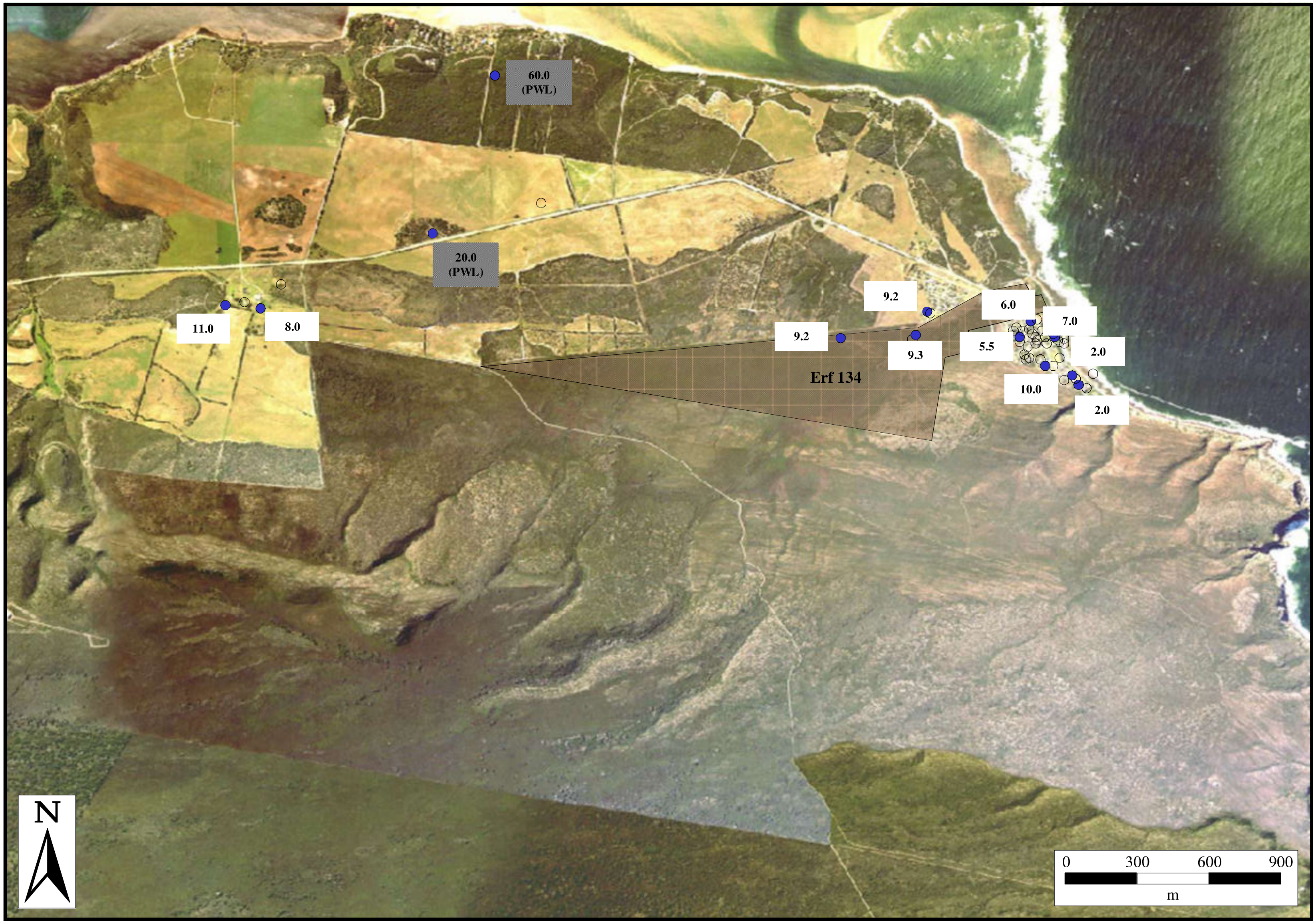

Figure 6. Depth to groundwater (mbgl) in the vicinity of Erf 134 Infanta (note: 'PWL' is pumped water level)

