Ground Floor, Bay Suites
1a Humewood Rd,
Humerail
Port Elizabeth, 6001
P O Box 21842
Port Elizabeth 6000
South Africa
T: +27 (0) 41 509 4800
F: +27 (0) 41 509 4850
E: portelizabeth@srk.co.za
www.srk.co.za

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507956

Directorate: Human Settlements
Sub-Directorate: Development and Support
Nelson Mandela Bay Municipality (NMBM)

Attention: Mr Rayno Madatt

Dear Rayno

Groundwater Investigation near Seaview for Low Cost Housing Development

1. Introduction and Scope of Report

SRK Consulting (SRK) (Pty) Ltd. was appointed to conduct a groundwater investigation where low cost housing is to be developed at selected locations to the north of Seaview. SRK understands that there are a number of possible sites where the development can take place. The proposed sanitation system is low-volume flush toilets and leach pits (on-site sanitation), since bulk sanitation facilities are absent in the area.

The groundwater investigation is based on the document "*A Protocol to Manage the Potential of Groundwater Contamination from on Site Sanitation*", March 2003 (referred to as the Groundwater Protocol in this document) of the former Department of Water Affairs and Forestry.

The Groundwater Protocol guides groundwater and sanitation planners and practitioners to make sure that groundwater is protected when development programmes for communities are carried out. The aim of any sanitation practise is to ensure that contaminants do not reach humans or animals.

Sewage from the sanitation system will likely follow two possible routes: into the ground and / or groundwater table; or into the ground and then seeping back out onto the surface at lower elevation levels. The unsaturated zone (area in the soil above the groundwater table) removes contaminates to a certain level, depending on the types of contaminants, the contaminant loads and the type of material in the unsaturated zone. It is therefore important to know the thickness of the unsaturated zone (thus the depth of the water table) and the materials constituting the unsaturated zone. Attenuation of contaminants also takes place in the saturated zone (in the groundwater) but to a lesser extent.

The following scope of works was proposed by SRK, accepted by the Client and is quoted below from the proposal dated 3 March 2016:

- *"Conduct a desktop assessment of the geology and hydrogeology within a radius of approximately 1 km of the proposed Site. This will include an assessment of the geological, hydrogeological and topographical maps; and the National Groundwater Archives (NGA) – a database of the Department of Water and Sanitation (DWS).*
- *Undertake a hydrocensus of boreholes at properties neighbouring the current proposed sites. The hydrocensus will be limited to identifying existing boreholes and recording any available information of this borehole, including its position, depth, water level, water pH and conductivity. Existing potential contamination sources will also be recorded.*
- *Drilling of boreholes in order to establish the thickness of the unsaturated zone, the materials constituting the unsaturated zone, and the depth to groundwater table within the area. It is proposed that ten boreholes be drilled, spaced out approximately 500 m from each other across the proposed sites, in areas that are accessible to a drilling rig. An average depth of 10 m bgl is proposed. Should the water level not be reached by 10 m bgl, then the borehole will be stopped, the soils logged, and the borehole backfilled.*
- *Sieve Analysis is to be conducted on selected samples from the boreholes to determine the specific soil types below the surface.*
- *Reporting on the results of the investigation.*

2. Results

The results of the investigation are discussed in the section below.

2.1 Desktop Study

2.1.1 Geology

According to the publication "*The Geology of the Port Elizabeth-Uitenhage Area*" by FC le Roux of the Council for Geoscience (2000), the geology of the area mainly comprises aeolian sands of the Schelmhoek Formation (Algoa Group). These sands overly the older Nanaga Formation (Algoa Group) to the north and also the older Kleinrivier Formation (Gamtoos Group) to the south (refer to Figure 1).

The Schelmhoek Formation is the youngest formation of the Algoa Group and occurs up to six kilometres inland from the coast. It comprises windblown, unconsolidated, calcareous quartz sand with intercalated lenses of strandloper middens and isolated very immature soil horizons. The absence of clasts distinguishes it from the beach deposited sands. Dune sand accumilations of up to 140 m thick have been measured.

The Nanaga Formation to the west of Port Elizabeth comprises mainly unconsolidated sand/sandstone that is whitish to yellowish, or reddish in some places. The sand/sandstones are calcareous in nature due to the high content of shell fragments.

The Kleinrivier Formation of the Gamtoos Group (this group representing the oldest know rocks known in the south-eastern Cape Province) is exposed along the coast.

