DRAFT ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED KLEINFONTEIN SETTLEMENT

Kleinfontein Portions 38, 90, 96 and Farm Kleinfontein 368 JR and Portions 63, 67, 68 and RE of Portion 14 of the Farm Donkerhoek 365 JR

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Part 2

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6.2.10 The prime objective of the application for the establishment of the land development area is, first and foremost, to regularize an existing situation (*de facto*) as also called for in the guidelines of the SDF. Any decision which may not accommodate the regularization of Kleinfontein will, by extension, create a somewhat invidious position for all concerned. The development at Kleinfontein cannot be ignored nor can it be expected that such development (of substantial proportions) must be removed, given that the adopted policy for the area did not properly acknowledge its existence in 2010. This fact is not a critiscm of the SDF and the manner in which it was formulated. Rather, it indicates factual circumstances where a substantial development was possibly overlooked, given its peculiar situational context.

6.2.11 The aforesaid circumstances can never serve as sufficient grounds to refuse the regularization of a development which has existed for a considerable time. If such a decision should be taken, it will set a dangerous precedent with regard to the various other informal settlements which have indeed been identified in the Spatial Development Framework (Status Quo Report). In this regard reference is made to page 55 of the Status Quo Report (copies enclosed under ***Appendix Q*** hereto) where the so-called "*Main Informal Settlements*" within the Kungwini jurisdiction were identified and denoted on the relevant map. The Settlement Strategy for Kungwini, inter alia, provided for the formalization of the various settlements for reasons similar to those which apply to the Kleinfontein Settlement. It would therefore appear that Kleinfontein Settlement should have formed part of the identified settlements listed in paragraph 2.9.4 of the Status Quo report of the SDF.

6.2.12 The Kleinfontein area is acknowledged in passing in paragraph 2.9.5 under the heading "*Illegal Developments*". However, other than a general description to the effect that the illegalities are to be rectified, the SDF does not venture into any other further detailed guidelines with regard to this matter. The somewhat curious distinction between so-called "*informal*" settlements and "*illegal*" developments in the Status Quo report must be considered in a circumspect manner. Both an "*informal*" settlement and what is described as an "*illegal*" settlement are of the same ilk when considering the prescripts of ruling legislation. The common denominator that such settlements (both informal/illegal) are not the subject of any formal approval by an authorized authority. An "*informal*" settlement is, by extension, "*illegal*" in the absence of any recognized authorization by a proper authority. In this regard the SDF should not attempt to distinguish between these land use categories.

6.2.13 In the above context it is evident that the initiative to regularize the Kleinfontein Settlement and to provide for its sustained development over time (by providing for a certain measure of expansion) and its unique mix of land use typologies (providing support for each other) motivate strongly in favour of approving the establishment of the land development area.

7. DEVELOPMENT PRINCIPLES OF THE DEVELOPMENT FACILITATION ACT, 1995

7.1 Any land development applicant seeking to establish a land development area, as contemplated in the Development Facilitation Act, 1995 (the "*Act*") is obliged to demonstrate compliance with the applicable and relevant Development Principles enshrined in the Act under Chapter 1 thereof. This applies equally to an application aimed at regularizing an existing settlement. Any decision-making authority such as a Development Tribunal or Municipality is bound by the provisions of the Act and, more particularly, the manner in which the Development Principles of the Act guide and inform decision making relevant to land development projects.

7.2 Having regard to the Commentary on the Development Facilitation Act, 1995 contained in Juta's New Land Law by Budlender, Latsky and Roux, it is evident that the single most important central theme of the Act is the integration of various aspects of land development, dealing with, inter alia:

- the spatial patterns;
- integrating all embracing development planning approaches with physical planning considerations;
- applying policy formulation as a technique to give direction to decision making; and
- using technical and procedural matters to achieve the stated objectives of development.

In the paragraphs to follow, the Land Development Applicant (the "Applicant") will demonstrate that, having regard to the planning initiatives undertaken by the Kungwini Local Municipality (the "*Municipality*") in preparing and adopting policies for its area of jurisdiction and bringing into effect a Spatial Development Framework proposal by the Applicant is positively aligned with the thought processes underpinning the provisions of the Act. The Applicant's proposal is also aligned with the new normative approach to planning and development. The application finds support in the context of the Development Principles enshrined in the Act and the prevailing policies affecting the area in which the subject properties are located.

7.3 In the Commentary by Messrs Budlender *et al*, it is acknowledged that many stakeholders in the land development field agree that inherited laws and policy directives which came about prior to the enactment of the Development Facilitation Act, 1995 were not always developmentally appropriate. It is therefore understandable that such previous planning laws and policies could not provide a holistic developmental framework within which to address spatial planning. It is now common knowledge that the Act has provided the country with a nationally uniform approach to spatial planning and development matters, including the important imperative to integrate physical land development planning into the overall planning system of the country. It is in this context that the Act also facilitated the creation of new policy frameworks by framing a set of Land Development Principles in Chapter 1.

7.4 Chapter 1 of the Act employs an unusual approach of providing principles in the form of legislation. By following this course of action, the Act empowers decision making authorities (i.e. Tribunal and Municipality) to apply their developmental visions to daily administrative tasks associated with land development projects. At the same time the principles reduce the likelihood of capricious or arbitrary decisions with regard to land development. The Applicant submits that the development proposal is the product of the informal settlement of land in a planned manner which, when properly analyzed, generally complies with the Development Principles which are dealt with in more detail below. This new approach to development planning, in a general sense, is intended to render the development environment more rational. The concept of informal settlement of land is fully acknowledged in the Act. The Act even incorporates certain extraordinary measures to facilitate speedy development processes where informal settlement is at issue. The regularizing of Kleinfontein Settlement should be evaluated against this background.

7.5 Chapter 1 of the Act deals with two sets of general principles namely:

- ***General Principles for land development***

  These are of a general nature and aim to guide decision making where relevant

- ***General Principles of Decision making and Conflict Resolution***

  These principles guide decisions of development tribunals and municipalities pertaining to land development. The Development Principles serve as guidelines by reference to which any competent authority, including a provincial tribunal, must exercise discretion or take decisions in terms of the Act or any other relevant law dealing with land development. It is in this regard that the applicant submits that the land development proposal finds support with reference to the relevant Development Principles read with the adopted policy framework for the area concerned. The more detailed principles are addressed below.

7.5.1 **Policy administrative practice and laws should provide for <u>urban and rural land development</u> and should facilitate development of <u>formal and informal, existing and new settlements</u>**

The relative weight or importance associated with different forms of land development is at issue here. This principle <u>aims to equalize</u> these aspects such that no particular form of land development may be <u>favoured to the detriment</u> of another. This also pertains to the intended regularization of an existing informal settlement at Kleinfontein.

7.5.2 **Illegal occupation of land should be discouraged with due recognition of informal land development processes (where relevant).**

This principle seeks to strike a balance between two competing considerations namely:

- the illegal occupation of land (or land invasion) which must be discouraged; and
- due recognition of informal land development processes.

The former is not particularly relevant in the circumstances, having regard to the locational context of the development area and the ownership thereof (a co-operative). In the context of the development proposal, the illegal occupation of land is not likely to occur as the development area is not a greenfield initiative. The essence of the application is to facilitate the regularization of an existing development in accordance with the adopted policies of the Municipality. The recognition of the informal development process at Kleinfontein is specifically relevant. To the extent that it is relevant, the applicant therefore complies with this principle in general terms.

7.5.3 **Efficient and Integrated Land Development should be promoted**

This is probably the most important principle from a land development perspective and focuses on the important premise that development should take place in an <u>integrated manner</u>, to achieve levels of efficiency which support longer term sustainable practices. The principle presents a vision of land development which goes far beyond the traditional approach to physical planning, expressly requiring that the physical aspects of land development should be integrated with other equally important aspects such as:

- Social;
- Economic; and
- Institutional considerations.

In the Kleinfontein context it has been demonstrated that the nature of the mixed land use regime is such that the larger settlement demands extensive expanses of land which, by implication, precludes a situational context within the confines of the defined urban development boundary. The integration of a sizeable agricultural component suggests that the Kleinfontein model must, of necessity, be situated in a predominantly rural setting. Kleinfontein presents both rural and urban type development and whilst the physical nature of the settlement is the produce of proper layout design and planning, the status of Kleinfontein remains inherently informal, given the absence of formal authorization in terms of ruling legislation.

From an environmental perspective, sustainability is also required in the context of integrated land development. In this regard an environmental evaluation process has been conducted in the context of Regulation 31 to the Act, also involving interested and affected parties and stakeholders. Suffice it to confirm that in all relevant respects, the existing and anticipated impact on the receiving environment does not appear to militate against the intended regularization of the Kleinfontein Settlement. Typical mitigating measures required for the upgrading of infrastructure will more than adequately address the environmental concerns relevant to the development proposal.

It has been demonstrated that the Kleinfontein Settlement provides a wide range of social, economic and educational amenities to compliment the residential/agricultural components. To this extent the local integration of such components has already occurred successfully, in compliance with the relevant principles of the Act.

7.5.4 Members of Communities Affected by Land Development should participate in the development process

In the period leading up to the submission of the application in terms of the Act, there were various stages during which members of the affected community and other stakeholders were offered the opportunity to participate in the land development process namely:

- During the planning process associated with the creation of the SDF, independent facilitators arranged a number of meetings/work sessions with identified parties, including representatives from the local residents, local councillors and others. The approach to creating guidelines for the Kungwini area was presented to the various stakeholders on a number of occasions and opportunities were granted for comment and input.

- Representatives of the land owner/applicant made contact with the local residents during the Environmental Assessment process. The opportunity to raise issues for further investigation was presented during the Regulation 31 Environmental process.

- During the notification process associated with the application for the establishment of a development area in terms of the Development Facilitation Act, 1995, a completely separate participation process was conducted, allowing interested parties to raise issues/objections.

It follows that the members of the affected communities were indeed offered ample opportunity to participate in the process of land development. Being a co-operative, the land owner (applicant) indeed represents those individuals who reside at Kleinfontein. It follows that the applicant is also the affected community within the existing settlement.

7.5.5 **Skills and capacities of disadvantaged persons should be developed as part of land development processes**

This principle aims to transfer skills during the process of land development. Consultants forming part of the larger project team appointed by the Land Development Applicant generally report to representatives of the owning co-operative who, in turn, derive benefit from being involved in the planning process, gaining new insight and skills as the matter unfolds. When the time comes for construction, it will be prudent for the Land Development Applicant to involve companies who are involved in the area, with a view to effecting the transfer of skills.

7.5.6 **The contribution of all sectors of the economy (both government and non-government) to land development should be optimised and encouraged.**

This principle aims to discourage extreme approaches to land development by the possible exclusion of certain sectors of the economy. Joint partnerships between Government agencies and private sector companies is generally encouraged through the application of this principle. It is matter of record that the private and municipal sectors co-operated in developing the guidelines which now inform the application for consideration by the Development Tribunal (SDF). In addition, other government agencies (SANRAL and Gautrans) have been indirectly involved in the context of a larger roads scheme associated with the national road and the provincial road K169. It follows that there has indeed been collaboration between private and public sectors in respect of this matter.

7.5.7 **The principle dealing with the requirement that land development policies should be clear and generally available and should provide guidance to promote trust and acceptance to those affected by it.**

This principle generally applies to the Government sector, where policy guidelines and legislation are created. The SDF is not very specific with regard to Kleinfontein other than stating that its "illegal" status should be rectified. This is indeed part of the relief sought by the applicant. To the extent that it may be relevant to the application under consideration, there has indeed been compliance with this principle.

7.5.8 **Sustainable land development at an appropriate scale should be promoted.**

Various sub-principles are provided under this heading, aimed generally at discouraging approaches to land development which are unlikely to make a substantial contributions over time. The Land Development Applicant has submitted an application which supports the notion of a truly mixed use settlement combining a mix of land use typologies in a sustainable manner, such that the various components may be inter-dependent on one another whilst also providing support for each other.

Considerations relevant to geotechnically sound conditions or any other form of hazard which may be associated with the area will also inform this principle. This application is based on sound information, provided by an array of consultants, including geotechnical experts and various consulting engineers responsible for analysing the area in as far as it may be required to prove sustainability.

The test of sustainability, to a large extent, will be whether the settlement will be maintained as a viable enterprise, once it has been formally established. Kleinfontein has existed for a considerable period, fully maintained and sustained in a self-sufficient manner. In regularizing the settlement certain more stricter standards of service delivery will be enforced further supporting the fact that Kleinfontein is indeed a sustainable settlement.

7.5.9 **Speedy land development**

This principle does not place an obligation on the applicant, but rather on the authorities that consider and manage land development applications. In this regard the decision-making authorities are committed to efficient and effective procedures, in accordance with the development principles, introduced to facilitate speedy development.

7.5.10 **No one land use is more important than any other**

This principle determines that each proposed land development area and land use category should be judged on own merits. The merits of regularizing the proposed multi-use land development area have been appropriately demonstrated. An existing integrated development will be regularized by the approval of this application. In turn, the Municipality will be placed in a position to regulate the ongoing use of the land, based on adopted minimum standards for this type of development.

7.5.11 **Security of Tenure**

The development will be privately owned in freehold title. Security of tenure is ensured.