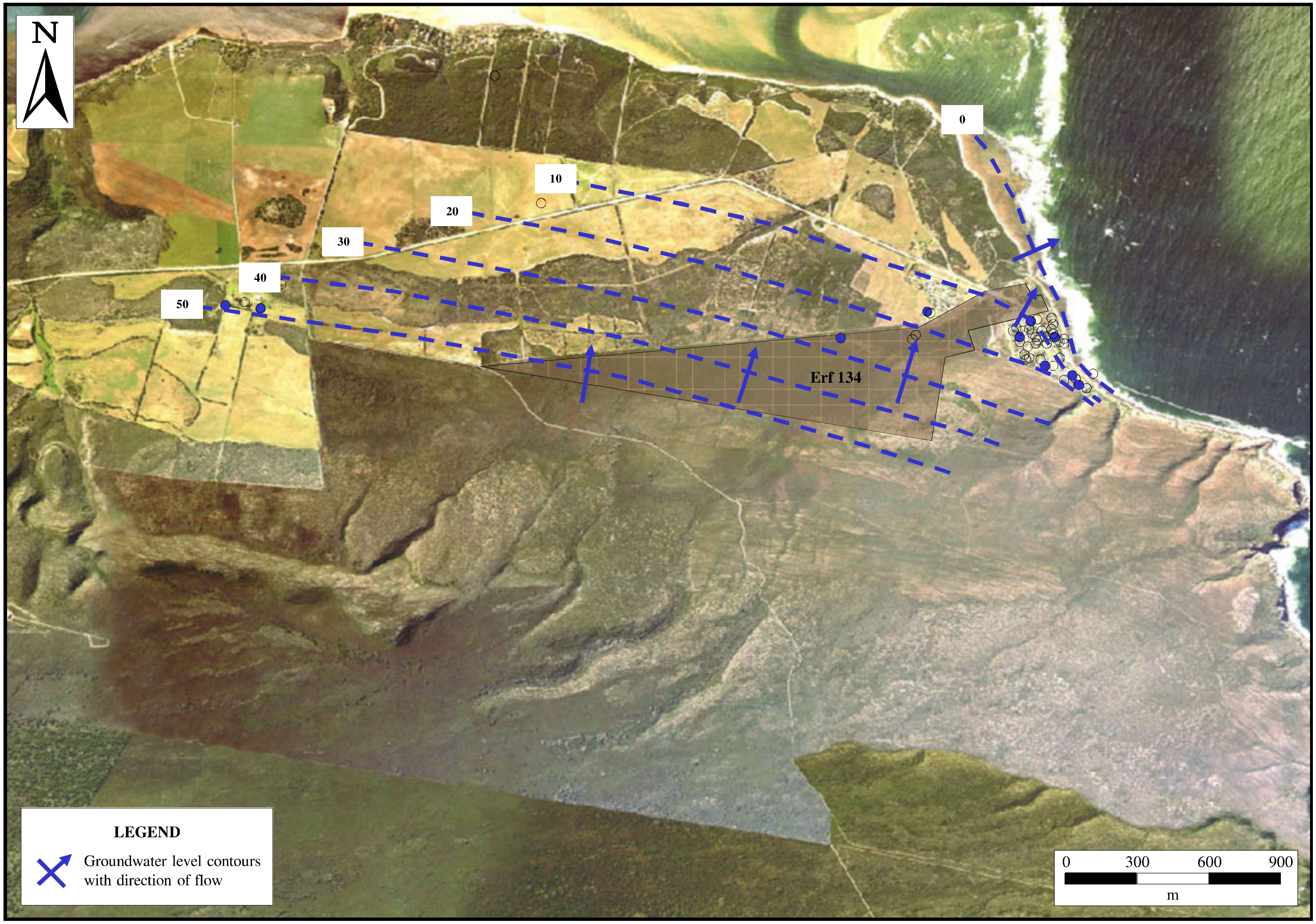

Figure 7. Groundwater elevation map (mamsl) showing interpreted direction of groundwater flow in the vicinity of Erf 134 Infanta