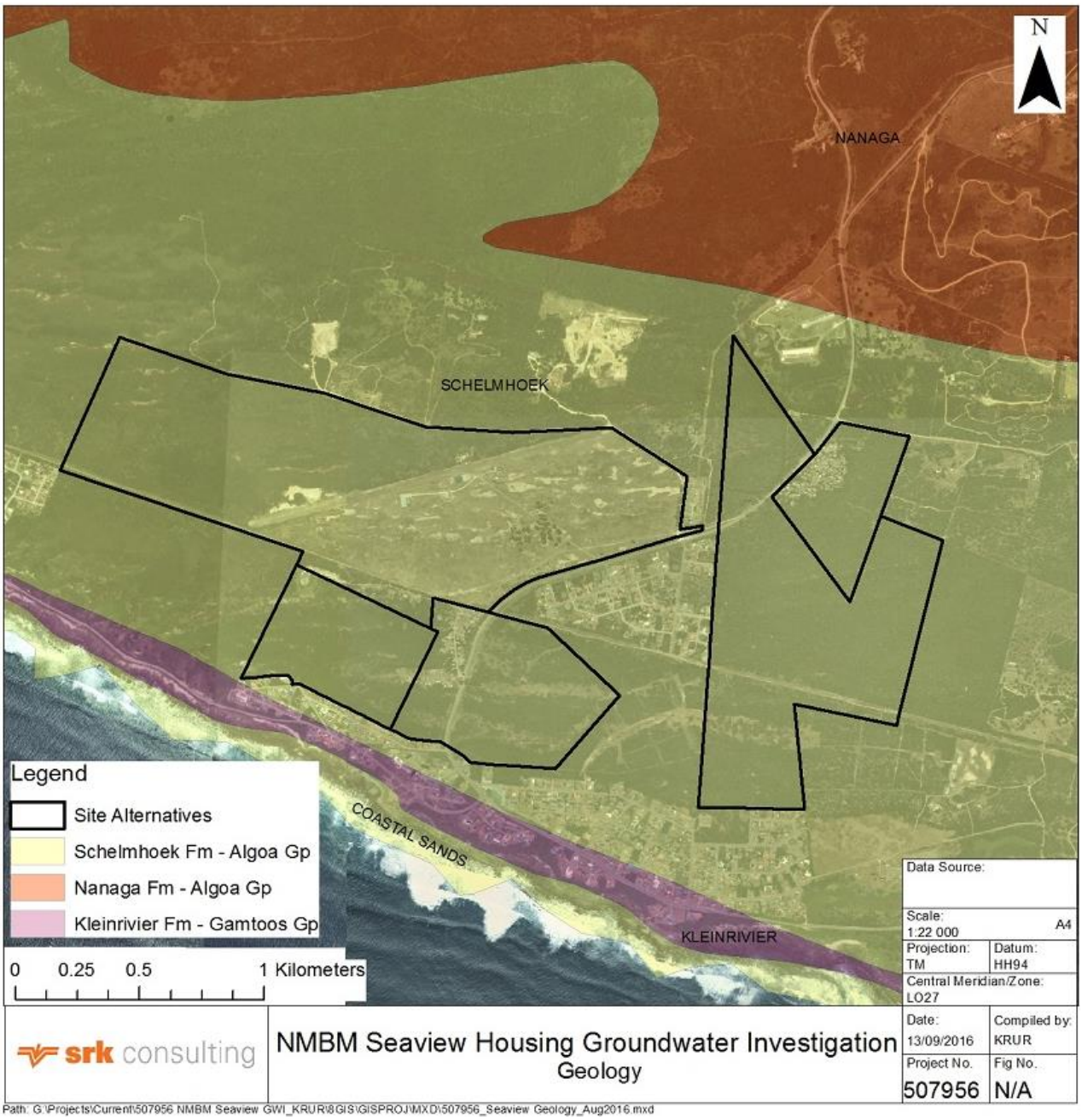

Figure 1: Geology

2.1.2 Hydrogeology

According to the publication “An Explanation of the 1:500 000 General Hydrogeological Map of Port Elizabeth 3324” by PS Meyer of the Department of Water Affairs and Forestry (1998), borehole yields in the coastal sands of the Schelmhoek Formation may vary between 0.1 and 15 L/s. An analysis of yields in 39 boreholes drilled into this formation, revealed the following:

- 34% of boreholes yield between 0.5 and 2 L/s;
- 28% of boreholes yield between 2 and 5 L/s;
- 18% of boreholes yield between 0.1 and 0.5 L/s;
- 13% of boreholes yield between 0 and 0.1 L/s; and
- 7% of boreholes yield > 5 L/s.

The groundwater quality is considered potable with conductivity measurements generally being less than 300 mS/m. Sodium, total alkalinity and chloride often exceed the recommended limits.

A sandy aquifer, such as this one, will be dependent on direct recharge from rainfall and may become dry during droughts.

2.1.3 National Groundwater Archive (NGA) Database

During the desk study, the NGA database of the Department of Water and Sanitation (DWS) was searched for information on existing boreholes within a 1 km radius of the Sites. Three boreholes were identified to the west and south of the sites. Available information on these boreholes is given in Table 1, and their positions are given in Figure 2. One water level measurement is recorded at a depth of 28.5 m bgl; and borehole depths vary between 114 and 149.7 m bgl. Water was intersected in borehole EC/M20/593 at 94 m bgl and an airlift yield of 0.8 L/s was measured.

Table 1: NGA Borehole Information

Borehole ID	Latitude	Longitude	Water Level (m bgl)	Depth (m bgl)	Water Strike Depth (m bgl)	Water Strike Airlift Yield (L/s)
EC/M20/593	-34.01414	25.35561	n/a	115	94	0.8
337/40/1	-33.99274	25.33247	28.5	114	n/a	n/a
337/40/2	-33.9925	25.33226	n/a	149.7	n/a	n/a