7.5.12 **Co-ordination of Land Development**

The optimal use of land remains important and in this regard development should be co-ordinated to ensure that such development can address specific needs and requirements in a changing environment. The regularization of mixed land uses will support co-ordinated land development and will result in optimised use of existing infrastructure.

7.5.13 **Promotion of Open Markets and Competition**

The Kleinfontein development can be regarded as a response to a specific market demand and a specific attempt to ensure that the demand for an integrated development is satisfied. The approval of the land use rights and subsequent development on the property will lead to promotion of an open market (i.e. freehold title ownership vs. communal ownership at present). In all relevant respects, the application complies with the Development Principles enshrined in the Act.

8. SPECIALIST REPORTS IN SUPPORT OF THE APPLICATION

8.1 ENVIRONMENTAL SCOPING REPORT

8.1.1 In terms of the provisions of Regulation 31 to the Development Facilitation Regulations, the applicant is obliged to include a Scoping Report to properly inform the decision to be taken by the Development Tribunal. This must not be confused with the further obligation on the land development applicant to possibly also have to comply with the provisions of parallel legislation such as the

National Environmental Management Act, 1998 (Act 107 of 1998) or other legislation. The Scoping Report contemplated in Regulation 31 is specific to the provisions of the Development Facilitation Act, 1995 and it must be considered that the Development Tribunal *per se* is not an authority responsible for granting environmental authorisation (or refusing same). Rather, the environmental issues to be addressed in the Scoping Report are to inform the decision to be taken by the Tribunal with regard to the land development application.

8.1.2 In ***Appendix A*** to the application bundle, the Scoping Report prepared by Messrs Bokamoso Environmental Consultants has been enclosed. The investigations which preceded the preparation of the scoping report indicate a number of sensitivities which attach to the subject property which would, under normal circumstances (i.e. a greenfield development) have a different bearing on the decision to be taken by the Tribunal. Although certain more sensitive areas have been identified which, inter alia coincide with the existing development footprint of as built structures on the subject property, the reality which presents itself in this regard is the fact that the development on the land is a *fait accompli* and the evaluation of environmental sensitivities must therefore be considered against this background.

8.1.3 The report concludes that, whilst a number of impacts have indeed been identified, mitigations and adaptive monitoring should generally result in limited adverse impacts on the receiving environment. In the final analysis, the sensitivities which may be identified in terms of the environmental authorisation process under the National Environmental Management Act, 1998 (Act 107 of 1998) may indeed identify parts of the larger Kleinfontein site assembly which should be kept free of development. Such final conditions will be forthcoming from the relevant department at provincial level, responsible for environmental matters. Considering that such matters have not been concluded, the final decision of the Tribunal with regard to the layout plan (in phased format) may well be influenced on by the decisions and conditions of the environmental authorities.

8.1.4 The current layout plan, enclosed for approval by the Tribunal, to a large extent, identifies the areas which are anticipated to be excluded/avoided for development purposes. Alternatively, the development envisaged on such areas will be of a lesser extent when compared to the more densely developed residential component of the existing settlement.

8.1.5 The environmental scoping did indeed also identify a number of positive outcomes which may be anticipated should the Kleinfontein Settlement be properly regularized and be properly contained, so as not to expand in an unchecked manner. These include:

- Contributions to the upgrading of infrastructure and engineering services in the area.
- Overall beneficial positive economic and related impacts (i.e. job creation, security of tenure).
- An improvement of security levels in the area.
- Upgrading of roads (both internal and external to the subject property).
- The proper protection of certain wetland and sensitive areas through proper zoning and "*ring fencing*" upon registration of the regularized land development area.
- An improvement of the general "sense of place" associated with the area, based on proper urban management and the enforcement of municipal bylaws and associated regulatory mechanisms.

8.1.6 The environmental scoping report includes a number of recommendations which may further serve to enhance the final product, should it be approved by the Tribunal. These include:

- The implementation of a proper stormwater management plan.
- The provision of open space linkages to counteract fragmentation of local habitats.
- The development of an ecological management plan for open space areas, to protect biodiversity and related environmental considerations.
- The preparation of detailed plans with regard to engineering services networks and the upgrading of the latter where required, to meet minimum standards.

8.1.7 Whereas the environmental scoping report has identified a number of relevant considerations which may affect the decision of the Tribunal, the reality of the existing development at Kleinfontein must be taken into account. To the extent necessary, the undeveloped parts of the larger land assembly must be subjected to stringent environmental management and control mechanisms, to ensure longer term sustainability. These include the proper demarcation of 4 identified wetlands (including associated 15 metre buffer zones), to be retained as natural open spaces within the development. The demarcated wetland areas are illustrated by way of superimposition on ***Map 9*** hereto, indicating the layout plan proposals for the larger Kleinfontein Estate and the demarcated wetland and 15m buffer zones in each instance.

8.2 CONVEYANCER CERTIFICATE

8.2.1 A Conveyancer's Certificate prepared by the Conveyancer Mr PJ Viviers is enclosed under ***Appendix B*** to the application bundle. The component land portions are generally affected by Conditions of Title reserving historic water rights in favour of parties in the vicinity of the subject property. In general terms, the issue of water rights has become *pro non scripto* and has been replaced by the provisions of the National Water Act, 1998. As such the conditions of title making reference thereto may be suspended by the Tribunal, so as to free the component land portions from such encumbrances.

8.2.2 Certain portions are encumbered by servitudes of right of way, alternatively for the conveyance of electricity or similar matters. In such instances, the servitudes will either be protected in the conditions of establishment where such servitudes affect certain erven within the land development area, alternatively be cancelled and rerouted to the satisfaction of the relevant authority.

8.2.3 Certain historic grazing rights are protected in favour of land owners of other portions of land in the area and as a result the beneficiary of the grazing rights needs to be informed of the intention of the land development applicant so as to make arrangements accordingly. If possible, the servitude protecting the grazing rights will have to be cancelled by way of agreement, alternatively in circumstances where the parties so notified do not respond to the invitation of the Tribunal to present his or her case, the servitudes may be suspended.

8.2.4 There are no other conditions of title or servitudes which militate against the approval of the application by the Tribunal. Certain bonds encumber certain of the component land portions and in this regard the consent of the bondholders has been procured and has been enclosed under ***Appendix H*** to the application bundle.

8.3 GEOTECHNICAL REPORT

8.3.1 A Phase 1 Engineering Geological Investigation has been completed to satisfy the requirements of Regulation 30 to the Development Facilitation Regulations. The report by Messrs Holland Muter and Associates is enclosed under ***Appendix C*** to the application bundle. The aim of the investigation was to determine, on a preliminary basis, if the terrain is suitable for development or whether obvious geotechnical problems occur which will restrict or prevent the execution of the existing and future development at Kleinfontein.

8.3.2 The report confirms that, topographically, the site is characterized by an undulating landscape, including a ridge extending west to east and culminating in a crest occurring along the north-eastern boundary of the site. This takes the form of a watershed, sloping towards the south-west, north and south. This results in a number of tertiary drainage channels which originate in the higher lying topography and form a drainage system which feeds into the tributaries of the Pienaars River.

8.3.3 The report makes reference to an outcrop of scattered rock which occurs on the terrain, mainly associated with the Hillcrests. A description of the rock formations includes reference to Diabase, Shale and Quartzite. Soils are described as soft rock, shale, diabase gravels. Transported colluvium is coarse and medium and fine, resulting in sands including clayey sands. The report makes reference to the fact that permeability of the soils is generally low, whilst a high water table is found in the areas associated with quartzite.

8.3.4 No obvious founding problems were foreseen for light residential structures, subject to further determination of on site engineering properties prior to construction. The report notes that the terrain is home to vast amounts of construction material available for road construction and other purposes. With regard to the sloping nature of the land, the report confirms that generally, the topography is flat and should not give rise to any instability.

8.3.5 The report includes the mapping of various units described with regard to the suitability thereof for housing development. With reference to ***Map 10*** hereto:

- the north-eastern area is regarded as a zone with good land use potential which can be used for any type of development.
- In the central, northern and eastern areas, the report concludes that the zone has good land use potential in a general sense.
- As far as the north-western area is concerned, the zone illustrates a fair land use potential.
- The southern area also displays a fair land use potential.
- The area which displays poor land use potential is generally described as affecting the central/northern, and southern areas and the northern and central/southern areas and the southern/western area.

8.3.6 The so-called "*Priority Development Zones*" identified in the report are illustrated by reference to ***Map 10*** hereto, indicating an overlay of the zones and illustrating the existing as built configuration of the Kleinfontein Settlement. From this it appears that the least favourable zones for housing development are restricted to areas which have not been designated for substantial development (either to accommodate existing development or for proposed future development). To this extent the geotechnical investigation generally accords with what is proposed by the land development applicant as illustrated on Layout Plan 600/588/02 hereto.

8.4 TRAFFIC INVESTIGATION

8.4.1 Messrs Techworld Consulting Engineers have prepared a Traffic Investigation Report (***Appendix D***). In general, the existing traffic demand versus supply in the study area indicates that the existing road network is sufficient to support the development (both existing and planned components of Kleinfontein). Further investigations of certain intersections may be required including:

- Terminals of road D483 (Cullinan Road) and the N4 interchange.
- Intersection of Road D483 (Cullinan Road) and the Northern Access Road (Kleinfontein Road).
- Intersection of Road D483 (Cullinan Road) and Road D964 (Renosterfontein Road).
- Intersection of Road D483 (Cullinan Road) and Road D631 (Boschkop Road).
- Intersection of Road D483 (Cullinan Road) and Road P6-1 (Bapsfontein Road).
- Intersection of Road D964 (Donkerhoek Road) and Road D631 (Boschkop Road).
- Intersection of Road D631 (Boschkop Road) and Road D2762 (Graham Road).

8.4.2 Certain upgrading proposals are contained in the report including reference to:

- The upgrading of road D1342 (Renosterfontein Road)
- The intersection of the Northern Access Road (existing Kleinfontein Road) with road D483 (Cullinan Road)
- The intersection of Road D1342 (Existing Renosterfontein Road) with Road D483 (Cullinan Road).
- The intersection of the Southern Access Road (new road) with road D631 (Boschkop Road).

8.4.3 The improvements are to be determined on a phased basis, when the larger Kleinfontein is approved and to be incrementally registered as separately identifiable phases to accord with available engineering services capacity, road access and related considerations. The report concludes that the regional accessibility of the application site is excellent, given the major road network in the area. It is also confirmed that none of the planned k-routes (provincial routes) will traverse the application site although the southern part of the application site may border the road reserve of the planned K-40 provincial road. To the extent necessary, the road reserve for K-40 will be excluded from the application site.

8.4.4 As far as road D1342 is concerned (the Renosterfontein Road), a 30m road reserve is proposed to be excluded from the township application site, so as to accord with the requirements of the Gauteng Department of Roads and Transport. In general, the traffic report does not identify any major flaws that may militate against the approval of the land development area.

8.5 CIVIL ENGINEERING SERVICES

8.5.1 A report prepared by Messrs PVA Consulting Engineers CC is enclosed under ***Appendix E***. Having regard to the situational context of the subject property, it is evident that the settlement is not served by existing formal engineering services networks associated with the responsible municipality or any other service provider.

8.5.2 As far as water supply is concerned, groundwater resources are utilized and the report confirms that water storage tanks will be provided throughout the settlement for such purpose. Initially the abstraction of groundwater from boreholes will be followed by the pumping thereof to the holding tanks, whereafter reticulation within settlement will be attended to. Future phases may be served from external sources, such as a relevant Water Board.

8.5.3 As far as sanitation is concerned, similar circumstances apply, given that the settlement is not linked to any formal municipal system. Current sewage disposal is managed via septic tank and seeping trench systems. Although a proposed sewer network system has been planned and parts thereof have been commenced, the system is not yet complete. The network intends to link the effluent from individual septic tanks and thereafter to redirect the effluent to an undeveloped area of the larger site assembly in a collective seepage trench, separated from existing ground water sources.

8.5.4 Matters such as the abstraction of groundwater and the management of sewage effluent are generally regulated through the provisions of the National Water Act, 1998 for which purpose water use licenses are required for various activities listed in said legislation. The proposal includes the development of a so-called "activated sequential batch reactor sanitation plant". This will involve an activated sludge waste water treatment process, utilizing an aerator and mixer process. Purified effluent will thereafter be reusable. The technical requirement in this regard precludes the positioning of the plant which may allow discharge of effluent water below any demarcated 1:100 year floodline.

8.5.6 Internal roads within the settlement are to be retained as private roads which will ultimately vest in the co-operative or similar legal entity and will not be taken over by the Municipality. As far as stormwater drainage is concerned, the extent of the land assembly (some 793ha) results in the fact that the pre- and post-development stormwater discharge volumes are very similar and this is indicative of the fact that the impact of the development on the receiving environment is limited. As a result, the fully developed scenario of the intended development is not expected to increase the discharge of stormwater to any great extent. The engineers propose that, at concentrated points of discharge, retention facilities be installed, aimed at preventing erosion and to reduce the velocity of the discharged stormwater to acceptable levels.

8.5.7 As far as waste removal is concerned, the report confirms that the co-operative property owners association or similar legal entity will be responsible for the collection of refuse and the management thereof on site to a point where it may be removed by an external service provider to, for instance, the licensed landfill site in Rayton. The latter falls under control of the Municipality.