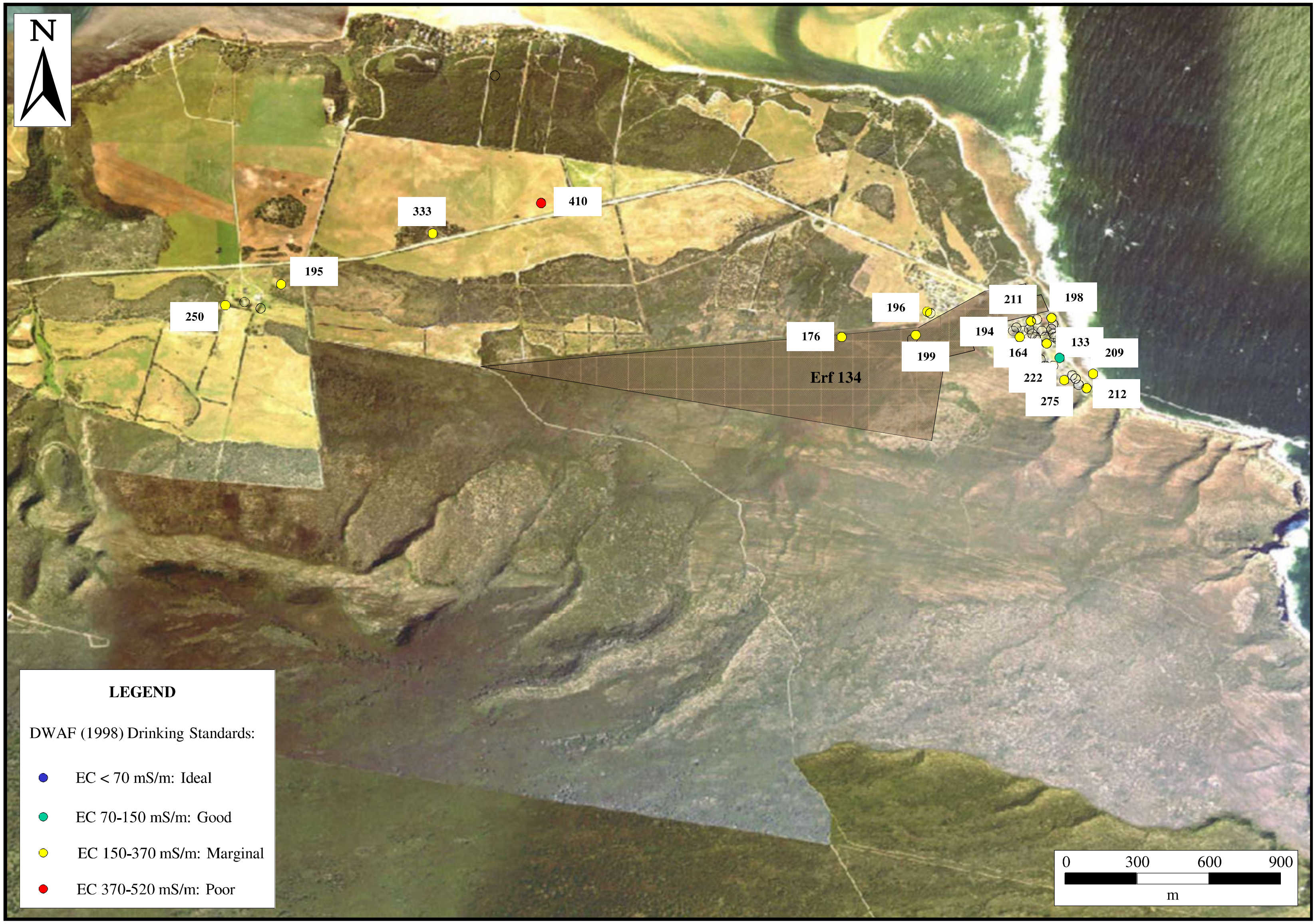

Figure 8. Electrical conductivity levels (mS/m) measured in the vicinity of Erf 134 Infanta