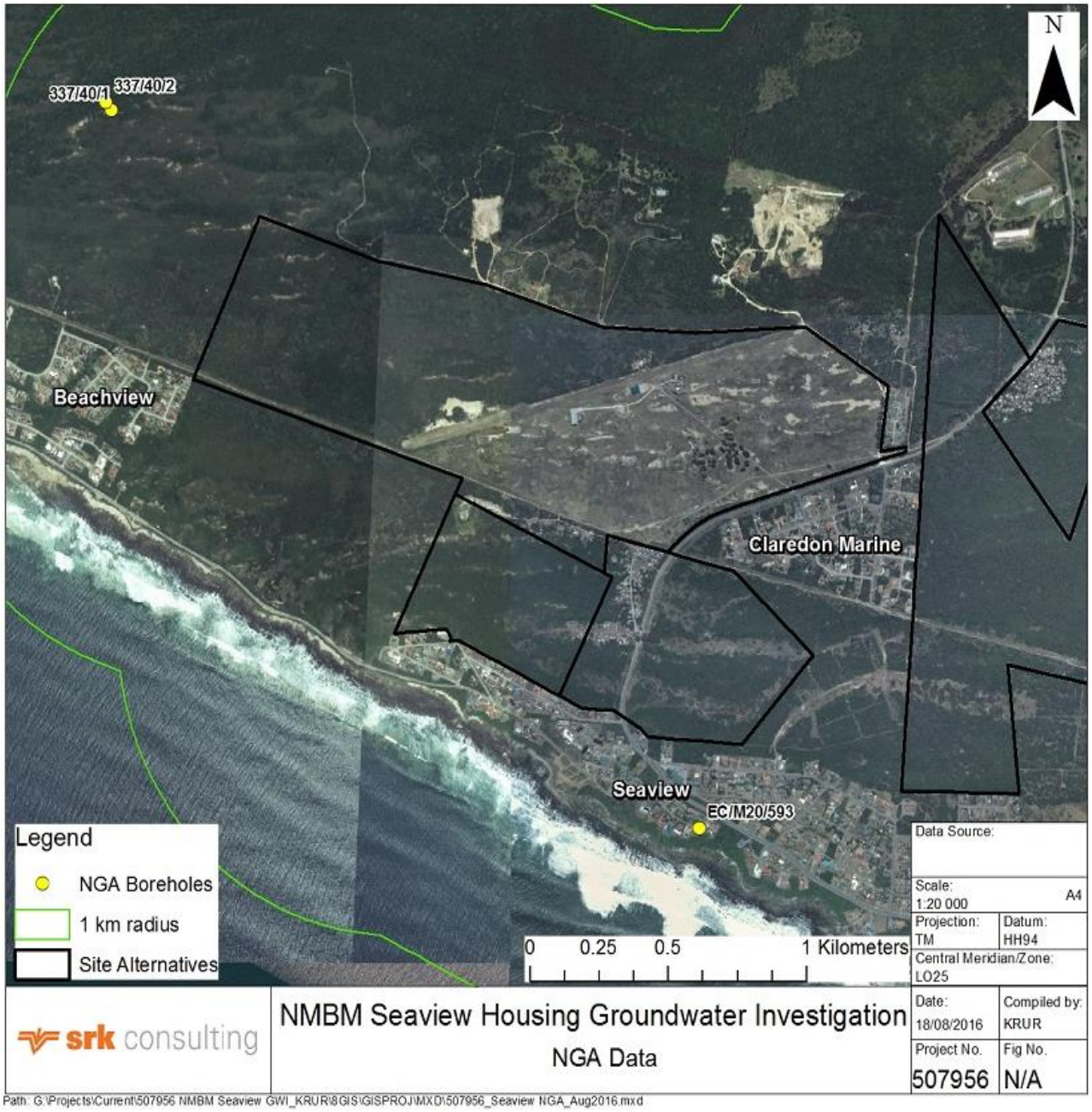

Figure 2: NGA Boreholes

2.1.4 Surface Water and Shallow Groundwater Drainage

In general, the Site dips to the south; and the main drainage direction of inferred surface water and shallow groundwater is therefore assumed to be to the south, towards the sea (refer to Figure 3).

