SPECIALIST GROUNDWATER AND SOIL STUDY ON THE POTENTIAL IMPACT BY THE STEYNS QUARRY, BOT RIVER.

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Submitted to
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EXECUTIVE SUMMARY

Creo Design (Pty) Ltd was appointed to undertake a specialist groundwater and soil study as part of the broader environmental impact assessment. Using existing information and a reconnaissance site investigation at the quarry, it was found that Steyns Quarry is unlikely to have any significant impact on groundwater and soil resources or the users thereof.

- Blasting may impact local groundwater users. However, an appropriate and sensitive approach to blasting will significantly reduce the threat posed. This includes undertaking site blast characterisations, identifying potentially impacted users and establishing contingency measures should water supplies be disrupted.

- Groundwater is not used during sand and aggregate processing on site and rehabilitation activities, but it is used as potable and ablution water at the offices. As no large scale groundwater abstraction on site takes place this threat is not considered significant and could be readily mitigated.

- Accidental spills of pollutants and other substances, generally because of accidental machine failures (ruptured hydraulic oil pipes or oil seal failures), cannot be predicted. Further, the risk posed by this threat is not significant. Rapid response to accidental spillages and timeous implementation of remedial actions will significantly reduce the potential impact to the groundwater resource and soil. This issue needs to be addressed in the Operational Environmental Management Plan.

- Sewage and waste from the offices and workshops pose a minor threat to groundwater in the immediate vicinity of these facilities and should be no different from a small light industrial unit. Thus, this threat is not considered significant and could be readily mitigated.

Implementation of a set of mitigation measures will ensure the significance of any impacts to groundwater users remains very low. Recommended mitigatory measures include the following:

- Controlled blasting in the stone quarry is to be preceded by blasting site characterisation and identification of water sources that could be impacted. Contingencies plans need to be put in place should water supplies be disrupted.

- Any measures to reduce the likelihood of accidents and spills will reduce the risk of groundwater and soil contamination. However, rapid response to accidents and spills of hazardous and other chemicals is required to ensure the impact thereof remains localised and of low significance. Provision of alternative water supplies may be required if existing potable supplies are threatened.
1. INTRODUCTION

1.1 Background

PHS Consulting recommended a groundwater and soil specialist study to be included as part of the broader environmental impact assessment. Consequently, Creo Design (Pty) Ltd was appointed by Salandra Ondernemings cc (Steyns Quarry) to undertake the required specialist groundwater and soil study. The findings of these specialist studies are presented in this report.

1.2 Terms of Reference

The Terms of Reference for the specialist groundwater and soil study set by PHS Consulting were as follows:

1.3 Extent of Scoping Phase

A geohydrological and soil impact study as part of scoping to determine the following:

- Identify key issues and no-go zones
- Identify alternative concepts that could avoid or minimise impacts
- Identify measures to optimise possible benefits to the downstream receiving environment
- Advise on the need for additional specialist work if required
- Address issues raised by I&AP’s during scoping
- This is a scoping phase specialist assessment with details limited to the extent required at this phase

1.4 Extent of Impact Assessment Phase

- Impact assessment including impact ratings and cumulative impact determination in accordance with the alternatives carried forward, summarised in the rating table layout; including where applicable assessment of the infrastructure component
- Identification of mitigation measures for impacts identified or measures for increasing benefits
- Address any relevant issues which may be derived from the Public Participation Phase, Interested and affected parties, organs of state or authorities derived from public participation phase or authorisation
- Identification of realistic, implementable, as well as auditable and quantifiable conditions and/or guidelines to be included in the Construction and Operational Environmental Management Plan’s Comments
- Specific comments relating to the service layout and associate infrastructure on site
2 APPROACH TO STUDY

2.1 Information Used
The study was based on a reconnaissance site inspection at the quarry on 4 October 2016, available geological, soil and geohydrological information and geological, as well as geohydrological, experience gained by the author whilst undertaking consulting and research projects in the general area. No primary field data was collected during the study.