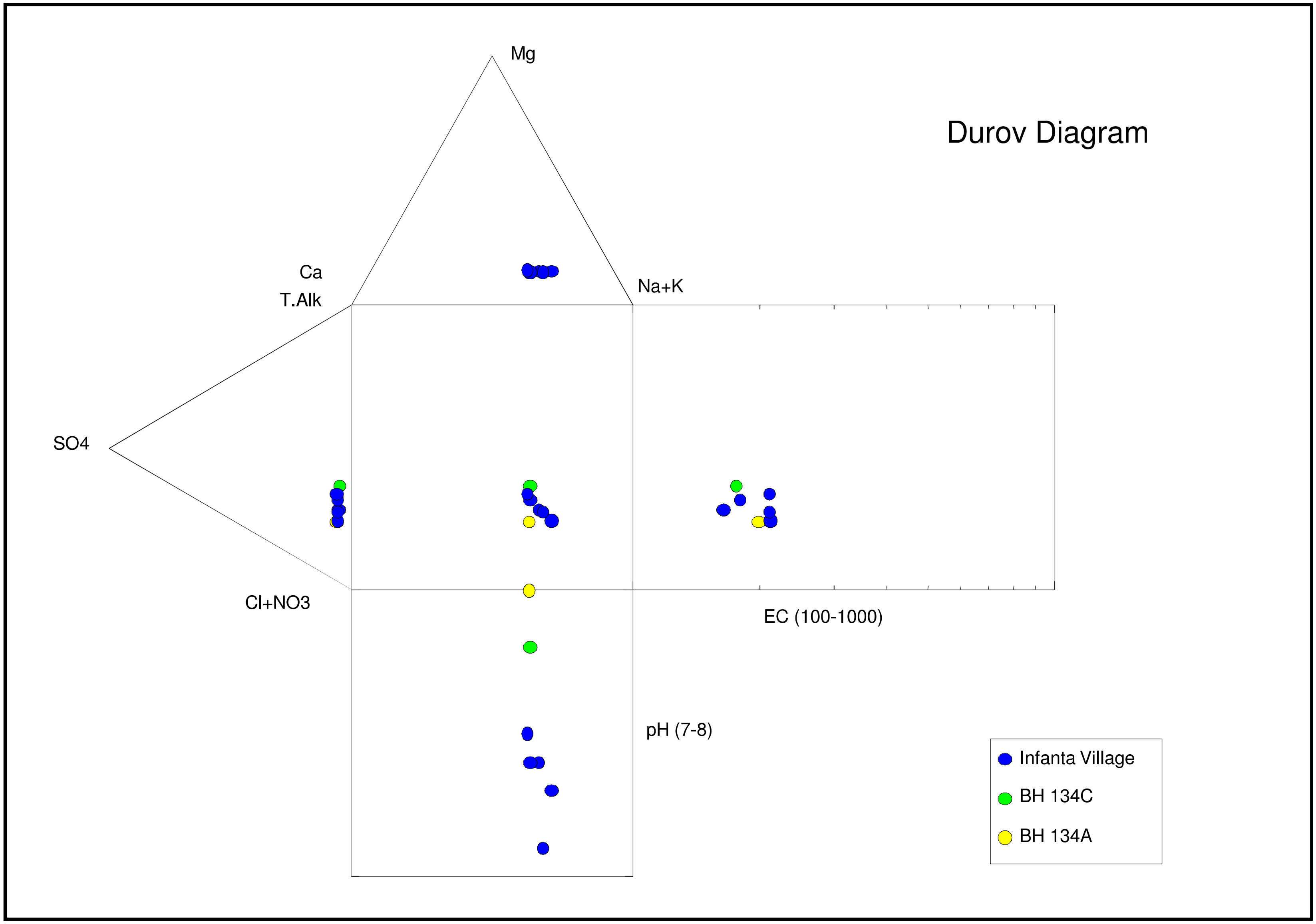

Figure 9. Hydrochemical character of groundwater sampled at Infanta Village and Erf 134 Infanta