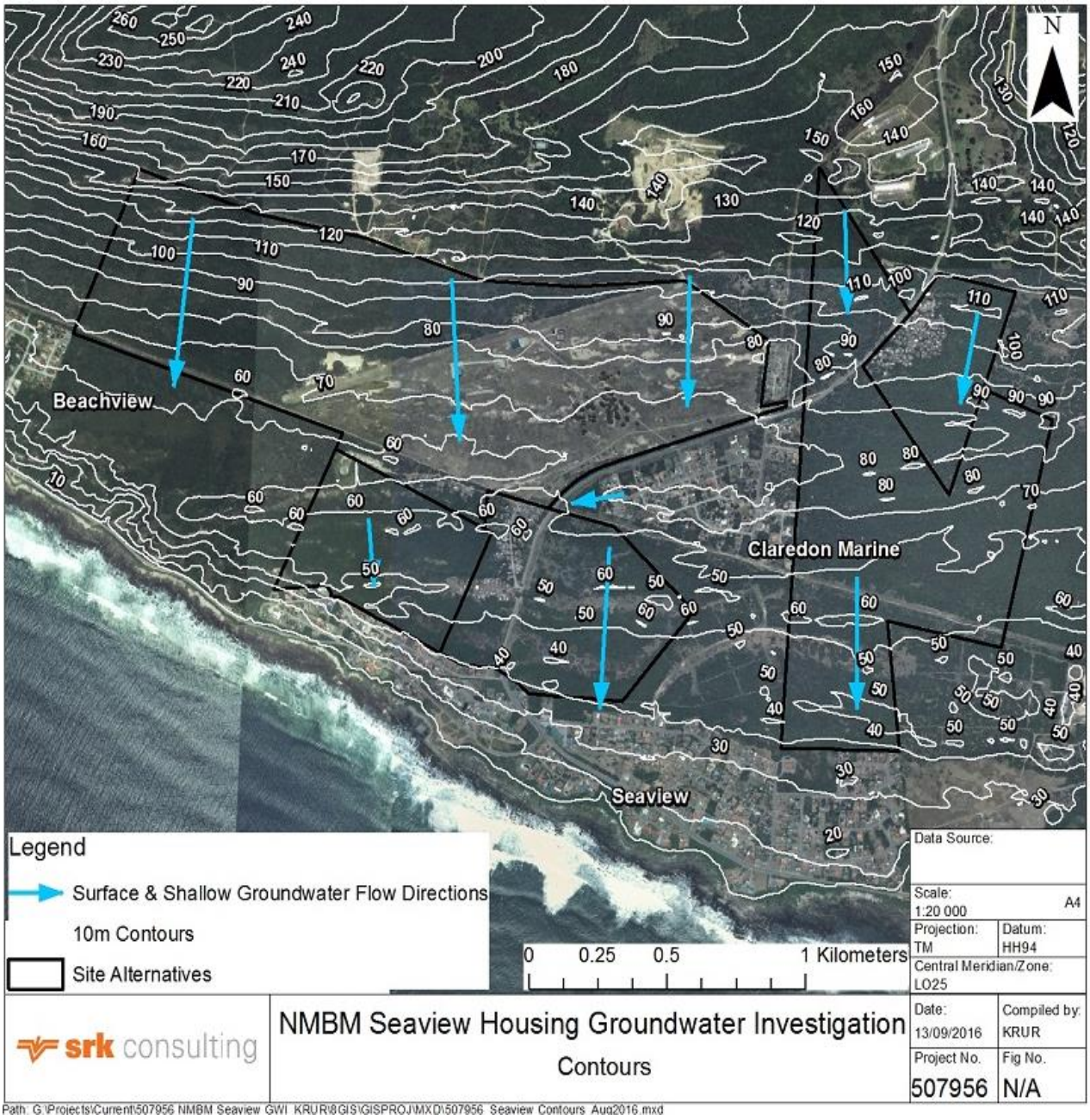

Figure 3: Contour and Assumed Surface Water and Shallow Groundwater Flow Direction

2.1.5 Rainfall Data

The closest rainfall station to Seaview is at Blue Horizon Bay, which was commissioned in 2012. Monthly rainfall figures are given in Figure 4 below. The average rainfall figure since July 2012 is ~50 mm per month. During the month of August, when the boreholes were drilled, the rainfall was 13.6 mm, which is considered low. Sandy aquifers, like the one at the land surface at Seaview, is mainly recharged by rainfall that gravitates from the surface, and moves downwards and down-gradient through the sands until it reaches a hard, lower permeability surface (e.g. older hard rock formations like the Peninsula Formation). From here the bulk of the water will move laterally towards the sea. Therefore it can be assumed that, during periods of higher rainfall, the water levels may be higher in the sands; and during periods of lower rainfall, the water levels will be deeper.

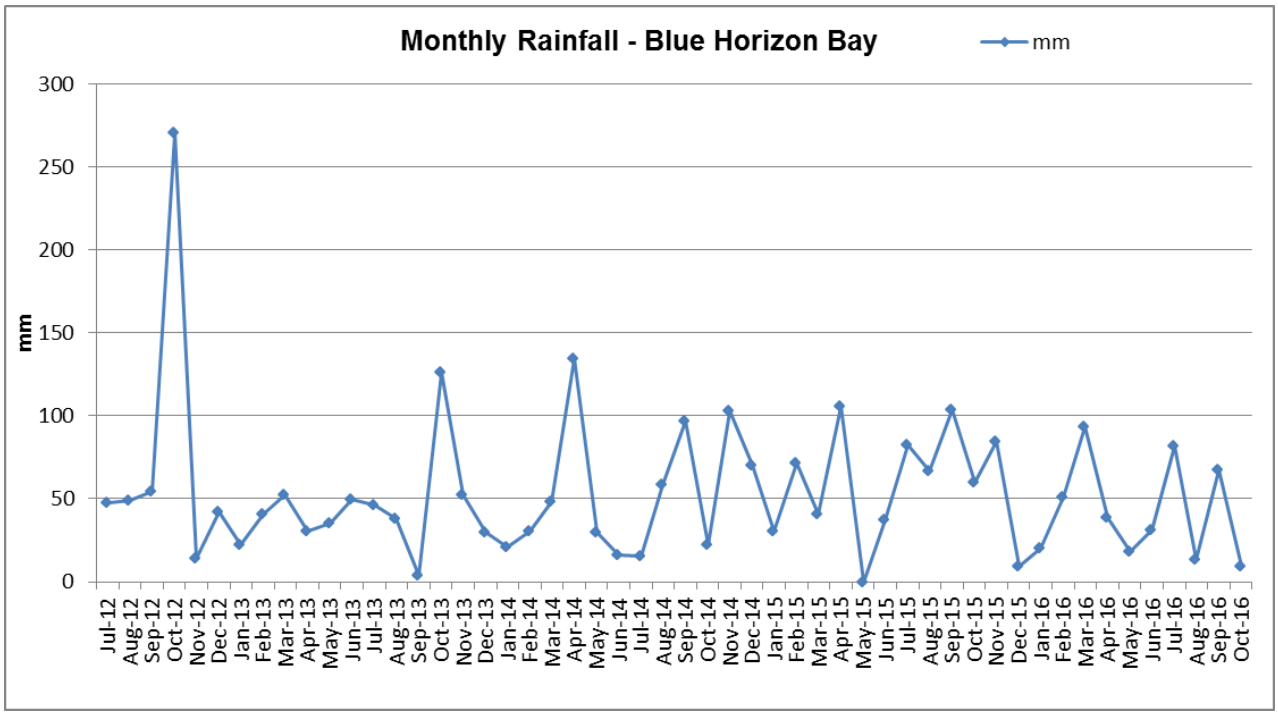

Figure 4: Monthly Rainfall Figures for Blue Horizon Bay

2.2 Hydrocensus

A hydrocensus was conducted on 29 and 30 August 2016. Five boreholes were identified in the area (refer to Figure 5) and limited information was available (refer to Table 2). One depth was reported (by the borehole owner) at 11 m bgl, which is considered very shallow. No water level measurements could be recorded.