2.2 Assumptions
The following key assumptions were made during the execution of the groundwater study:

- All mining and infrastructural development will be designed and constructed in an environmentally sensitive manner; so, flow (groundwater, river and storm water) will not be restricted and sensitive soil horizons not exposed to prolonged erosion during the winter rain season. If these principles are adhered to, restriction of groundwater flow and uncontrolled erosion are unlikely to be ‘red-flag’ issues.

- Local conditions will be considered in the mine development and the design of the plant and infrastructure.

2.3 Limitations of the Study
The following limitations to the study were recognised:

- The study was based on a reconnaissance site visit, available geohydrological and soil information and geohydrological and soil experience gained by the author whilst undertaking consulting and research projects in the general area. No fieldwork involving primary data collection was undertaken as part of this study.

- Individual groundwater users or specific boreholes that could potentially be impacted by the quarry were not identified during the specialist study.

3 DESCRIPTION OF AFFECTED ENVIRONMENT

3.1 Physiography and Climate
The study area experiences a Mediterranean climate with hot, dry summers and cool, wet winters. Average rainfall varies between 500mm/a and 600mm/a, but rainfall more
than 1,000mm/a occurs in the mountainous regions in the headwaters of streams draining through the mining area.

The quarry is situated on the southern slopes of the Houwhoek Mountains on relatively gently sloping land with low relief.

3.2 Geology

The geology at the quarry is dominated by the Cape Supergroup (comprising the Table Mountain Group and the Bokkeveld Group) and younger unconsolidated sediments of Tertiary to Recent age (Theron, 1984).

The Table Mountain Group (TMG) was deposited some 480 to 350 million years ago and represents shallow marine, glacial and fluvial depositional environments. The TMG comprises resistant quartzites, and sandstones and was extensively folded and faulted during the Cape Orogeny (280 – 220 million years ago). Most of the rugged topography and high-lying areas comprise rocks of the TMG.

The Bokkeveld Group conformably overlies the TMG and comprises a series of alternating shale and subordinate sandstone horizons. This group is also relatively susceptible to weathering and erosion and hence also forms low relief landforms.

Significantly younger unconsolidated sediments of Tertiary to Recent age are found on the coastal plains south of the Houwhoek Mountains and in floodplains along stretches of major rivers such as the Bot River. The nature, thickness and extent of these deposits vary significantly.

The property is mainly underlain by a TMG substrate with only the southern limit of the property underlain by Bokkeveld Group rocks covered by unconsolidated sediments. The TMG and Bokkeveld Group rocks are separated by a large north-northeast trending fault (Figure 1). The TMG rock on the property shows drastic variation. In the eastern part of the property the TMG consists of quartzitic sandstone that have a fractured nature but with no to very little chemical alteration of the rock. The stone quarry is located on this part of the quarry.

In the western part of the property deep weathering extending beyond 30m below surface, resulted in the complete alteration of the sandstone to a semi- to unconsolidated sand with a moderate to high clay content. This part of the property is occupied by the sand quarry.
Figure 1: Regional Geological map of the quarry (yellow area) and surroundings (Theron, 1984).

Figure 2: Plan of the Steyns Quarry defined by the red boundary. Borehole locality indicated by the yellow spot.
3.3 Aquifer Types

Based on lithostratigraphy considerations, various aquifer types are readily distinguished on the quarry site. Primary aquifers associated with unconsolidated deposits on the western and southern parts of the property are generally classified as major aquifer systems. It is recognised saturated thickness and hydraulic properties vary to some extent throughout the mining area. Groundwater levels are generally low on the low laying part of the property only (less than 20m below surface) and therefore considered vulnerable to mining impacts. On the steeper upper part of the property (north of the processing plant) the groundwater levels are much deeper due to the high relief caused by the local topography and not considered vulnerable to mining.

Aquifers associated with the TMG are also classified as major aquifer systems vulnerable to anthropogenic impacts (Meyer, 2000). Folding and faulting significantly enhanced the geohydrological properties of this Group, resulting in high yielding aquifer systems that produce relatively good quality groundwater. Depth to groundwater is expected to be variable, being relatively deep in the higher-lying mountainous slope at the stone and sand quarries.

3.4 Groundwater Users

Groundwater is used to various degrees at neighbouring properties. At Steyns Quarries it is used as potable and ablation water at the site offices. Only surface water is used during the processing of sand and stone in the washing plants.