8.5.8 Considering the challenges of on site engineering services and self sufficiency, the report does not identify any major concerns, save for the availability of groundwater for purposes of larger development. The abstraction of groundwater will always be regarded as an interim measure until development in the area justifies a linking to an external piped water source. This may take the form of a future municipal system alternatively a service provider such as Magalies Water or Rand Water or similar. It follows that the "ring fencing" of the phase of the larger settlement dependent on the currently available groundwater source will be important, so as to negate the prospect of permitting physical development beyond the available volume of potable water (in situ) and until an alternative source becomes available.

8.5.9 The Development Facilitation Act provides for the phasing of an approved land development area. It is in this regard that the available potable water (proven by Geohydrological Study and appropriate tests) will define the extent of development that may be accommodated in the short/medium term, based on the available water resource in a sustainable manner. Future phases of the development will therefore be dependent on alternative sources which will develop over time.

8.6 ELECTRICAL SERVICES

8.6.1 Under ***Appendix F*** to the application bundle, a services report prepared by Messrs Burotech Electrical Engineers has been inserted. The report confirms that the Kleinfontein Settlement is currently supplied by Eskom via the Tweedracht/ Donkerhoek 11 kV feeder. It appears from historic consumer accounts and records that the notified maximum demand for the settlement has rounded off to approximately 1,2 MVA, whilst the total estimated load comes to some 18,3MVA.

8.6.2 It must be considered that such load estimations are based on the entire development occurring in physical terms. It is evident from the submissions herein that the settlement will take place incrementally. The focus will, of necessity, be on the as built development within the residential enclave, whilst future expansion will be held in abeyance until sufficient supplies of engineering services (including bulk electricity) become available therefore.

8.6.3 This is the principal reason for providing the option of phasing in the Development Facilitation Act, 1995. It follows that, on the basis of the existing demand and the available network from Eskom, the ring fencing of the permitted development (dependent on the existing supply) will inform the phasing. Future expansion will therefore be made subject to additional external sources before being permitted to be registered.

8.7 GEOHYDROLOGICAL REPORT

8.7.1 Messrs Aurecon have prepared a geohydrological report, a copy of which is enclosed under ***Appendix H*** to the application bundle. The desktop study was undertaken to inform the land development application to the extent possible, in the knowledge that further more detailed site specific studies will follow, depending on the requirements of the responsible authorities and with due regard to the intended phasing of the development over time.

8.7.2 The information available to the consultants indicate a good quality of water being available for domestic use, associated with the existing aquifer in the vicinity. It appears that some 70 000m^3/a was previously recorded, based on a split of 50% from an existing fountain on the subject property and 50% from a number of boreholes on the subject property.

8.7.3 It appears that the Department of Water Affairs holds records of registered water usage exceeding the aforesaid quantities by some measure (more than 70%) whilst no formal water use license exists for the area. It follows that these matters are to be regularized through the provisions of the National Water Act, 1998 and applications for the appropriate water use licenses will be processed for such purpose.

8.7.4 Whilst the current sewage disposal system (septic tanks and seepage trenches) holds an identified risk for groundwater, it appears that the alternative construction of an activated sequential batch reactor will replace the latter and, if found to be acceptable to the relevant authorities, will dispense with the anticipated risk of groundwater being contaminated. The report concludes with certain recommendations including that borehole testing be undertaken to verify the available information followed by a hydro census including testing of neighbouring boreholes (on neigbhouring properties). Also, certain water quality monitoring and testing will be required to satisfy the stipulations of the controlling authorities.

8.8 DEMOGRAPHIC PROFILE AND MARKET DEMAND

8.8.1 Under Appendix I to the application bundle, a report on the market research findings and recommendations for the Kleinfontein mixed use development as prepared by Messrs Demacon Market Studies has been included. The demographic overview include:

- Number of people resident in Kleinfontein end 2011: 980 people
- Number of resident households: 380 households
- Average household size: Approximately 2,6 persons per household
- Approximately 48% of the resident community comprises retired persons/ pensioners.

The anticipated take up of new housing units within Kleinfontein was projected as follows:

- Between 2011 and 2016: approximately 285 new households (i.e. 48 units per annum across the full housing spectrum). The report recommends that such a project (with specific reference to the report) should be developed in phases. The first phase focusing on the first ten year period, and to provide ... for approximately 200 units for a range of erf sizes affordability levels.
- Based on the existing and anticipated residential growth within the confines of Kleinfontein Settlement, it is recommended that a convenience type shopping centre in the order of 1723m² (say 2000m²) gross leasable area should be provided as far as office accommodation is concerned, the recommendations suggest a gross leasable area of between 961m² and 2072m² over the period extending to 2022.
- As far as a light industrial development is concerned, the report recommends a floor area component of some 10 250m² gross leasable area punitively height space of some 2.05ha and for the period extending to 2022.
- As far as educational facilities are concerned, the report concludes that there is demand for an additional school within the Kleinfontein Settlement aimed at approximately 156 learners to be accommodated within the period extending 2016.
- As far as medical facilities are concerned, it is recommended that a day clinic be developed with the capacity of 7 beds for the period extending to 2016. As far as the frail care medical facility is concerned, certain recommendations are inserted with regard to the provision of 2, 3 and 4 bedded wards to compliment the existing care facility within Kleinfontein. As far as land use budgets are concerned, the anticipated take up of land to provide for the aforesaid facilities will require:
    - Approximately 33,3 ha to accommodate economic uses; and
    - Approximately 35 ha to accommodate residential expansion.

8.8.2 The Kleinfontein Settlement is not a typical development seeking to serve the general housing market. As a result, the typical market analysis and projections are not specifically relevant to the development which, to an extent, is self generating and has little to do with general market demand. The above indicators of required land for expansion and the take up rate anticipated for the Kleinfontein Settlement should therefore be considered against the above background. The sustainability of the development (from an economic perspective) is not specifically dependent on a certain number of land transactions per annum. What remains relevant is the intended scale of development envisaged for the larger estate which, based on the economic indicators provided by Demacon, remains sound and within reasonable limits. The greatest determinant with regard to the development at Kleinfontein will be the provision of potable water and associated engineering services which will unfold in a phased manner. The overall land supply in Kleinfontein is sufficient to accommodate the anticipated growth projected in the market study report and no considerations relevant to the economic and market demand indicators militate against the regularisation of the existing development at Kleinfontein.

9. CONCLUSIONS

9.1 Kleinfontein Settlement is an existing facility which accommodates approximately 980 persons (residents) in a self contained development, midway between Pretoria in the west and the Bronkhorstspruit in the east.

9.2 The residential component of Kleinfontein has been laid out in a formal pattern and is serviced by on site reticulated engineering services, utilizing fountain and borehole water abstraction, septic tank, sewage disposal and Eskom power.

9.3 The residential component is supported by a small commercial enclave including local retail facilities, financial facilities and the like. A school (pre-primary and primary facilities) is provided within the settlement whilst a retirement facility (frail care centre) is also on offer.

9.4 Large expanses of land owned by the Kleinfontein Co-operative remain largely undeveloped and are earmarked for agricultural small holdings.

9.5 It is intended to regularize the existing settlement through the establishment of a land development area as contemplated in the Development Facilitation Act, 1995 whilst simultaneously providing for a measure of future expansion based on incremental phases which may be permitted according to available service supply (specifically water and related services) over time.

9.6 The Kleinfontein Settlement is inherently informal in that it enjoys no official approval from any recognized authority. The physical development has been executed according to acceptable standards and an array of specialist reports support the proposals of the applicant. There appear to be no specific considerations which militate against the approval of the application by the Development Tribunal.

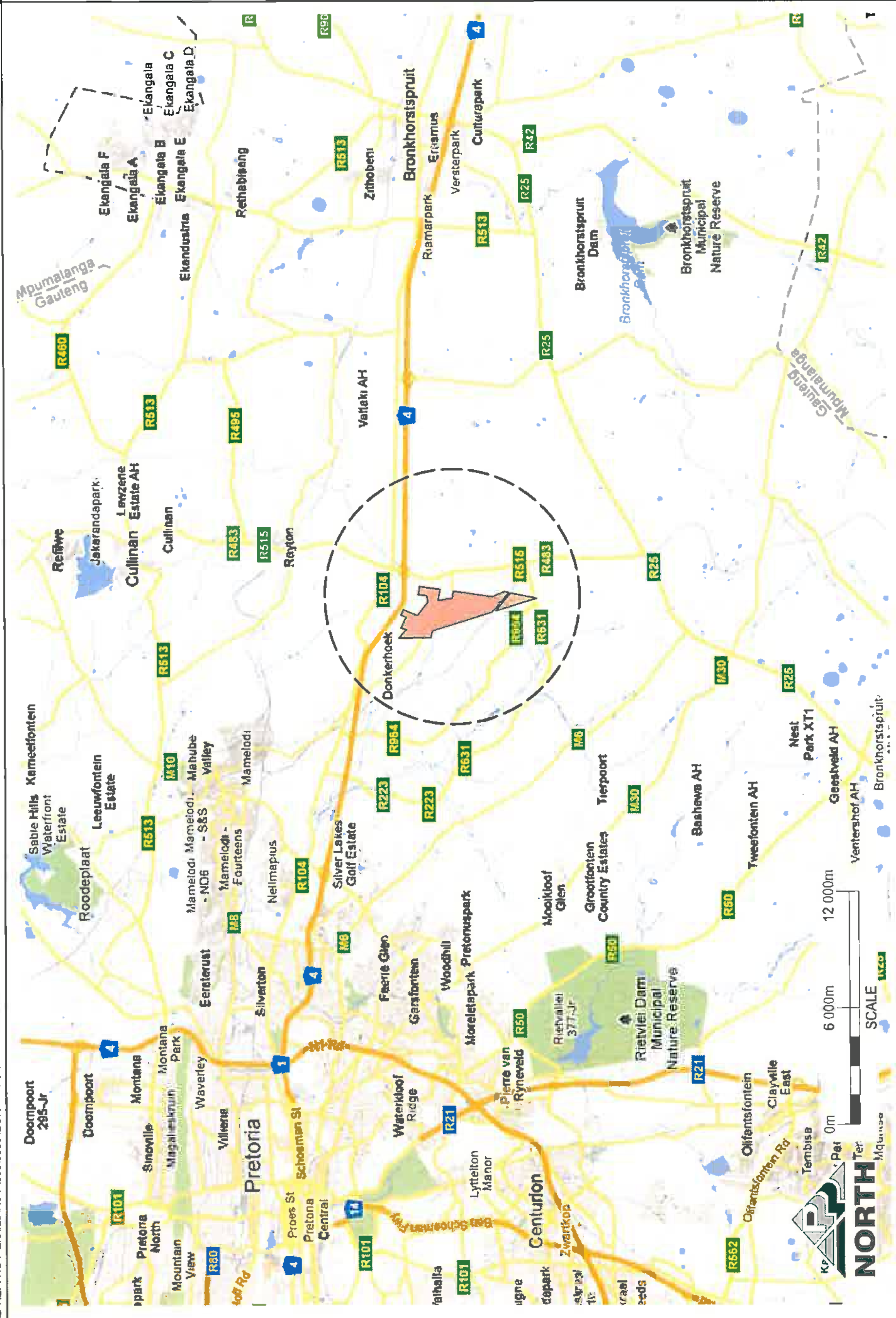
MAP 1

LOCALITY MAP: REGIONAL CONTEXT

THE PRACTICE GROUP

LOCALITY MAP - REGONAL CONTEXT

MAP 1



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MAP 2

LOCALITY MAP: LOCAL CONTEXT

LOCALITY MAP - LOCAL CONTEXT

MAP 2

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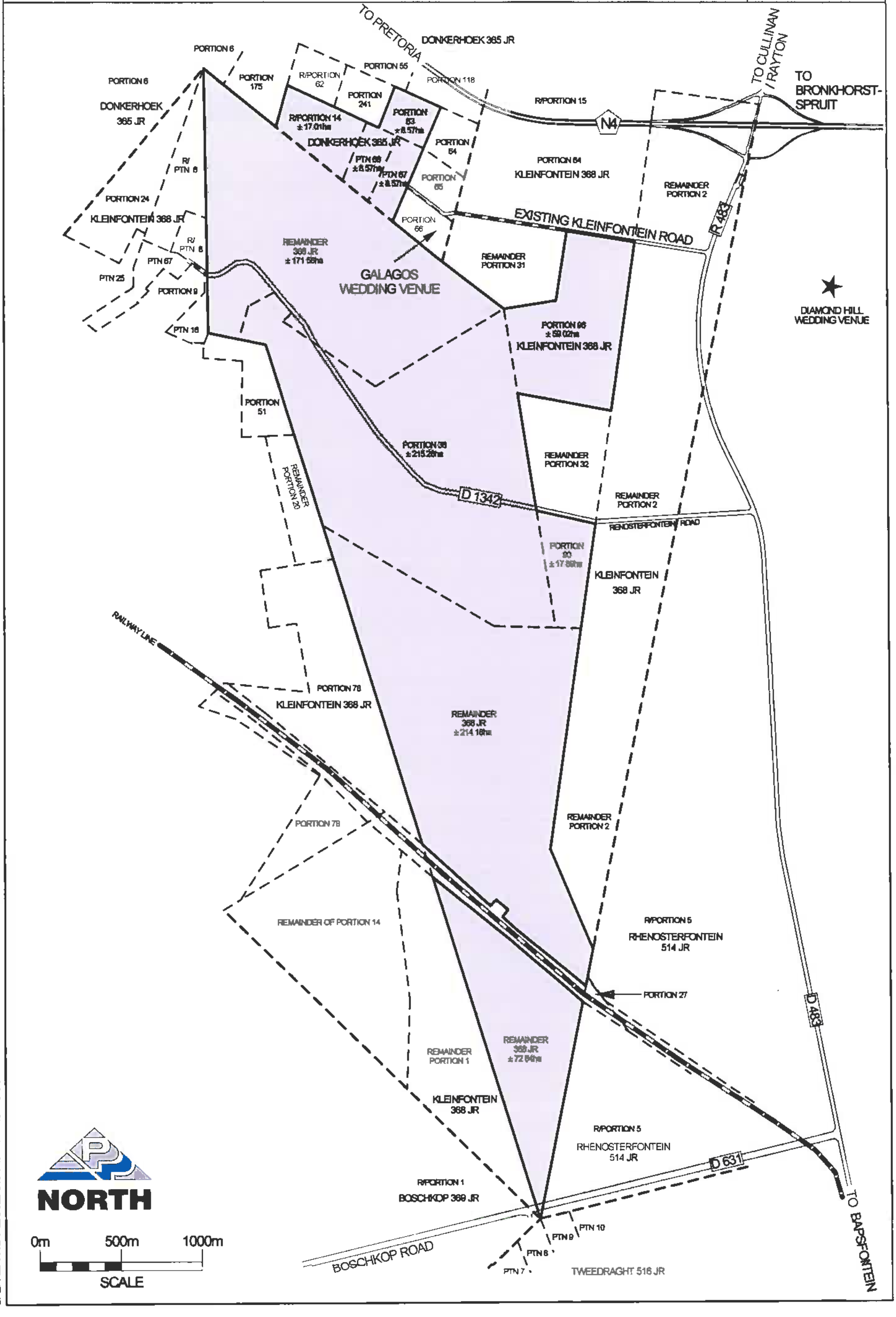
MAP 3