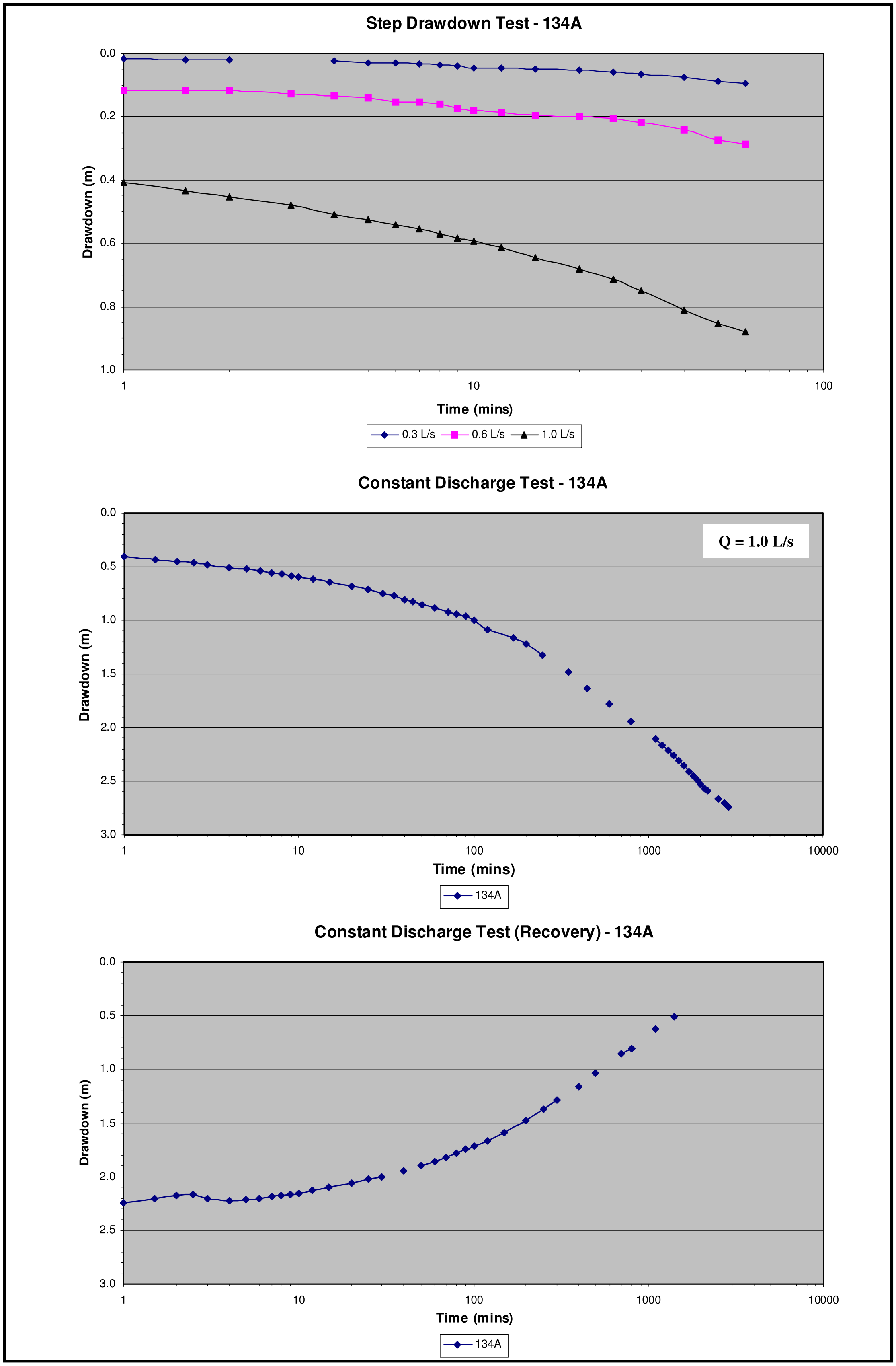

Figure 10. Pumping tests conducted on borehole 134A at Erf 134 Infanta (data source: Pumpcor)