Individual groundwater users in the immediate vicinity of the quarry were not identified during the specialist study. It appears that local groundwater users have been in co-existence with the quarry for decades with no impact on their access to ground water.
3.5 Soil

3.5.1 Land types and soil inventory
During the compilation of the land types and soil inventory, extensive use was made of the land type dataset. This dataset was compiled by the ARC-Institute for Soil, Climate and Water and contains the most comprehensive soil database for the whole of South Africa (Land Type Survey Staff 1972-2006). Because the inventory was completed on a 1:250 000 scale, it outlines individual land types, rather than individual soil units. Land types are compiled by grouping similar soils together, considering soil characteristics such as soil horizons, permeability, degree of leaching, average depth, average clay percentage and other structural limitations that might be of interest to the user. Terminology and classification was based on the official soil classification system for South Africa (Soil Classification Working Group 1977). The land type units are seen as areas with a homogeneous character where similar management practices can be applied across the unit. Although a compilation of the soil types within a land type unit is present, the precise distribution thereof is not.

The dataset contains individual land type unit polygons. The soil component is represented by the land type data at a scale of 1:250 000. These data can also be used at a scale of 1:50 000, but not for detailed planning and design as is expected for the construction phase. Regarding parent materials, the fine sandy soils owe their origin to deposition in valleys as stream sediments on floodplains, while the loamy and clayey soils have been derived from the underlying shale and granite deposits. For the formation of duplex soils, the significant influence of weathered shale and granite material is apparent (MacVicar et al., 1984).

Similarly, the topsoil of the duplex soils is susceptible to water erosion when disturbed, while the clayey subsoils show swell-shrink properties and therefore require special preventative measures to manage erosion.

3.5.2 Soil types

3.5.2.1 Mesotrophic to Dystrophic Soil
This soil unit occurs in the south-western limits of the property, and encompasses some 3% of the property. The soil is characterised by gravelly, sandy, clay loam of considerable depth (Figure 5).

Topsoil
The topsoil generally consists of a coarser-textured surface layer, overlying a structured clay horizon up to 55cm in depth. It is generally dark brown and grey in colour. The structure of the topsoil is typically poorly sorted, with the underlying horizon formed by moderate angular-blocky peds. Texture generally consists of loam to clay loam, with clay content of approximately 18% and sand and gravel content of 65%. The topsoil is structurally stable, with an Emerson rating of 8/3(1), indicating a low potential for dispersion.
These soil types represent soils that have experienced a high degree of leaching, rendering the soil relatively depleted of exchangeable ions. The clay content is generally moderate to low.

In places the soil tends to be more mesotrophic where it retains a fair percentage of nutrients resulting in a more fertile soil.

### 3.5.2.2 Sandy Duplex Soil

This soil unit is associated with the mountain slope areas, and encompasses some 75% of the property (Figure 5). The soil is characterised by dark grey to yellow-brown sandy and clay loam of varying depths (Figure 4). These soils can be identified by the accumulation of clay by illuviation in the B-horizon. Clay enrichment in the B-horizon results in a strong, blocky or prismatic soil structure. The B-horizon is often very hard and dense and is commonly an obstruction to root growth and water movement.

![Figure 4: Duplex soil profile at the edge of the sand quarry. Note the kaolinisation at the base below the E horizon.](image)

Topsoil

The topsoil generally consists of a coarser textured surface layer up to 35cm in depth, overlying a structured clay horizon. The topsoil is generally dark grey to light grey in colour. The structure of the surface layer is typically poorly sorted, with the underlying horizon formed by moderate angular-blocky peds. Texture generally consists of loam to clay loam, with clay content of approximately 22% and sand content of 60%. The topsoil is structurally stable, with an Emerson rating of 8/3(1), indicating a low potential for dispersion. The stones were generally rounded to sub-rounded. Surface stone cover observed to vary between 2% and 20%. Root penetration in the topsoil was noted as common.
Ferricrete development in these soils have been noted in the area and more so in areas of low lying and flat terrain where water during the winter months saturates the soil.