Table 2: Hydrocensus Information

Borehole ID	Latitude	Longitude	Depth (m bgl)	Equipped	Comments
SV BH 1	-33.99814	25.34892	n/a	n/a	Owner not home, borehole with pump visible from driveway.
SV BH 2	-34.00303	25.35678	Unknown	Yes but not operational	Unknown depth, borehole was tested by NMBM some time ago, did a yield test for 5 days. "Strong" borehole. Not operational for ~1 year, was used for horses drinking water. There is a pump on the borehole.
SV BH 3	-34.01409	25.35889	n/a	Yes	Owner not home, borehole with pump visible from driveway.
SV BH 4	-34.01418	25.35554	n/a	n/a	Owner not home, house for sale. Borehole visible
SV BH 5	-34.01212	25.35594	11	Yes	Water tastes fresh, unknown yield. Used for garden.

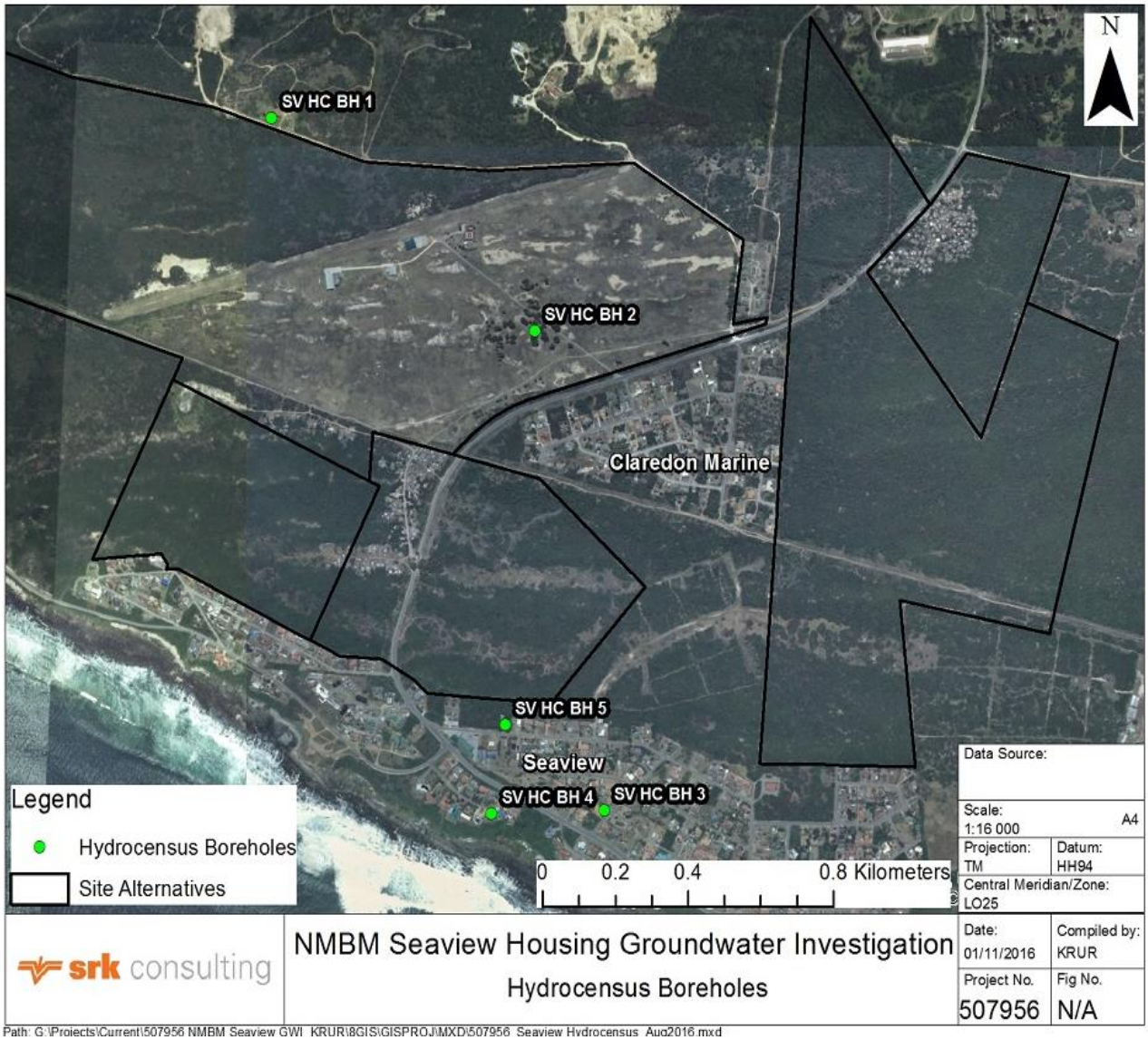

Figure 5: Hydrocensus Boreholes

2.3 Drilling of Boreholes

Nine boreholes were drilled in accessible locations shown in Figure 6. The boreholes were drilled in areas that were accessible to the drilling rig. A small percussion drilling rig that is mounted on a trailer was used to dill through the sands.