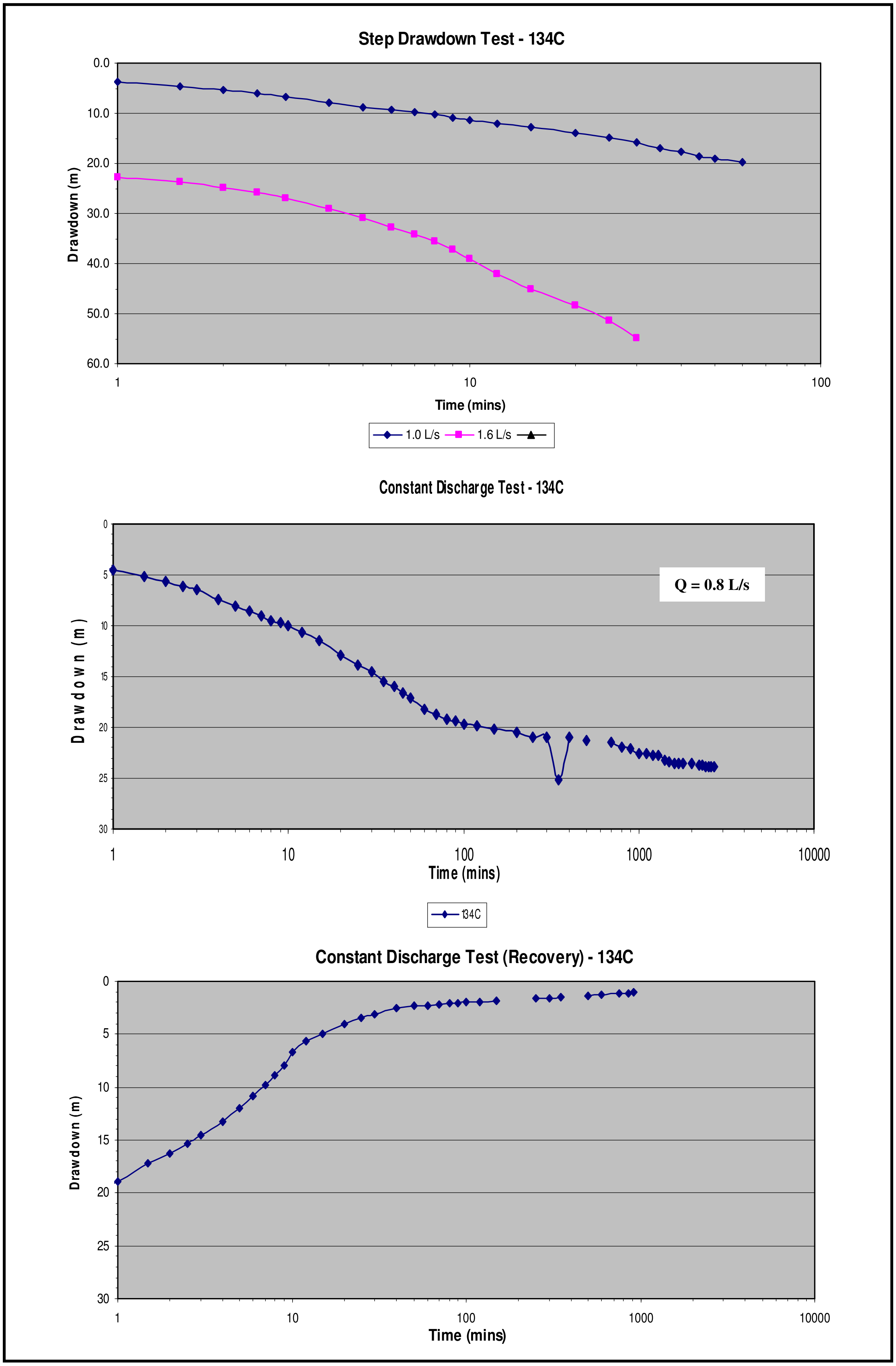

Figure 11. Pumping tests conducted on borehole 134C at Erf 134 Infanta (data source: Pumpcor)

APPENDICES

Appendix A

Toens & Partners (1999) hydrocensus data

Borehole no.	Property name	Latitude (WGS84)	Longitude (WGS84)	Groundwater level (mbgl)	EC level (mS/m)	Borehole depth (m)	Abstraction (m^3/a)
CI3	Erf 3, Cape Infanta	-34.42390	20.85677	2.00	212		
CI5	Erf 50, Cape Infanta	-34.42362	20.85657	10.00		75	
CI7		-34.42343	20.85635				
CI21	Erf 21, Cape Infanta	-34.42369	20.85594		222	30	
CI27	Erf 27, Cape Infanta	-34.42294	20.85533	2.00		30	
CI35	Erf 35, Cape Infanta	-34.42256	20.85472				36
CI37	Erf 37, Cape Infanta	-34.42294	20.85496				
CI39	Erf 39, Cape Infanta	-34.42253	20.85414		164		
CI42		-34.42233	20.85384				
CI44		-34.42255	20.85390				
CI48	Erf 48, Cape Infanta	-34.42161	20.85363	5.50	194	61	240
CI49		-34.42142	20.85355				
CI53		-34.42107	20.85324				
CI54		-34.42091	20.85340				
CI57	Erf 57, Cape Infanta	-34.42107	20.85377		180		
CI64		-34.42190	20.85403				
CI67		-34.42174	20.85447				
CI68		-34.42158	20.85450				
CI69		-34.42143	20.85447				
CI71	Erf 71, Cape Infanta	-34.42123	20.85425				10
CI72		-34.42095	20.85411				
CI74	Erf 74, Cape Infanta	-34.42053	20.85417	6.00	211	140	12
CI75	Erf 75, Cape Infanta	-34.42048	20.85456			105	340
CI78		-34.42103	20.85480				
CI80	Erf 80, Cape Infanta	-34.42137	20.85497		195		
CI84		-34.42173	20.85499				
CI85		-34.42172	20.85594				
CI86		-34.42150	20.85592				
CI88		-34.42138	20.85542				
CI89	Erf 89, Cape Infanta	-34.42126	20.85533	5.20	211	70	10
CI91	Erf 91, Cape Infanta	-34.42099	20.85526		187		
CI92	Erf 92, Cape Infanta	-34.42072	20.85533	9.00	190	90	55
CI95	Erf 95, Cape Infanta	-34.42040	20.85530		198		
CI143	Erf 143, Cape Infanta	-34.42408	20.85711		209		
CI149		-34.42158	20.85563				
CI151	Erf 151, Cape Infanta	-34.42167	20.85568	7.00		96	
Mark Plein		-34.42247	20.85571			55	