Subsoil
Yellowish-brown subsoils show strong consistence and are massive in structure. Textures consist mainly of light clays (dominated by kaolin), with clay content between 26% and 43%.

Stable subsoils indicate a low potential for dispersion, with Emerson ratings of 4 to 5. Root penetration in the soil was moderate in the initial subsoil to none low down, and stone content was typically between 5-10%.

Limiting Factors
Generally, the Sandy Duplex topsoil does not display any specific management risk related to potential disturbance during stripping. The lower level (B Horizon) clay subsoil is texturally and structurally unsuitable for stripping. The lower clay subsoils should not be recovered or used as a surface cover in rehabilitation, due to high clay content, massive structures, and alkalinity. Clay dispersibility results in soils that are prone to surface crusting and susceptible to severe erosion if not managed carefully.

Figure 5: Approximate distribution of the various soil types: Orange – Residual Soil; Red – Sandy Duplex Soil; Green – Alluvial Soil & Blue – Mesotrophic Soil.
3.5.2.3 Residual soils
This soil unit is associated with the high-lying, and more specifically the apexes, of hills and ridges in the study area, and encompasses some 12% of the property. The soil is characterised by dark grey to black clay loam of varying depths.

Topsoil
The topsoil generally consists of a coarser-textured surface layer, overlying a structured clay horizon up to 40cm in thickness. It is generally dark grey to black in colour. The structure of the top layer is typically poorly-sorted, with the underlying horizon formed by moderate, angular-blocky peds. Texture generally consists of loam to clay loam, with clay content of approximately 24% and sand content of 56%. The topsoil is structurally stable, with a high potential for dispersion. The stones were generally rounded to sub-rounded. Surface stone cover observed to vary between 5% and 20%. Root penetration in the topsoil was noted as common.

Subsoil
Brownish-grey subsoils show strong consistency and are massive in structure. Textures consist mainly of light clays, with clay content between 30% and 45%.

Stabile subsoils indicate a high potential for dispersion, with Emerson ratings of 1 to 2. Root penetration in the soil was moderate in the initial subsoil to none low down and stone content was typically between 5-10%.

Residual soils are products of in situ chemical weathering and thus their characteristics are dependent upon environmental factors of climate, parent material, topography, drainage, and age. These conditions are optimized during periods of warm, humid climates. In poorly drained parts of the quarry site the soil development trend is towards a montmorillonitic expansive black clay. The residual soils are susceptible to property changes upon drying, and exhibit compaction and strength properties not indicative of their classification limits. Conversely, black soils are unpopular for embankments.

Black expansive residual soils respond to lime treatment by demonstrating strength gains and decreased expansiveness. Rainfall induced landslides are typical of residual soil deposits.

3.5.2.4 Alluvial soils
This soil unit is associated with the low-lying areas in the southwest of the study area. The alluvial soil encompasses some 10% of the property. The soil is characterised by grey to light grey sandy loam of varying depths. This soil form is defined as a young, immature soil that is weakly altered with an increase in clay content with depth. The alluvial soil types are usually deeply developed soils with very few restrictions relating to permeability.
Topsoil
The topsoil generally consists of deeply developed sandy loam, fine-grained sand with a high organic content. It is generally grey to yellow white in colour. Texture generally consists of loam to clay loam, with clay content of approximately 14% and sand content of 68%. The topsoil is structurally stable, with an Emerson rating of 8/3(1), indicating a low potential for dispersion. Root penetration in the topsoil was noted as common.

Subsoil
Reddish-brown, unconsolidated subsoils show an increase in clay content in depth. Textures consist mainly of light clays, with clay content between 12% and 22%. Stabile subsoils indicate a low potential for dispersion, with Emerson ratings of 4 to 5. Root penetration in the soil was high in the initial subsoil to moderate low down, and stone content was typically between 5-10%. Stones comprise well-rounded gravel clasts located near or at the base of the soil profile.

Limiting Factors
Generally, the alluvial soil does not display any specific management risks related to potential disturbance during stripping. This soil may exhibit a high collapse potential when saturated with water.