SITE COMPOSITION

THE PRACTICE GROUP

SITE COMPOSITION

MAP 3



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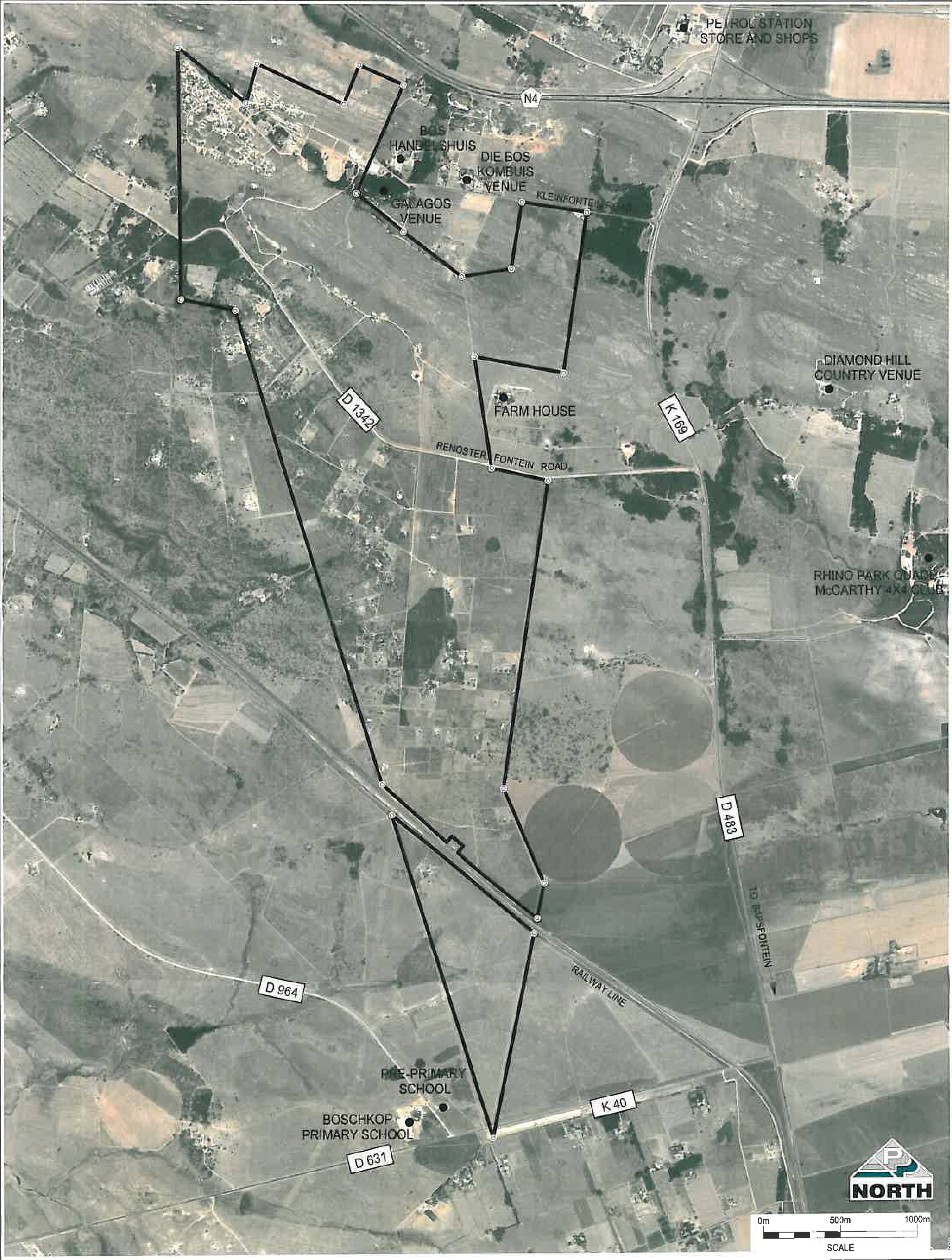
MAP 4

AERIAL PHOTO

THE PRACTICE GROUP

AERIAL PHOTO

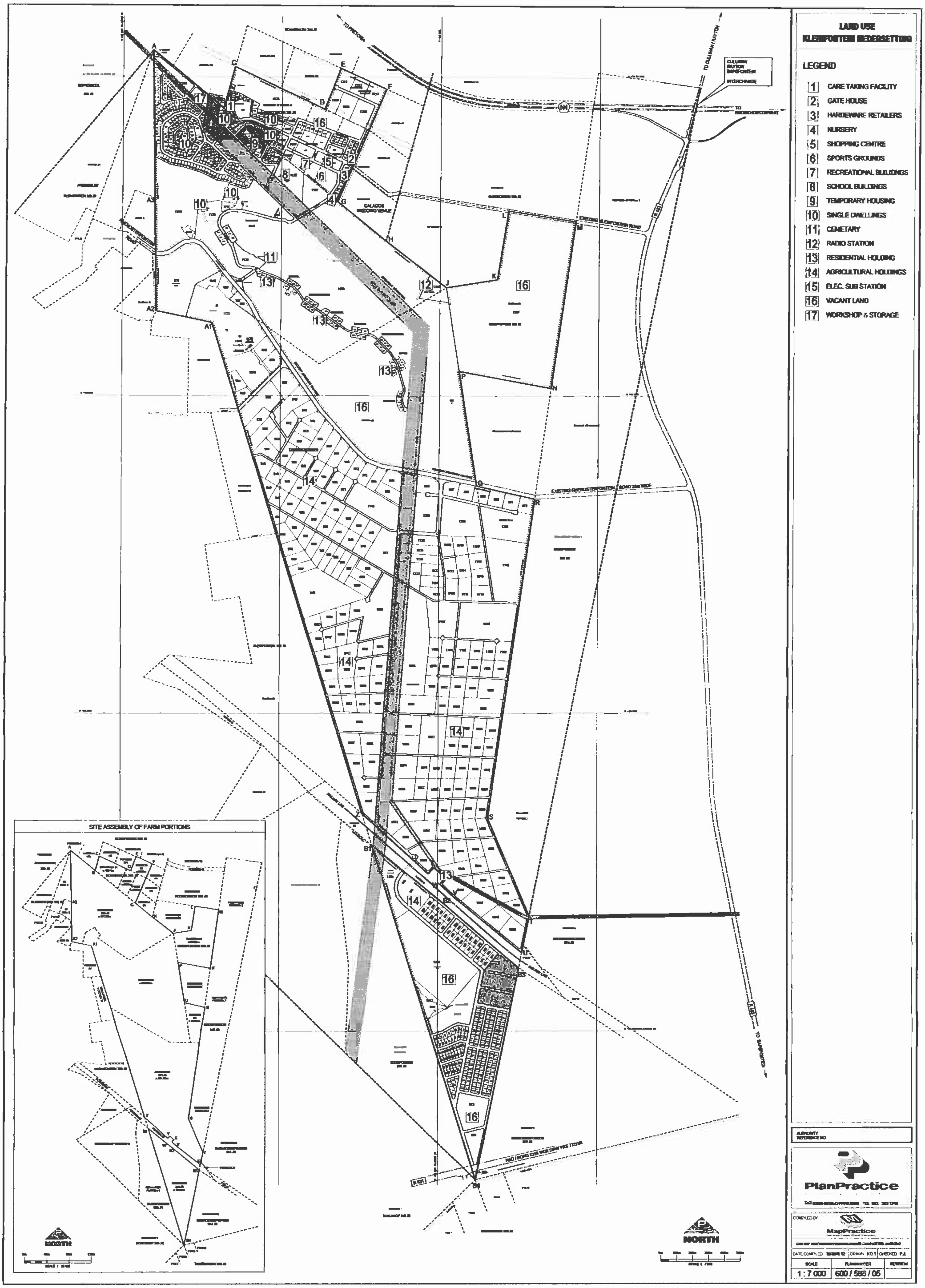


PP 600/588

MAP 5

LAND USE

THE PRACTICE GROUP


LAND USE
KLEINFONTEIN NEDERSETTING
LEGEND
1 CARE TAKING FACILITY
2 GATE HOUSE
3 HARDEWARE RETAILERS
4 NURSERY
5 SHOPPING CENTRE
6 SPORTS GROUNDS
7 RECREATIONAL BUILDINGS
8 SCHOOL BUILDINGS
9 TEMPORARY HOUSING
10 SINGLE DWELLINGS
11 CEMETARY
12 RADIO STATION
13 RESIDENTIAL HOLDING
14 AGRICULTURAL HOLDINGS
15 ELEC. SUB STATION
16 VACANT LAND
17 WORKSHOP & STORAGE
SITE ASSEMBLY OF FARM PORTIONS
TO PRETORIA
TO CULLINAN / RAYTON
TO BAPSFONTEIN
EXISTING KLEINFONTEIN ROAD
NORTH
AUTHORITY
REFERENCE NO
PlanPractice
COMPILED BY
MapPractice
DATE COMPILED
DRAWN K.D.T
CHECKED P.A
SCALE
1 : 7 000
PLAN NUMBER
600 / 586 / 05

MAP 6

DEVELOPMENT TRENDS

THE PRACTICE GROUP

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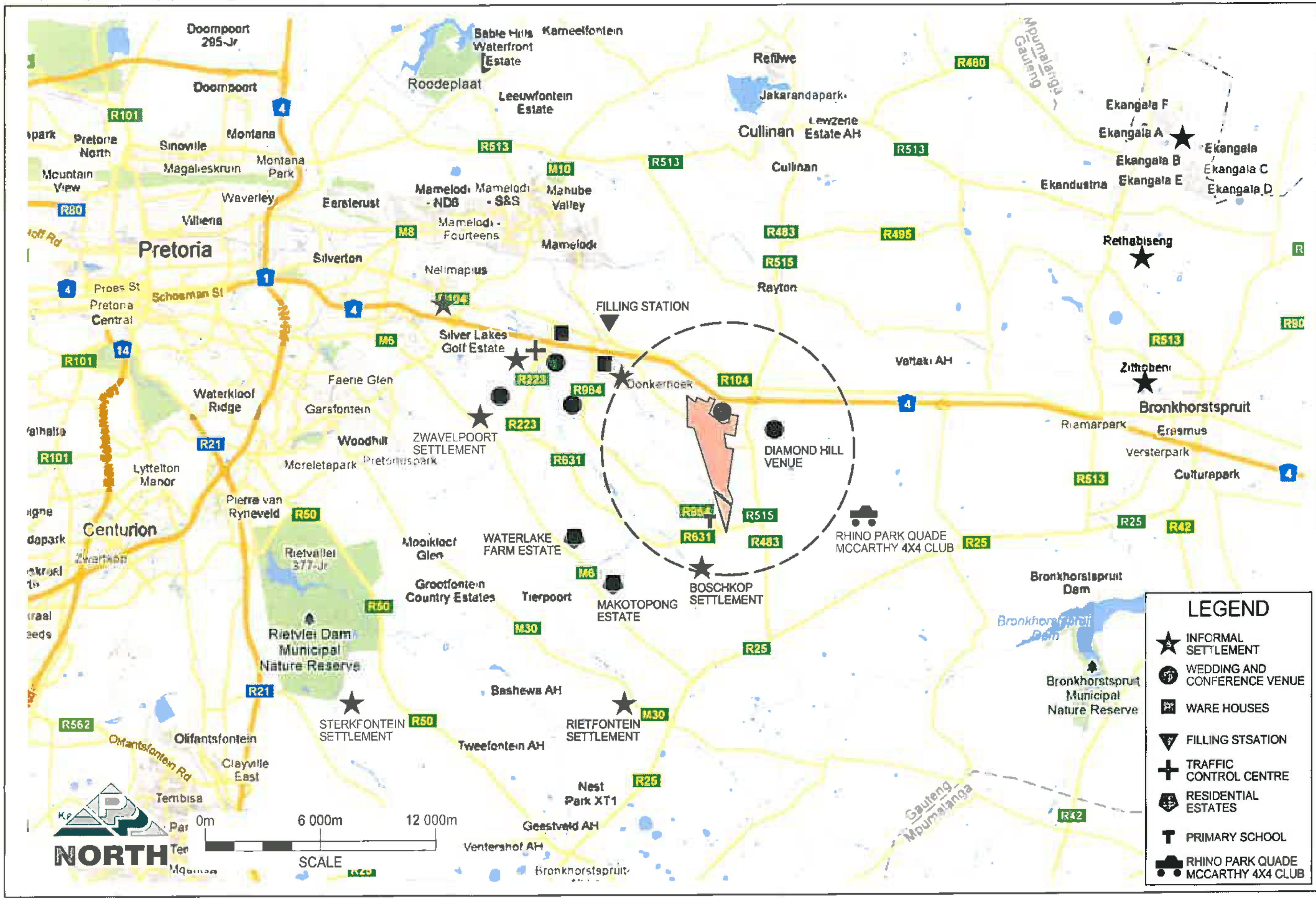
DEVELOPMENT TRENDS