Appendix B

DWAF (1998) drinking standards

Parameter		DWAF Quality for Domestic Water Supplies (1998)					SABS 241-1984		Erf 134		Infanta village				
		Ideal	Good	Marginal	Poor	Unaccept	Recommend	Max. allow	134A	134C	CI57	CI48	CI39	CI74	CI80
K	(mg/L)	< 25	25 - 50	50 - 100	100 - 500	> 500			5.4	5.0	7.5	6	4.8	8.4	6.9
Na	(mg/L)	< 100	100 - 200	200 - 400	400 - 1000	> 1000	100	400	255.4	225.1	217		206	253	
Ca	(mg/L)	< 80	80 - 150	150 -300	> 300				120.6	104.7	102	105	81	124	111
Mg	(mg/L)	<70	70 - 100	100 - 200	200 - 400	> 400	70	100	31.7	27.5	27	30	25	34	29
NH_4-N	(mg/L)										< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
SO_4	(mg/L)	< 200	200 - 400	400 - 600	600 - 1000	> 1000	200	600	57	46	45		40	60	
Cl	(mg/L)	< 100	100 - 200	200 - 600	600 - 1200	> 1200	250	600	481.8	430.0	379		361	443	
T.Alk	(mg/L)										232		188	302	
NO_x-N	(mg/L)	< 6	6 - 10	10 - 20	20 - 40	> 40	6	10			< 0.1	< 0.1	0.19	0.38	< 0.1
F	(mg/L)	< 0.7	0.7 - 1.0	1.0 - 1.5	1.5 - 3.5	> 3.5	1	1.5			0.25		0.15	0.27	
EC	(mS/m)	< 70	70 - 150	150 - 370	370 - 520	> 520	70	300	199	176	180	194	164	211	195
pH		5.0 - 9.5					6 - 9	5.5 - 9.5	7.0	7.2	7.6		7.6	7.5	
pHs											7.3		7.4	7.1	
TDS	(mg/L)										1152	1242	1050	1350	1248
Hardness	(mg/L)	< 200	200 - 300	300 - 600	> 600		20 - 300	< 650			364	388	307	451	398
As	(mg/L)	<0.01	0.01 - 0.05	0.05 - 0.2	0.2 - 2.0	> 2.0	0.1	0.3							
Cd	(mg/L)	< 0.003	0.003 - 0.005	0.005 - 0.02	0.02 - 0.05	> 0.05	0.01	0.02							
CN	(mg/L)						0.2	0.3							
Cu	(mg/L)	< 1.0	1 - 1.3	1.3 - 2	2 - 15	>15	0.5	1							
Fe	(mg/L)	< 0.01	0.01 - 0.2	0.2 - 2	2 - 10	> 10	0.1	1	< 0.01	0	3.45		0.1	0.04	
Hg	(mg/L)						0.005	0.01							
Mn	(mg/L)	0.1	0.1 - 0.4	0.4 - 4	4.0 - 10	>10	0.05	1	< 0.1	0					
Pb	(mg/L)						0.05	0.1							
Se	(mg/L)						0.02	0.05							
Zn	(mg/L)	< 20	> 20				1	5							
Phenols	(mg/L)						0.005	0.01							
Total coliforms	(c/100mL)	0	0 - 10	10 - 100	100 - 1000	> 1000	0	5					141		
E.coli	(c/100mL)						0	0							
Faecal coliforms	(c/100mL)	0	0 - 1	1 - 10	10 - 100	> 100	0	0					12		
Total Plate Count	(c/1 ml)														
Turbidity	(ntu)	0.1	0.1 - 1	1 - 20	20 - 50	> 50	1	5							