4 IDENTIFICATION OF RISK SOURCES

Steyns Quarries have been mining sand and stone for decades at this locality. In general terms, geohydrological and soils considerations are unlikely to govern mine development and rehabilitation, processing plant and workshop and office locations as much of the infrastructure already exists. Further, threats posed by mining and processing to underlying aquifers are considered small. However, at a local scale, geohydrological criteria may be important, because of the consequence of impacts to groundwater users.

Four potential risk sources associated with the Steyns Quarries were identified. These are blasting and groundwater abstraction during construction, accidental spills and sewage and waste from the workshops and offices. Further, positioning of an infrastructure or mining pits near the southern part of the property, adjacent to the R43, also required consideration.

4.1 Impacts of Blasting

Inappropriate blasting in sensitive environments could result in changes to aquifer properties and borehole performance and structure. The impact of blasting and extent thereof is governed by the size and timing of the charge and the nature of the material being blasted. It is unlikely significant blasting will be required in areas underlain by Primary aquifers while the impact in weathered TMG aquifers is expected to remain localised. Blasting in the areas underlain by unaltered TMG aquifers, and to a lesser extent, Bokkeveld aquifers could be an issue of concern. This is particularly true in the eastern part of the property where blasting could impact boreholes and the yield of springs directly up-gradient. Expert opinion and consideration of local conditions is required to address this issue adequately.
By considering local conditions, proximity to boreholes, site blast characteristics and controlled blasting, the impacts of blasting can be mitigated. As a result, blasting would be of low to very low significance in the decision-making process.

4.2 Accidental Spills

Contamination of surface and groundwater as well as soils during mining operations can occur because of accidental spills and always remains a possibility. This applies to spills by both mining equipment in the mining area as well as equipment maintenance at the workshop and processing plant areas.

Because ongoing protection measures against groundwater and soils contamination from accidental spills are costly, prompt implementation of effective remedial actions is considered the only viable means of addressing this issue from a geohydrological and soils perspective. Groundwater and soil contamination and potential impacts to local users thus need to be included in disaster management plans and should be addressed in an operational Environmental Management Plan (EMP).

Pollution prevention and control of emergency incidents is addressed in Sections 19 and 20 of the National Water Act (Act 36 of 1998). Section 19 of the Act requires the person who owns, controls, occupies or uses land to take measures to prevent pollution or remedy its effects. Under Section 20, the person responsible for the accidental spill is responsible for remedying the effects of the spill.

4.3 Sewage and Waste from the Quarry

The potential threat posed by sewage and waste generated by the workshop and office buildings are expected to be of a similar order of magnitude of that of a small industrial site. Sewage disposal by means of a reticulated system, conservancy tank or soakaway and removal of waste will significantly reduce the threat and result in this issue being of very low significance in the decision-making process. This aspect requires consideration during the day to day operation of the quarry.

5 IMPACT DESCRIPTIONS AND ASSESSMENT

Given the above threats, the following impacts may be expected:

- Impact to aquifer properties and borehole yield and structure
- Localised over-exploitation of the resource
- Contamination of soil
- Contamination of groundwater

5.1 Impact to Aquifer Properties and Soils

It is possible blasting could impact aquifer properties and borehole performance and structure (Table 1). These potential impacts may be of low significance near Steyns Quarry where landowners have boreholes in close proximity to the quarry. Impacts to other groundwater users are expected to be of very low significance.
Blasting could either create new fractures or close existing fractures, thereby affecting the ability of water to be transmitted in the subsurface. Similarly, blasting could induce subsurface movement and result in rocks being displaced. This could cause a borehole to collapse or prevent the removal of pumps.

Proper blast site characterisation by a qualified blast expert and consideration of proximity to water supply boreholes could mitigate against potential impacts. This requires appointment of an appropriately qualified and experienced blast expert and identification of boreholes in proximity to blast areas. Blast site characterisation entails pre-blasting tests to assess site conditions and appropriate charges and techniques. Similarly, a hydro-census near blast areas will be required to identify boreholes that could potentially be impacted, with the extent of the hydro-census being guided by the blast expert.