MAP 6



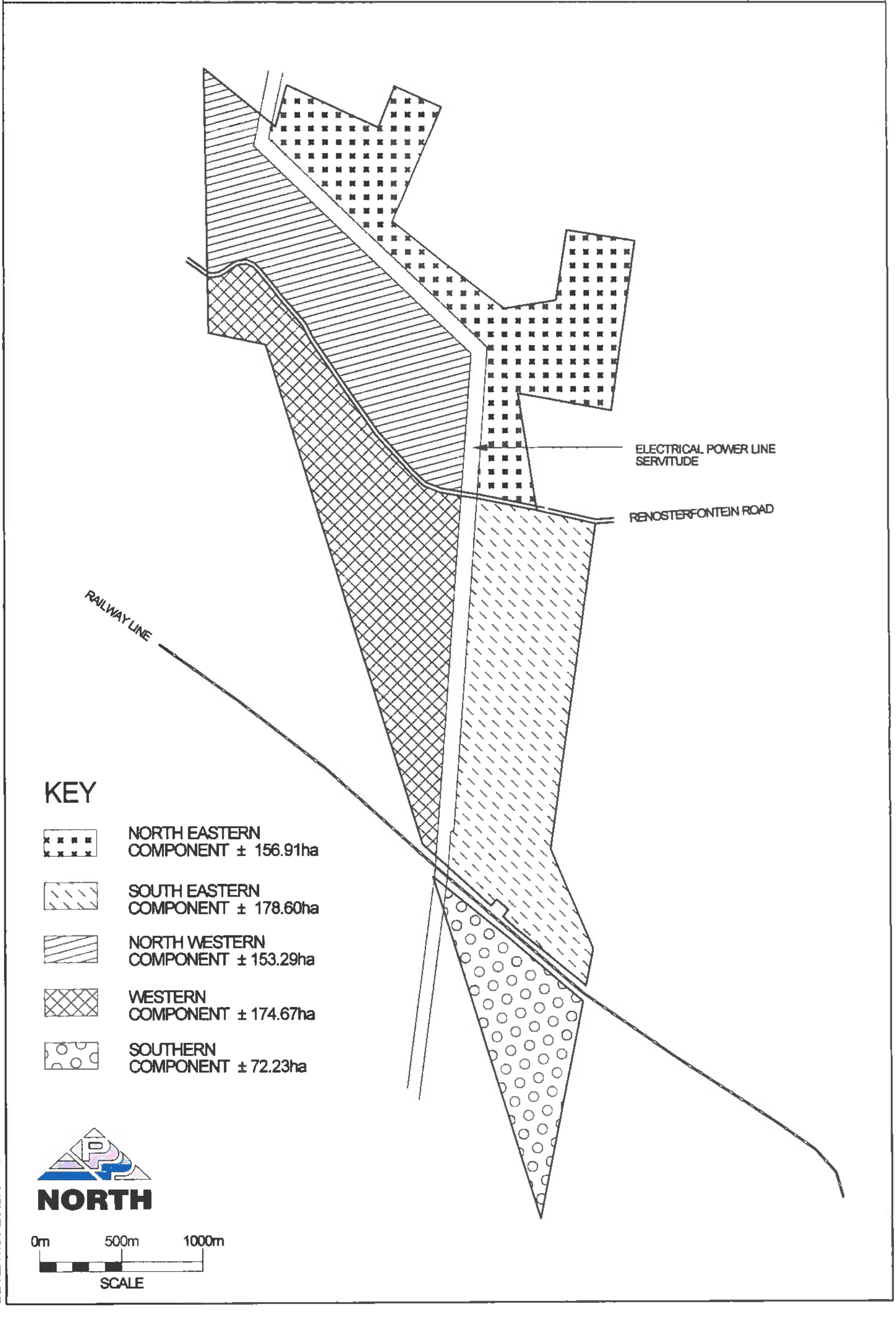
MAP 7

GEOGRAPHICAL COMPOSITION

THE PRACTICE GROUP

GEOGRAPHICAL COMPOSITION

MAP 7



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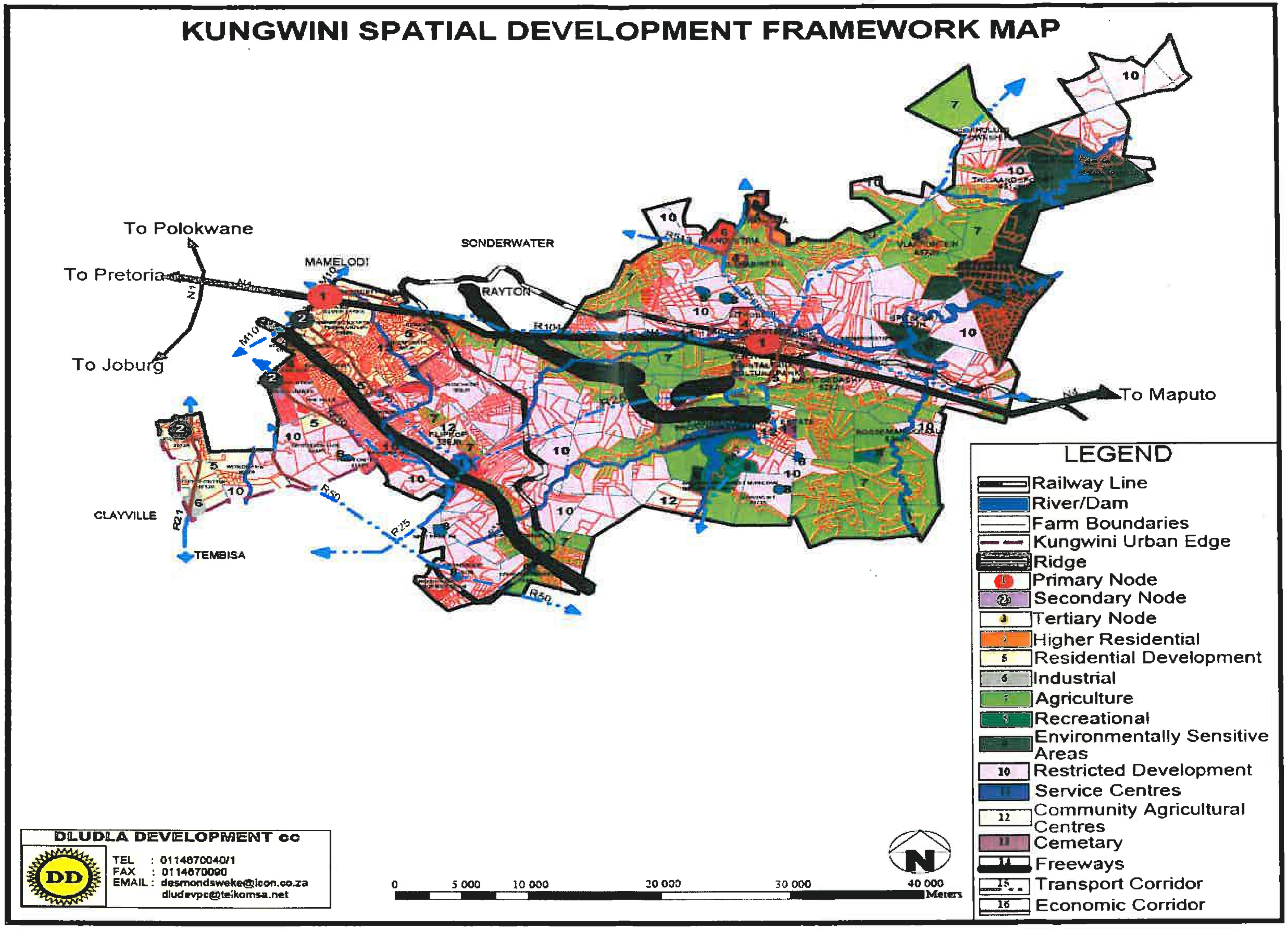
MAP 8

EXTRACT FROM THE KUNGWINI SDF 2010

THE PRACTICE GROUP


KUNGWINI SPATIAL DEVELOPMENT FRAMEWORK MAP
To Polokwane
To Pretoria
To Joburg
MAMELODI
SONDERWATER
RAYTON
CLAYVILLE
TEMBISA
To Maputo
LEGEND
Railway Line
River/Dam
Farm Boundaries
Kungwini Urban Edge
Ridge
Primary Node
Secondary Node
Tertiary Node
Higher Residential
Residential Development
Industrial
Agriculture
Recreational
Environmentally Sensitive Areas
Restricted Development
Service Centres
Community Agricultural Centres
Cemetary
Freeways
Transport Corridor
Economic Corridor
DLUDLA DEVELOPMENT cc
TEL : 0114670040/1
FAX : 0114670090
EMAIL : desmondsweke@icon.co.za
dludevpc@telkomsa.net
0
5 000
10 000
20 000
30 000
40 000
Meters