In the majority of holes, a top layer of organic, silty sand was intersected (up to 3 m deep), which overlies a fine, yellow creamish sand. In some holes, the sands have been calcretised, creating hard layers in between the softer sand horizons. The soils profiles are summarised in Table 3 below.

The water table was not intersected in any of the boreholes. In two of the boreholes, the sand became moist towards the bottom (SV BH 6 and SV BH 9). These are topographically situated closest to the coast. It can therefore be assumed that the water level may be close to 10 m bgl in these boreholes.

A number of soil samples were taken from the boreholes and sent to a laboratory for a sieve analysis, to determine the soil type. From the sieve analysis, all samples can be described as fine sand, which is predominantly uniformly-graded.

Table 3: Borehole Profile Logs

From	To	BH 1	BH 2	BH 3	BH 4	BH 5	BH 6	BH 7	BH 9	BH 10
0.0	0.5									
0.5	1.0									
1.0	1.5						s			s
1.5	2.0						s			s
2.0	2.5	s			s	s		s		
2.5	3.0	s			s	s		s		
3.0	3.5								s	s
3.5	4.0								s	s
4.0	4.5			s						
4.5	5.0			s						
5.0	5.5	s	s			s				
5.5	6.0	s	s			s				
6.0	6.5							s	s	
6.5	7.0							s	s	
7.0	7.5				s					
7.5	8.0				s					
8.0	8.5			s			s			
8.5	9.0			s			s		m	
9.0	9.5		s						m	
9.5	10.0		s				m		m	
10.0	10.5						m		m	
10.5	11.0								m	
11.0	11.5								m	

Legend	
Organic Silty Sand	
Fine Sand	
Calcretised Sand	
Moist	m
Sampled	s

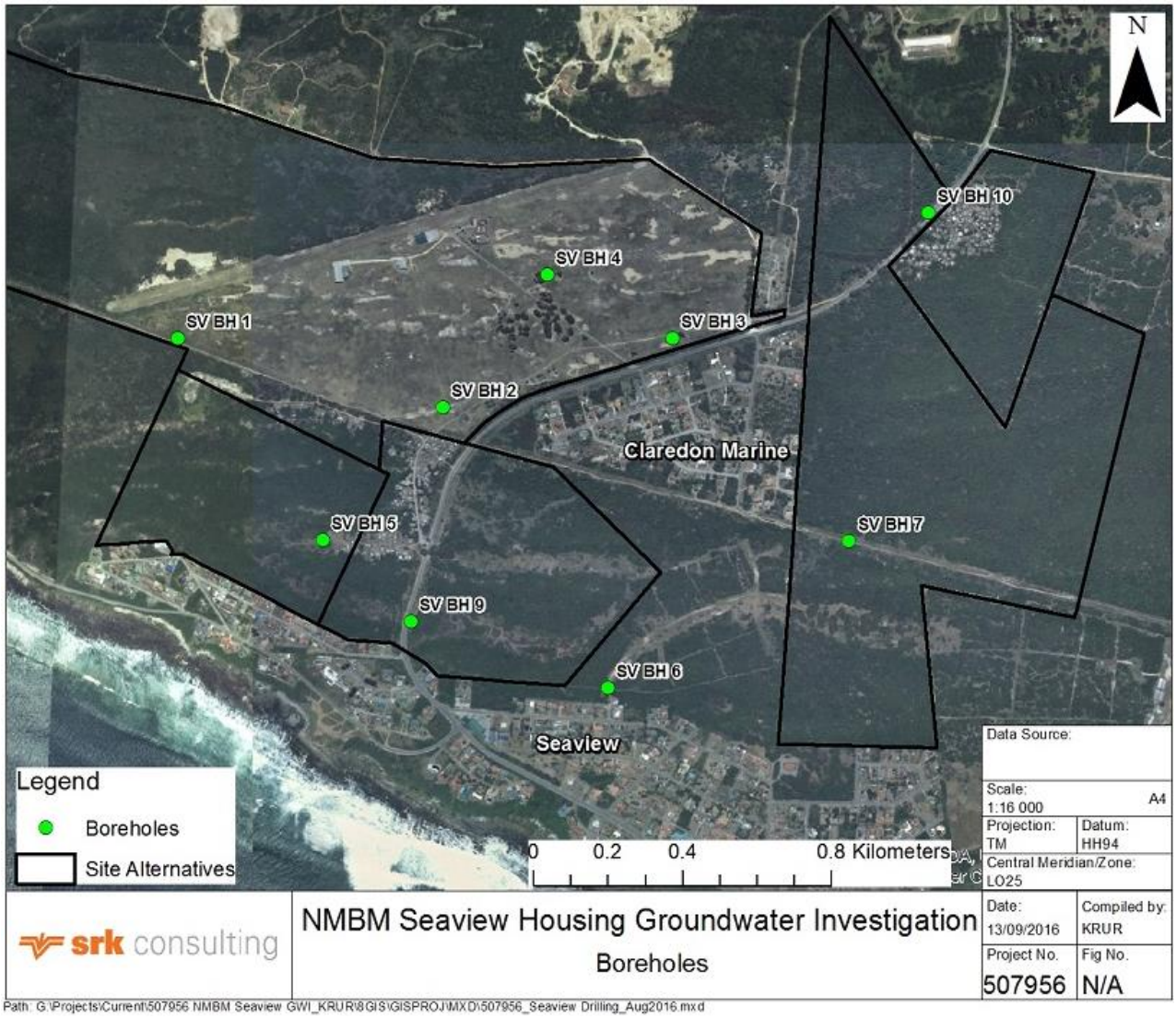

Figure 6: Drilled Borehole Positions

3. Impact Assessment

From the desktop study and hydrocensus / site work, the following can be accentuated with regards to the impact assessment:

- Limited information on boreholes was available from the NGA database as well as the hydrocensus.
- Only one water level measurement was available (NGA data) and was 28.5 m bgl.
- Water was not intersected in any test boreholes, drilled to depths between 10.5 and 11.5 m bgl.
- Calcretised sand was found in places between 1 and 8 m bgl.
- Even though there are not many recorded groundwater users, the water is considered potable. The geological formations in the area have successfully been targeted for groundwater, and may also be targeted in the future.