Boreholes threatened by blasting will require detailed pre- and post-blast monitoring of groundwater levels, chemistry and abstraction to assess whether borehole performance had changed because of blasting. Similarly, the yield of threatened or important springs would have to be monitored. Intensity and duration of monitoring is to be decided by an appropriately qualified geohydrologist in consultation with the appropriate authorities and land owners.

5.2 Soil Contamination

It is not possible to predict or protect against accidental spills caused by mechanical failures. The impact of soil contamination during normal day to day mining activities is unlikely to be of major concern (Table 2). Because of the relatively small volume of fluids in mining equipment and the short duration of potential spills, impacts will remain localised.

Spills at the workshops is a more likely occurrence but is still a localized and relative low significance impact.

5.3 Groundwater Contamination

Because of the relatively slow rate of groundwater movement, spills of hazardous and other chemicals are expected to remain localised (Table 4). However, experience has shown the remediation of contaminated aquifers is technically difficult and generally expensive. Quick response to spills increases the success of remedial actions considerably.

Rapid response to mechanical failures and timeous implementation of remedial measures is the most practical mitigatory means of addressing this issue. Potential for groundwater contamination must be included in disaster management plans.

Similarly, the contamination threat posed by sewage and waste disposal at workshops and offices is expected to be no more than that of a small industrial site (Table 5).
These impacts are expected to be localised and of very low significance, even without mitigation.

**Table 1: Assessment of impact to aquifer properties and boreholes**

<table>
<thead>
<tr>
<th>POTENTIAL IMPACT</th>
<th>CRITERIA</th>
<th>Steyns Quarry</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Without</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mitigation</td>
</tr>
<tr>
<td>Impact to aquifer properties and individual boreholes caused by blasting and mining</td>
<td>Extent</td>
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</tr>
<tr>
<td></td>
<td>Duration</td>
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<td></td>
<td>Confidence</td>
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**Table 2: Assessment of impacts resulting from groundwater and soil contamination (accidental spills)**

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<td></td>
<td>Without</td>
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<td></td>
<td></td>
<td>mitigation</td>
</tr>
<tr>
<td>Impact to groundwater users and environment caused by accidental spills</td>
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<td>site</td>
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<td></td>
<td>Duration</td>
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<td></td>
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<td>Probability</td>
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<tr>
<td></td>
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<td>Status</td>
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<tr>
<td></td>
<td>Confidence</td>
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</table>

**Table 3: Assessment of impacts resulting from groundwater contamination and soil (sewage and waste from offices and workshop)**

<table>
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<th>POTENTIAL IMPACT</th>
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<tr>
<td></td>
<td></td>
<td>mitigation</td>
</tr>
<tr>
<td>Groundwater and soil contamination caused by sewage and waste generated by the office and workshop</td>
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6. **RECOMMENDED MITIGATION MEASURES**

At this stage, it is only possible to submit a set of generic mitigation measures. Most of the identified impacts can readily be mitigated so impacts are of very low significance. These include:

- Controlled blasting in potentially sensitive areas is to be preceded by blasting
site characterisation by a qualified blast expert. Water sources that could be impacted by blasting also need to be identified by means of a hydro-census. This should be undertaken by a qualified geohydrologist. Further, contingency plans need to be put in place should water supplies be disrupted, while replacement of boreholes may be required if borehole performance and / or structure are negatively impacted.

- Groundwater abstraction during construction is unlikely to impact adjacent groundwater users. However, the possibility for impact must be recognised and rates of abstraction must be set with proximity to groundwater users being considered.

- Any measures to reduce the likelihood of accidents and spills will reduce the risk of groundwater and soil contamination. However, rapid response to accidents and spills of hazardous and other chemicals is required to ensure the impact thereof remains localised and of low significance. The provision of alternative water supplies may be required if existing potable supplies are threatened. This issue is to be addressed in the EMP.

- Toilets at the offices and workshop can either be linked to a sewer system or septic tanks. If septic tanks are used, these should be properly maintained and no boreholes used for potable supply should be located within 50 m of the septic tank system.
REFERENCES


Theron, J N (1984): The geology of Cape Town and environs; Explanation of 1: 50 000 sheet maps 3318 CD and DC and 3418 AB, AD and BA, Geological Survey, Pretoria.