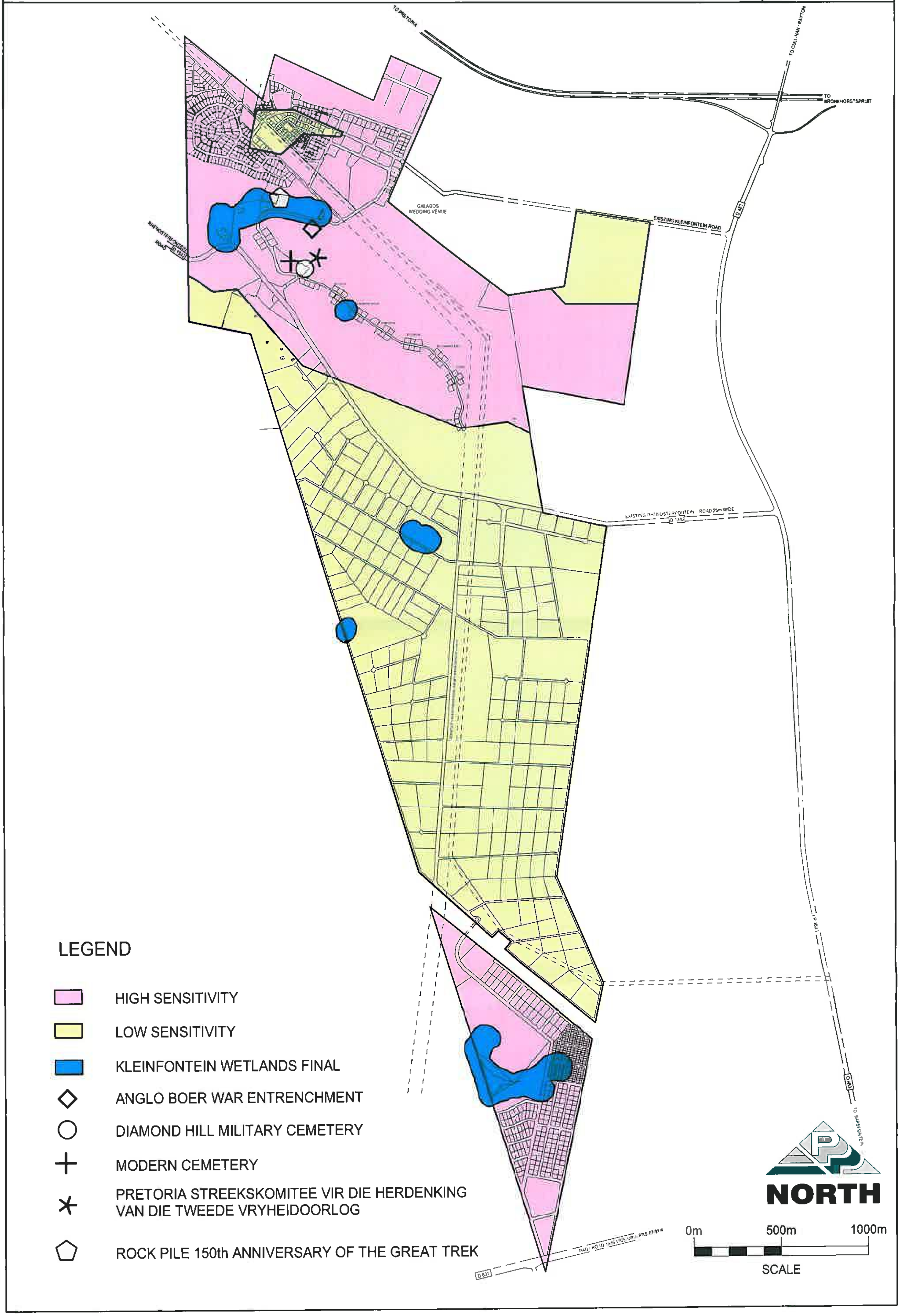
MAP 9

ENVIRONMENTAL SENSITIVITY MAP

THE PRACTICE GROUP

ENVIROMENTAL SENSITIFITY MAP

MAP 9



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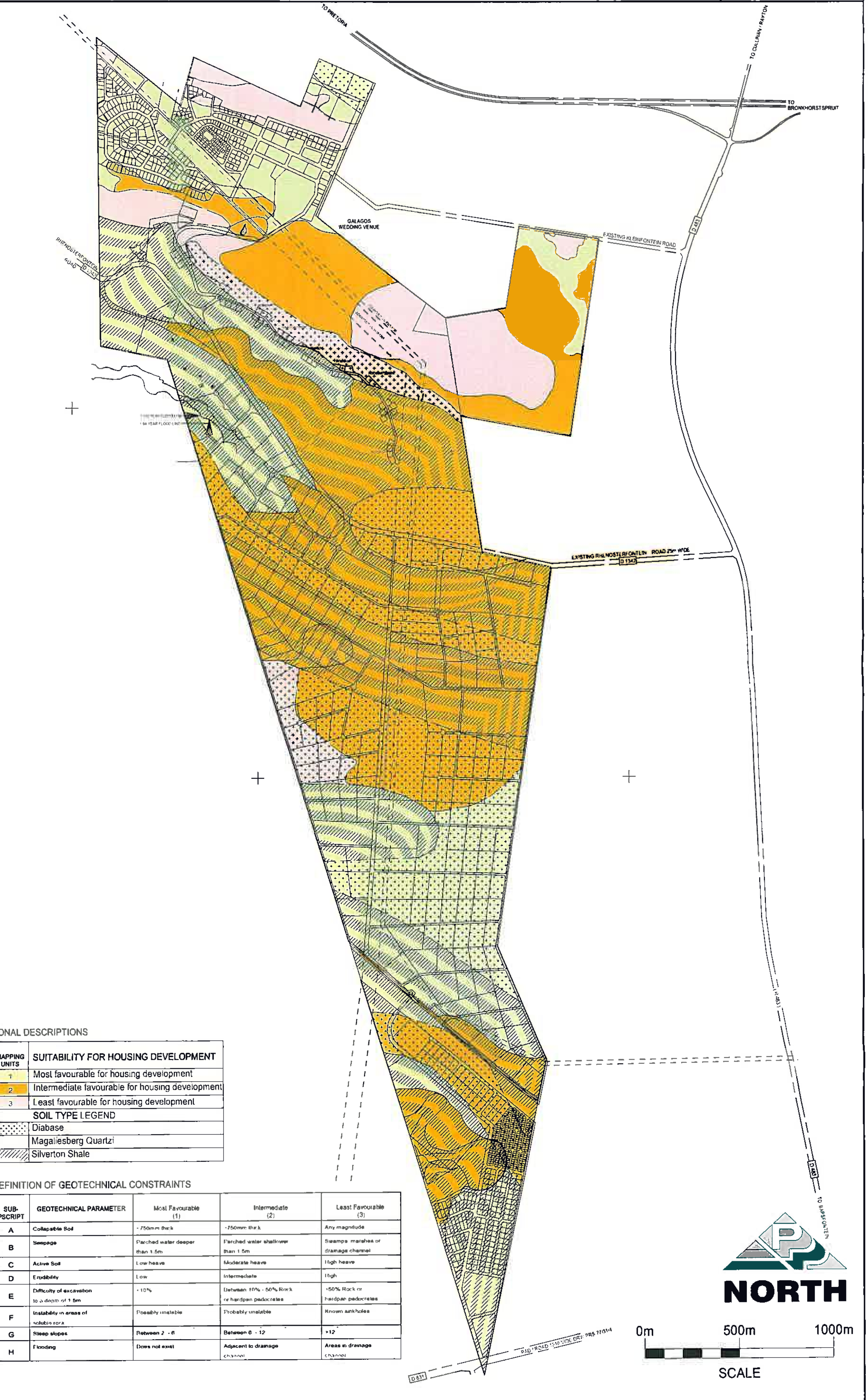
MAP 10

GEOTECHNICAL ZONES

THE PRACTICE GROUP

GEOTECHNICAL ZONES

MAP 10



ZONAL DESCRIPTIONS

MAPPING UNITS	SUITABILITY FOR HOUSING DEVELOPMENT
1	Most favourable for housing development
2	Intermediate favourable for housing development
3	Least favourable for housing development
	SOIL TYPE LEGEND
	Diabase
	Magaliesberg Quartzi
	Silverton Shale

DEFINITION OF GEOTECHNICAL CONSTRAINTS

Severity of constraint & Pcost increases from A-H

SUB-PSCRIPT	GEOTECHNICAL PARAMETER	Most Favourable (1)	Intermediate (2)	Least Favourable (3)
A	Collapsible Soil	<750mm thick	>750mm thick	Any magnitude
B	Seepage	Parched water deeper than 1.5m	Parched water shallower than 1.5m	Swamps, marshes or drainage channel
C	Active Soil	Low heave	Moderate heave	High heave
D	Erodibility	Low	Intermediate	High
E	Difficulty of excavation to a depth of 1.5m	<10%	Between 10% - 50% Rock or hardpan pedocretes	>50% Rock or hardpan pedocretes
F	Instability in areas of soluble rock	Possibly unstable	Probably unstable	Known sinkholes
G	Steep slopes	Between 2 - 6	Between 6 - 12	>12
H	Flooding	Does not exist	Adjacent to drainage channel	Areas in drainage channel

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Annexure G

SPECIALIST REPORTS

Annexure G(i)

Geotechnical Report

Phase I (Planning)

Engineering Geological Investigation for the KLEINFONTEIN SETTLEMENT

(Located on Kleinfontein 368 JR: Portions 38, 90, 96 and the remaining extent and Donkerhoek 365 JR: Portions 63, 67, 68 and the remaining extent of Portion 14)

City of Tshwane Metropolitan Municipality

DATE : November 2011
REPORT NO : LM 919/11

Holland-Muter & Associates CC
Reg. No: 2001/000656/23

Engineering and Environmental Geologists
P.O. Box 1450 Faerie Glen 0043
Tel: (012) 991-2695 Fax: (012) 991-0796 Cell: 083 455 2610
e-mail: lhmuter@lantic.net

ABSTRACT

This report details and comments on the results of a Phase I (Planning) Engineering Geological Investigation conducted for the Kleinfontein Settlement. The site is located on the farms Kleinfontein 368 JR : Portions 38, 90, 96 and the Remaining Extent and Donkerhoek 365 JR : Portions 63, 67, 68 and the Remaining Extent of Portion 14 – City of Tshwane Metropolitan Municipality.

INDEX

APPENDICES

FIGURES

PHASE I (PLANNING) ENGINEERING GEOLOGICAL INVESTIGATION FOR THE KLEINFONTEIN SETTLEMENT SITUATED ON VARIOUS PORTIONS OF THE FARMS KLEINFONTEIN 368 JR AND DONKERHOEK 365 JR : CITY OF TSHWANE METROPOLITAN MUNICIPALITY

Report No : LM 919/11, October 2011
Our Ref : HM&A PP KLEINFONTEIN SETTLEMENT

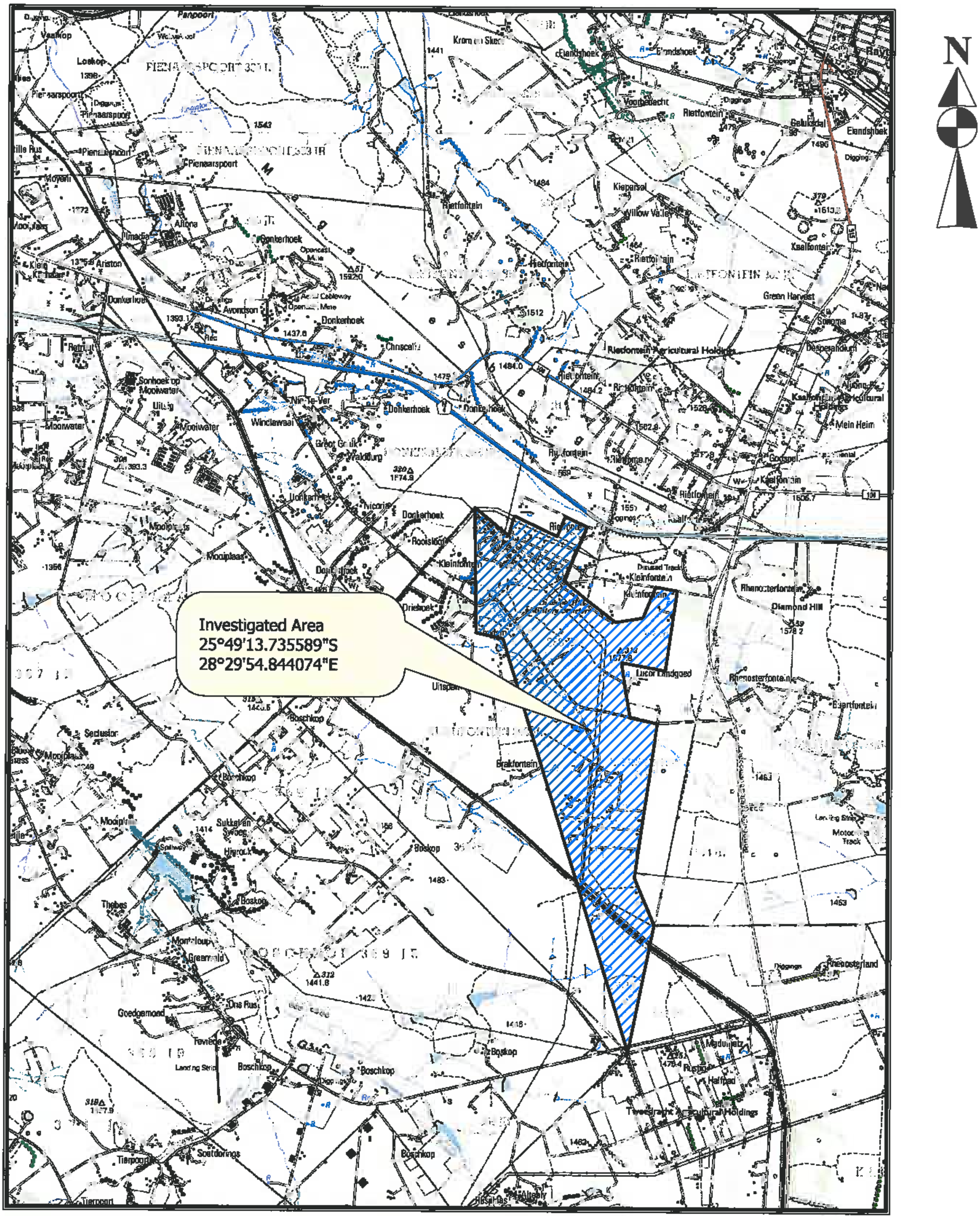
1. INTRODUCTION

1.1 GENERAL

This report details and comments on the results of a Phase I (Planning) Engineering Geological Investigation conducted for the Kleinfontein Settlement. The site is located on the farms Kleinfontein 368 JR : Portions 38, 90, 96 and the Remaining Extent and Donkerhoek 365 JR : Portions 63, 67, 68 and the Remaining Extent of Portion 14 – City of Tshwane Metropolitan Municipality. The site is located south of the N14 national road, west of the R483 road, north of the R964 road and to the east of the Donkerhoek Agricultural Holdings. A secondary road bisects the site from the southeast to the northwest (See Figure 1 : Locality Map). The terrain constitutes approximately 721hectares which comprises of a settlement area in the north and mostly agricultural holdings to the south.

1.2 AIM OF THE INVESTIGATION

The purpose of the study was to determine, on a preliminary basis, if the terrain is suitable for development or whether obvious geotechnical problems occur which will restrict or prevent the execution of the existing and future development.



Legend

Investigated Area

Scale 1:75000

0 1 2 km

HOLLAND-MUTER & ASSOCIATES CC; P.O. BOX 1450; FAERIE GLEN; 0043

FIGURE 1 : LOCALITY MAP : KLEINFONTEIN SETTLEMENT :
Located on Kleinfontein 368 JR : Portions 38,90,96 ,and the remaining extent and
Donkerhoek 365 JR : Portions 63,67,68 and the remaining extent of Portion 14.

DATE: NOVEMBER 2011

DRAWING NR : 101

1.3 BRIEF

To determine by means of a desk study and field walk-over study what the noticeable soil conditions are. This study will serve as a preceding phase to the subsequent detail geotechnical survey which will have to be conducted during the formal development phase for certain geotechnical constraints.