Sewage from the sanitation system will likely follow two possible routes: into the ground and / or groundwater table; or into the ground and then seeping back out onto the surface.

Bearing in mind the source - pathway - receptor concept, the following can be concluded for the study area:

- Potential sources of contamination / potential impacts: Sewage from the sanitation systems
- Potential pathways: Sands and groundwater
- Potential receptors: Groundwater as a natural resource; groundwater or surface water users (animals and humans); and the ocean.

Risk is considered to be present when a complete link exists between the source, pathway and receptor. SRK understands that the DWS sees all groundwater as a natural resource that must be protected, irrespective of the current water quality. No pollution or further pollution is allowed.

According to the Groundwater Protocol, risk levels are based on three factors:

- The vulnerability of the aquifer
- The contamination load from the particular sanitation system
- The strategic value or current and/or future use of water from the aquifer

Aquifer Vulnerability: According to the Groundwater Protocol, the vulnerability of an aquifer is related to the distance that the contaminants must travel to reach the water table, and the ease with which it can flow through the soil and rock layers above the water table. An aquifer is classed as having a medium vulnerability when the water level is deeper than 10 m bgl (thus an unsaturated zone[1] of more than 10 m in thickness); and a low vulnerability when the water level is deeper than 20 m bgl. Only one water level measurement was available from the NGA (28.5 m bgl), and the water table was not intersected in any of the boreholes drilled by SRK. The sandy aquifer can therefore be classified as having a medium to low vulnerability; and its risk to contamination is considered low to minimal, with medium to long distances to the water table. Fine sand has a minimal capacity to absorb contaminants, but it has the capacity to create an effective barrier to contaminants. This will result in a high reduction in bacteria, but minimal reduction in nitrates and phosphates. The sewage will be released into the ground between approximately 1 and 2 m bgl. It is important to note that the water level in the sandy aquifer may vary depending on recharge from rainfall in the area. The aquifer may be vulnerable to inorganic pollutants and the most persistent pollutants, but with negligible risk of organic or microbiological contaminants.

Contamination Loads: According to the Groundwater Protocol, the following can be stated for low-flush or pour flush on-site sanitation systems:

- The typical hydraulic output for low-flush or pour flush on-site latrines is 20 – 80 mm/day for up to five people using a latrine.

[1] Unsaturated Zone: The underground zone between the ground surface and the water table

- The typical time it takes releases from a low-flush or pour flush on-site latrines to travel one meter is estimated to be 12 days (reference Table 2, Groundwater Protocol), which supports a low risk to contamination. However, the typical time to travel 1m assumes that the permeability of the soil or rock is greater than the load. If the load exceeds the permeability of the sands, then ponding may occur.
- In high density settlements, the drainage may be inadequate for this sanitation system, and poorly drained zones may not cope with the load. There may also be a reduction in filtration or adsorption capacity over time, and dilution may be reduced in high density areas.
- The Groundwater Protocol comments that the low flush sanitation system should not result in ponding, except in poorly drained soils and when submerged. In this case, the rate of flow in sandy soils is classed as medium.

Strategic value or current / future use of groundwater: Currently there are groundwater users in and around Seaview. Please refer to Figure 7 for a generalised conceptual site model (CSM) of the ground conditions and groundwater setting within the project area. The CSM reflects (amongst others) the top sandy aquifer, the deeper hard rock aquifer, a down-gradient borehole, the approximate water level and the estimated flow directions of shallow groundwater and the sewage from the sanitation systems.

The following data gaps are identified:

- Calculated groundwater flow direction (it is assumed to be towards the ocean)
- Depth to water table (from data collected, assumed to be > 11 m bgl
- The extent of water level fluctuation that may occur during periods of high rainfall (i.e. the water level might become shallower than 11 m bgl during rainfall periods)
- Contamination loads (assumed a load from five people per latrine per day)