2. AVAILABLE INFORMATION

The following information has been used in the investigation and assessment of the terrain:-

2.1 Topographical & Geological maps 2528 CD RIETVLEIDAM on a scale 1:50 000.

2.2 Geological map 2528 PRETORIA on a scale 1:250 000.

2.3 Orthophotograph on a scale 1: 10 000.

2.4 Proposed Layout Map on a scale of 1 : 7 500

3. SITE DESCRIPTION

3.1 TOPOGRAPHY & DRAINAGE

Topographically the site is characterized by an undulating landscape comprising of a west to east stretching ridge with a hill crest elevation of 1577m above mean sea level occurring along the north-eastern boundary of the investigated area. This higher lying Magaliesberg Quartzite forms a clearly defined watershed which slopes towards the southwest, north and south. Several tertiary drainage channels originate in the higher lying topography and drain the area with an angular drainage system towards the tributaries of the Pienaars River. The pattern of the drainage system reflects that it is controlled or influenced by the local geology, intrusive or geological structures. From the tones on the aerial photographs, the potentially wet surface areas or near-surface groundwater conditions could be identified. These conditions occur along the drainage features, in the low lying marshy areas and isolated areas where the quartzite, layered shale or intrusive andesite interface with the surface slopes. The gullies occurring on the terrain reflect the textural composition and cohesiveness of the surrounding soils. All the drainage basins indicate an open character and have V-shaped drainage channels indicating granular and less cohesive soil materials.

Outcrop and scattered rock outcrop occur on the terrain along the hill crests and topographically moderate side slopes which are mantled by a thin layer of colluvium which consists of coarse grained sands while thicker pediment characterises the lower footslopes of the terrain. The pediment slopes comprise mainly of fine silty sands or sandy silts which may serve as a host of a variety of pedogenic materials or where it occurs on diabase materials, comprises of silty clays.

3.2 CLIMATE

The terrain lies in the Transvaal Highveld in the sub-humid, warm climatic zone. The site has a relatively high seasonal rainfall of more than 600mm. The Weinerts N-value is close to 2 indicating that chemical weathering dominates the physical weathering. This results in a specific soil profile to be expected over the entire site.

3.3 VEGETATION

The vegetation is typically that of the Temperate Grasses which consists primarily of grasslands and scattered trees. Acacia is prominent on the diabase dykes and andesite lavas while sparse grass covers the quartzite ridges.

4. GEOLOGY

4.1 GENERAL GEOLOGY (See Figure 2, Appendix I and Table 3- Page 10)

The investigated area is underlain by materials of both sedimentary and volcanic origin which vary from transported colluvium to insitu quartzite, shale and andesite rock while alluvial materials occur in the flood plains and drainage channels. These rock types belong to the Magaliesberg Quartzite Formation and Silverton Shale Formation of the Pretoria Group which have been intruded by diabase sills and dykes.

4.1.1 Rock Description

Diabase

The diabase occurs as narrow dykes or sills and outcrops as scattered boulders within a clayey soil matrix which predominates the surface. The fresh rock is very hard, fine to medium grained and greenish-grey in colour.

Shale

The shale is silty and locally graphitic with thin interbeds of limestone. This material comprises of soft to hard, olive grey to yellow brown, well bedded, very closely jointed, fine grained, moderately to highly weathered rock which is usually characterised by outcrop. Hardness of the rock depends on the amount of induration.

Quartzite

The outcrop and scattered outcrop rock comprises of hard, grey-white, medium grained, widely jointed, bedded, slightly weathered orthoquartzite.

4.1.2 Soils

The insitu weathered soils comprise of soft rock shale, diabase gravels, boulders in a sandy to clayey matrix and clayey or partially decomposed gravelly shale. The transported colluvium appears as coarse, medium and fine sands, clayey sands, sandy clays and clayey soils while the alluvial materials consist of gravel, sand and clays.

5. PROCEDURES OF INVESTIGATION

Utilising the available information sources, the developability of the terrain has been assessed and confirmed by means of a walk-over survey.

6. ENGINEERING GEOLOGICAL EVALUATION

6.1 GENERAL SOIL AND ROCK CONDITIONS

6.1.1 Magaliesberg Quartzite Formation

Where soils are encountered, the thickness of these materials may vary from 0,2m to 1,6m. A typical profile present on the terrain can be described as follows:-

0,0 - 0,2m (1,6m)	Transported, colluvial sandy Gravel of variable thickness.
-	Unweathered quartzite at depth

The poorly graded gravelly sands and/or mixtures of very fine sands, silts and clays usually dispose of a collapsible grain structure, have pervious to semi-pervious drainage characteristics with relative permeability's ranging between $5x10^{-1}$ cm/sec to $5x10^{-7}$cm/sec.

6.1.2 Silverton Shale Formation

The shale usually outcrops on the higher lying areas which occur directly south of the Magaliesberg Quartzite Formation. The transported and residual soil profile becomes progressively thicker along the slope from the higher lying topography towards the valleys. A typical profile present on the terrain can be described as follows:-

0,0 - 0,5m (2,5m)	Transported, colluvial sandy and clayey Gravel of variable thickness.
0,5 – 0,8m (2,2m)	Residual silty Gravel. Residual Shale
-	Shale at depth.

The transported and residual shale have impervious internal drainage characteristics with relative permeability's ranging between $1x10^{-5}$ cm/sec to $5x10^{-8}$cm/sec.

6.1.3 Diabase

The diabase usually outcrops as scattered boulders with interstitial red sandy clay of shallow depth. A typical profile present on the terrain can be described as follows:-

0,0 - 0,7m (4,0m)	Residual sandy clay (Diabase) of variable thickness.
0,7 – 2,0m (5,0m)	Soft friable sandy Clay. (Residual Diabase).
-	Diabase at depth.

The transported and residual diabase have impervious internal drainage characteristics with relative permeability's ranging between $1x10^{-6}$ cm/sec to $1x10^{-8}$cm/sec. The lateral and vertical extent of the various soil horizons occurring on the terrain as well as the engineering characteristics of the materials will have to be determined by a detail on-site investigation.

6.2 DRAINAGE & SERVICES

Permeability of the soils is generally low, except in the transported and residual sands. A high water table is often found in the Magaliesberg Quartzite, close to the river courses and in the shale during the wet season. Diabase dykes may act as both aquifers (highly jointed, slightly weathered rock) or as aquicludes (highly to decomposed rock). The shallow appearance of perched water conditions during the wet season will necessitate the execution of a detail geotechnical investigation to determine the effect of surface seepage, compressible, sensitive, and active soils as well as trenching and deep excavations. The gully heads and drainage features are usually wet and services should be designed to not trespass these zones. For purposes of road alignments most of these areas can be traversed, but detailed investigations should be conducted to determine the viability thereof. However, it is recommended that the flat areas and areas with a moderate slope be considered for this purpose. The stratigraphic appearance of the underlying bedrock may result in marshy conditions or manifestation of fountains along the slopes during the wet season of the year. These areas should be excluded from future developments.

6.3 FOUNDING

Although no severe founding problems are foreseen for light residential structures, the on-site engineering properties of the soils underlying each structure will have to be determined for design and construction purposes.

6.4 EXCAVATABILITY

The shallow rock head, scattered rock outcrop and occurrence of hardpan pedogenic materials near or at surface may require special equipment for the excavation of services and foundations. Blasting will be required for excavations in all areas of continuous or scattered outcrop, except for the shale areas, where the weathered rock is rippable to depths exceeding 2,0m. The actual extent of the rock types, its percentage problematic excavatability and its impact on the proposed development will have to be determined by a comprehensive geotechnical study.

6.5 CONSTRUCTION MATERIALS

The terrain seems to have vast amounts of construction materials available for roads etc. However, a more detailed study is required to locate these materials and to determine their suitability for construction purposes.

6.6 SLOPES

In general the topography is too flat to give rise to any instabilities. Talus on the quartzite ridges, where underlain by clay derived from diabase, may become unstable during wet periods. Deep excavations in the shale for foundations, road cuttings and services may exhibit instabilities if the orientation of the bedding and joint planes is unfavourable as well as in the quartzites, but to a far lesser extent. No unstable slopes which will pose a problem to the development were observed. However, it is important to take the steepness of the side slopes (indicated on Figure 3) into account and to prevent development on slopes in excess of 12 degrees, since it can promote the danger of erosion and require expensive engineering solutions to develop these areas.

7. PROVISIONAL TERRAIN CLASSIFICATION

The site was geotechnically classified according to the terrain classification parameters prescribed for a Phase I Engineering Geological Study or Planning Investigation (after Partrige, Wood and Brink 1993). Utilising these parameters the terrain can be classified into three mapping units as follows :-

TABLE 1 : MAPPING UNITS

MAPPING UNITS	SUITABLE FOR HOUSING DEVELOPMENT
1	Most favourable for housing development
2	Intermediate favourable for housing development
3	Least favourable for housing development

One or more subscript attached to each mapping unit (TABLE 2) indicates the nature of geotechnical constraint which will have an influence on the potential development in the relevant mapping unit. The severity of the constraints as well as the cost to overcome the constraints increases from subscript A to H.

TABLE 2 : GEOTECHNICAL CONSTRAINTS

		DEFINITION OF GEOTECHNICAL CONSTRAINT		
SUB-SCRIPT	GEOTECHNICAL PARAMETER	Most Favourable (1)	Intermediate (2)	Least Favourable (3)
A	Collapsible Soil	<750mm thick	>750mm thick	Any magnitude
B	Seepage	Perched water deeper than 1,5m	Perched water shallower than 1,5m	Swamps, marshes or drainage channel
C	Active Soil	Low heave	Moderate heave	High heave
D	Erodibility	Low	Intermediate	High
E	Difficulty of excavation to a depth of 1,5m	<10%	Between 10% - 50% Rock or hardpan pedocretes	>50%Rock or hardpan pedocretes
F	Instability in areas of soluble rock	Possibly unstable	Probably unstable	Known sinkholes
G	Steep slopes	Between 2^0 - 6^0	Between 6^0 - 12^0	>12^0
H	Flooding	Does not exist	Adjacent to drainage channel	Areas in drainage channel

The geology has been abbreviated for purposes of representation on Figure 3 to the symbols shown in the table below.

TABLE 3 : GEOLOGY

GEOLOGY SYMBOL	DESCRIPTION
D	Diabase
Q	Magaliesberg Quartzite
S	Silverton Shale

7.1 MAPPING UNITS

The terrain has been delineated into the mapping units as indicated in Figure 3, Appendix I by applying the criteria in Table 1, 2 and 3. The mapping units are discussed below.

Mapping Unit 1_AD – **See Figure 3, Sheet 1 : North Eastern Area**

This zone occupies the northern part of the site which is underlain by diabase covered by thick colluvium which has been derived from the weathered quartzite ridges occurring to the south. The sandy colluvium has an evident collapsible soil structure which should be accommodated in the design of any superstructures to be erected. No excavatability problems are foreseen in the well drained colluvial soils. However, where the colluvium is less than 1,5m thick, up to 10% hard ripping or power tools will be required to excavate for foundations or trenching for services. Some activity may occur where the diabase has weathered to residual clay. Perched water conditions can be encountered on the overburden/rock contact during periods of high precipitation. Surficial erosion of the colluvium can be expected when the vegetation has been removed for purposes of construction or excavation of borrow pits. The sandy overburden has the potential to be used as fine aggregate for building purposes.