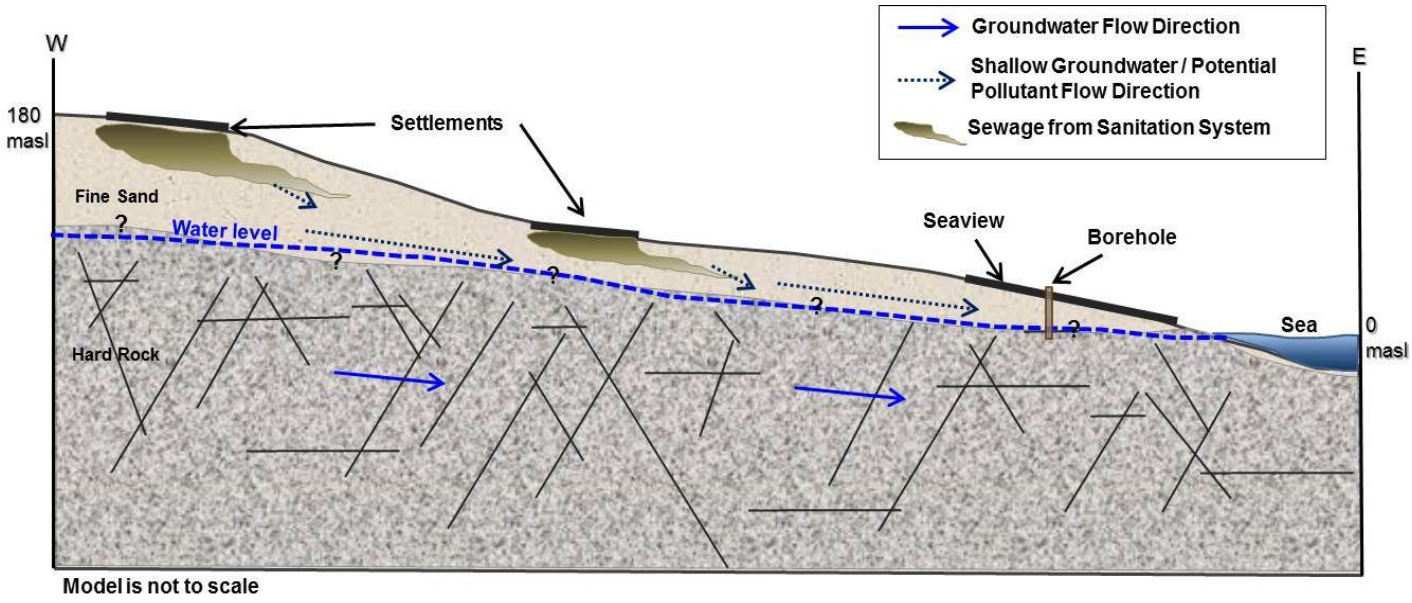

Figure 7: Generalised Conceptual Site Model

3.1 Potential Impact: Pollutants from Sanitation System Reaching Groundwater Receptors

During the time of the investigation, and with information on the sandy aquifer during this time, it can be concluded that the risk to the aquifer in general is low, specifically with regards to bacterial pollutants. The risk from nitrates and phosphates may be higher.

However, under certain conditions, the risk may increase and the potential exists that pollutants from the sanitation system may reach groundwater users (e.g. humans). These conditions include:

- A rise in water table, potentially during periods of higher rainfall;

- An increase in pollution loads, resulting in a pollution load that is greater than the permeability of the sands.

According to the Groundwater Protocol, low-flush or pour flush on-sited latrines produced a hydraulic output that constitutes a low risk of contamination.

Mitigation:

Because of the uncertainties with regards to the water table during periods of higher rainfall, as well as potential increasing contamination loads over time, it is advised that three monitoring boreholes must be installed at selected locations down-gradient of the settlements. These must be monitored for bacteria, nitrate and phosphate.

4. Conclusions and Recommendations

Based on the information obtained and analysed above, the following conclusions can be made:

- The geology underlying the Site comprises the Schelmhoek Formation of the Algoa Group. It consists of windblown, unconsolidated, calcareous quartz sand with intercalated lenses of strandloper middens and isolated very immature soil horizons.
- In general the water quality (electrical conductivity) in this sandy aquifer is less than 300 mS/m (the limit in drinking water according to the SANS 241:2015 Standard is 170 mS/m); and yields may vary greatly between 0.1 and 15 L/s. A sandy aquifer like this one will be dependent on direct recharge from rainfall, and may become dry during droughts.
- According to the NGA of the DWS, three boreholes are situated within a 1 km radius of the proposed developments. Only one water level measurement was available from the database, and was recorded as 28.5 m bgl.
- The surface water and shallow groundwater flow direction is assumed to follow the surface contours, and will be in and south, south-western direction towards the sea.
- During the time of the investigation, the area was experiencing a low rainfall period (13.6 mm measured for August 2016).
- Five boreholes were located during the hydrocensus, but limited information was available on these.
- Nine boreholes were drilled by SRK to depths between 10.5 and 11.5 m bgl across the project area, in order to establish whether the water table was present at those depths. None of the boreholes intersected the water table, but moist sand was intersected in the last meter or two in SV BH 6 and SV BH 9.
- Impact Assessment: During the time of the investigation, and with information on the sandy aquifer during this time, it can be concluded that the risk to the aquifer in general is low, specifically with regards to bacterial pollutants. The risk to nitrates and phosphates may be higher, as the sands create an ineffective barrier. According to the Groundwater Protocol, low-flush or pour flush on-site latrines produced a hydraulic output that constitutes a low risk of contamination. However, under certain conditions, the risk may increase and the potential exists that pollutants from the sanitation system may reach groundwater users (e.g. humans). These conditions include:
  - A rise in water table, potentially during periods of higher rainfall;
  - An increase in pollution loads, resulting in a pollution load that is greater than the permeability of the sands.
- Mitigation:

Because of the uncertainties with regards to the water table during periods of higher rainfall as well as potential increasing contamination loads over time, it is advised that three monitoring boreholes must be installed down-gradient of the settlements. These must be monitored for bacteria, nitrate and phosphate in order to establish if they are being attenuated efficiently.

Yours faithfully,

SRK Consulting - Certified Electronic Signature

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Riona Kruger (Pr Sci Nat)
Senior Geoscientist

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Gert Nel (Pr Sci Nat)
Principal Hydrogeologist and Partner

SRK Consulting (South Africa) (Pty) Ltd

Disclaimer

Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK's investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report, about which SRK had no prior knowledge nor had the opportunity to evaluate.