However, detail studies will have to be conducted to determine the quality and available quantities. **This Zone has a GOOD land-use potential an can be utilized for any type of development.**

Mapping Unit 1_AQ – **See Figure 3, Sheet 1 : Central Northern and Eastern Area**

This area reveals that thick coarse grained colluvial sands and gravels occur on the moderately flat topographical areas. These pediments are well drained and more than 2m thick with a noticeable collapsible soil structure. Very little excavatability constraints are expected to occur during the trenching for services and the excavation of foundations. Seasonally perched water conditions can occur in isolated areas where these soils are more clayey or where a shallow bedrock profile occurs. No erodibility of the surficial soils is expected unless the vegetation is disturbed. Sand and gravels suitable as fine aggregate for building and fill and subgrade materials in road construction can be located in this mapping unit. **This zone has a GOOD land-use potential.**

Mapping Unit 1_{AF}Q – **See Figure 3, Sheet 1 : North Western Area**

Similar in character as Zone 1_AQ except that up to 10% hard rock quartzite outcrops on surface or occurs within the soil profile which will necessitate power tools or limited blasting to excavate for foundations or installation of services. Superstructures must be designed to accommodate some differential movements which may be encountered on the rock/soil interface. **This Zone has a FAIR land-use potential.**

Mapping Unit $1_{BC}S$ – See Figure 3, Sheet 2 : Southern Area

This zone is underlain by shale occurring on a moderate dipping slope comprising of colluvial clayey/silty gravel on average 2,5m thick. The surficial soils are well drained but with a deficiency in deep drainage. Perched water conditions can be encountered on the overburden/rock contact during periods of high precipitation. No excavation problems are foreseen to an average depth of 2m with a normal size backhoe. Differential movement of up to 15mm can occur in the overburden which is potentially active or compressible. **This zone has a FAIR land-use potential.**

Mapping Unit $1_{ABE}S$ – See Figure 3, Sheet 1 : South Western Area and Figure 3, Sheet 2 : North Western corner

This area comprises of a moderate slope with shallow transported soil overlying shale with less than 10% rock outcrop. Normal founding can be done in this area provided that the design takes cognisance of potentially collapsible/compressible or moderately active soils. Limited excavation problems may be experienced for the excavation of foundations and services. However, hard ripping or power tools may be required in localised areas where the shale has been indurated to hard rock slate through the intrusion of the diabase sills and dykes. Perched water conditions can be expected during the wet season on the soils/rock contact which can influence the trenching operations and have an effect on the stability of the sidewalls of the excavations. Layout of the township and roads should be done sensitive to the slopes to prevent storm water or surface erosion. **This zone has a FAIR land-use potential.**

Mapping Unit 1_ED – **See Figure 3, Sheet 2 : Central Southern Area**

This zone defines an area underlain by diabase with a low to moderate relief which slopes to the south. The terrain has a good run-off but with a deficiency in deep drainage. Perched water conditions can be expected to occur during the wet season of the year on the soil/rock interface. Scattered appearances of up to 10% hard rock boulders of more than 0,5m in diameter outcrop on surface or may be encountered during trenching for the services or excavation for foundations. Limited blasting or use of power tools may be required for this exercise. The transported and residual soils can be active and may reveal between 2,5mm and 15mm differential movement. **This zone has a FAIR land-use potential.**

Mapping Unit $1/2_{ABE}$S – **See Figure 3, Sheet 1 : South Eastern Area and Figure 3, Sheet 2 : Northern Area**

Similar in character as Zone 1_{ABE}S which defines a moderate slope with shallow transported soil overlying shale with between 10% and 50% rock outcrop. Normal founding can be done in this area provided that the design takes cognisance of potentially collapsible/compressible or moderately active soils. Hard ripping or power tools may be required to excavate for foundations or services. Perched water conditions can be expected during the wet season on the soils/rock contact which can influence the trenching operations and have an effect on the stability of the sidewalls of the excavations. Layout of the township and roads should be done sensitive to the slopes to prevent stormwater or surface erosion. **This zone has a GOOD land-use potential.**

Mapping Unit 1_{BE}S – See Figure 3, Sheet 2 : Central Western Area

Similar in character as Zone $1/2_{ABE}$S except that less than 10% shale will require hard ripping for the excavation of foundations or installation of services. **This zone has a FAIR land-use potential.**

Mapping Unit 2_B (On Shale and Quartzite) –

See Figure 3, Sheet : Central Northern and Southern Area and

Figure 3, Sheet 2 : Northern and Central Southern Area

This unit describes the gully head areas of the weakly defined tertiary drainage channel occurring on the terrain. Perched water or wet conditions can be expected to occur throughout the year. Collapsible/compressible and active transported and residual materials characterise these zones which should be excluded from development and earmarked for recreational purposes. **This zone has a POOR land-use potential.**

Mapping Unit 2_{BC}S – See Figure 3, Sheet 2 : Southern Western Area

This zone is underlain by shale occurring on a moderate slope comprising of colluvial clayey/silt. The surficial soils are well drained but with a deficiency of in deep drainage. Perched water conditions occur on the overburden/rock contact which can occur during the course of the year. No excavation problems are foreseen to an average depth of 2m with a normal size backhoe. Moderate heave can be expected in the overburden and residual materials. **This zone has a POOR land-use potential.**

Mapping Unit $2c_E$D – **See Figure 3, Sheet 1 : South Western and South Eastern Area and Figure 3, Sheet 2 : Northern and Southern Area**

This zone defines an area underlain by diabase with a moderate relief which slopes to the south. The terrain has a good run-off but with a deficiency in deep drainage. Perched water conditions can be expected to occur during the wet season of the year on the soil/rock interface. Scattered appearances of between 10% and 50% hard rock boulders of more than 0,5m in diameter outcrop on surface or may be encountered during trenching for the services or excavation for foundations. Blasting or the use of power tools may be required for this exercise. The transported and residual soils can be active and may reveal between 2,5mm and 15mm differential movement. **This zone has a FAIR land-use potential.**

Mapping Unit 2_E Q – **See Figure 3, Sheet 1 : Central Area**

The surface slope is less than 6 degrees and effective stormwater designs will have to be implemented to effectively drain the area. Between 10% and 50% hard rock quartzite outcrops on surface or occurs within the soil profile which will necessitate power tools or blasting to excavate for foundations or installation of services. Where superstructures straddle the soil/ rock contact it is imperative to ensure that no differential settlements will occur which can be damaging to the structure. **This zone has a FAIR land-use potential.**

Mapping Unit 3_ED – **See Figure 3, Sheet 2 : North Western Area**

This zone defines an area underlain by diabase with a moderate relief. The terrain has a good run-off but with a deficiency in deep drainage. Perched water conditions can be expected to occur during the wet season of the year on the soil/rock interface. Scattered appearances of more than 50% hard rock boulders of more than 0,5m in diameter outcrop on surface. Blasting or the use of power tools may be required during trenching for the services or excavation for foundations. The transported and residual soils can be active and may reveal between 2,5mm and 15mm differential movement. **This zone has a POOR land-use potential.**

Mapping Unit 3_EQ – **See Figure 3, Sheet 1 : Northern, Central West and Central Eastern Area**

The surface slope is less than 6 degrees and effective storm water designs will have to be implemented to effectively drain the area. More than 50% hard rock quartzite outcrops on surface or occurs within the soil profile which will necessitate power tools or blasting to excavate for foundations or installation of services. Where super-structures straddle the soil/rock contact it is imperative to ensure that no differential settlements will occur which can be damaging to the structure. **This zone has a POOR land-use potential.**

Mapping Unit 3_{EG}D – **See Figure 3, Sheet 1 : Central Area**

This zone defines an area underlain by diabase with a steep relief of more than 12 degrees. The terrain has a good run-off but is covered by talus materials from the higher lying quartzite. Scattered appearances of diabase rock occur in places.

This zone has a POOR land-use potential.

Mapping Unit $3_{EG}Q$ – **See Figure 3, Sheet 1 : Northern and Central Area**

This zone defines an area underlain by quartzite with similar conditions as for mapping unit $3_{EG}D$ and steep relief of more than 12 degrees. **This zone has a POOR land-use potential.**

7.2 PRIORITY DEVELOPMENT ZONES

Figure 3 also indicates the areas most suitable for development from a geotechnical perspective during a process of phase development. These areas have been prioritized from highest to lowest priority.

7.3 CEMETERY SITE

The existing cemetery site occurs in mapping unit $1_{ABE}S$ Although this area can be used for this purpose, perched water conditions can occur in the excavated pits or drain through closed pits and cause pollution of the groundwater lower down the slopes or in the bedrock. Excavatabilty problems to a depth of 1,8m and unstable side walls of the graves can also be experienced. For a cemetery site to function optimally, a well drained soil profile of 2,5m is required situated above the general groundwater level. It is recommended that mapping unit $1_{A}Q$ be considered for the location of a potential cemetery site or that a detail investigation be conducted to prove the existing terrain suitable.

7.4 SEPTIC TANKS

The use of large septic tanks is considered for the development which will be located on mapping unit $2_{E}Q$. The effluent of septic tanks is infiltrated into soil. An unsaturated zone of at least 2m thick below the drain field is desirable to allow aerobic decomposition and other attenuation reactions. These tanks should be at least 30m from any drainage systems. Mapping unit 2_EQ comprises mainly of quartzite rock occurring at shallow depth and with between 10% and 50% rock outcrop occurring on the surface. Leachate from the septic tanks can occur on the rock/soil interface which can lead to potential pollution of the surface and groundwater systems. It is recommended that an alternative terrain be found or a different system be considered for disposing of the sewage.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 A Phase I (Planning) Engineering geological survey has been conducted over the terrain consisting of a desk study and walk-over survey.

8.2 The investigated area is mainly underlain by the Magaliesberg Quartzite and Silverton Shale Formations as well as sheets and dykes of diabase intrusives.

8.3 Slopes are of a moderate nature and no problems with regard to slope instability are expected although steep slopes do occur which may require cut-and-fill operations to create stable platforms for residential structures or should be exluded for development.

8.4 The variable nature of the intrusive materials results in the excavatability changing within a few metres. This criteria is also applicable to the rest of the shallow rock or scattered rock outcrop areas.

8.5 Collapsible soils, compressible soils and even moderate activity clays may occur on the terrain as indicated in the various zones and it is imperative that appropriate founding solutions be obtained prior to the erection of the superstructures.

8.6 The appearance of perched water conditions on the terrain will require the execution of detail surface and subsurface tests and examinations to determine the permeability, drainage etc. of the soil materials occurring on the site.

8.7 No geotechnical conditions exist to the extent of not allowing the proposed development to proceed. However, certain engineering geological investigations as mentioned throughout the report are recommended to ensure a safe and sound development.

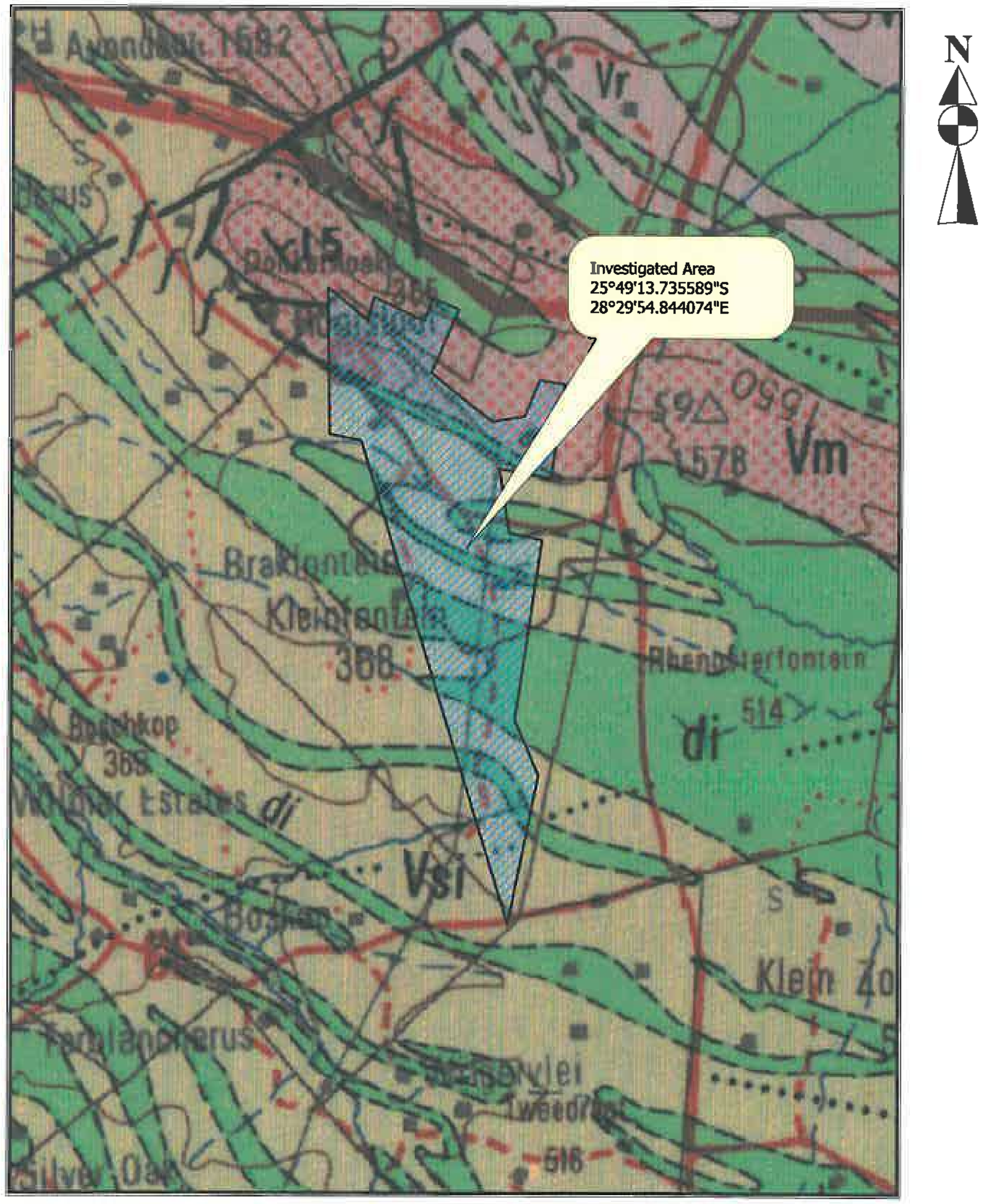
9. GENERAL

An effort has been made during the investigation to retrieve the maximum amount of data. The categorised development potential zones within the area are provided as a broad guide to the general suitability for development. It should be recognised that this reconnaissance work should be confirmed by detailed field engineering geological investigations.

L.M. HOLLAND-MUTER (Pr.Sci.Nat)

APPENDIX I

MAPS



Legend

Investigated Area

Scale 1:63360

0 6 12 km

HOLLAND-MUTER & ASSOCIATES CC; P.O. BOX 1450; FAERIE GLEN; 0043

FIGURE 2 : REGIONAL GEOLOGY MAP : KLEINFONTEIN SETTELMENT :
Located on Kleinfontein 368 JR : Portions 38,90,96 ,and the remaining extent and
Donkerhoek 365 JR : Portions 63,67,68 and the remaining extent of Portion 14.

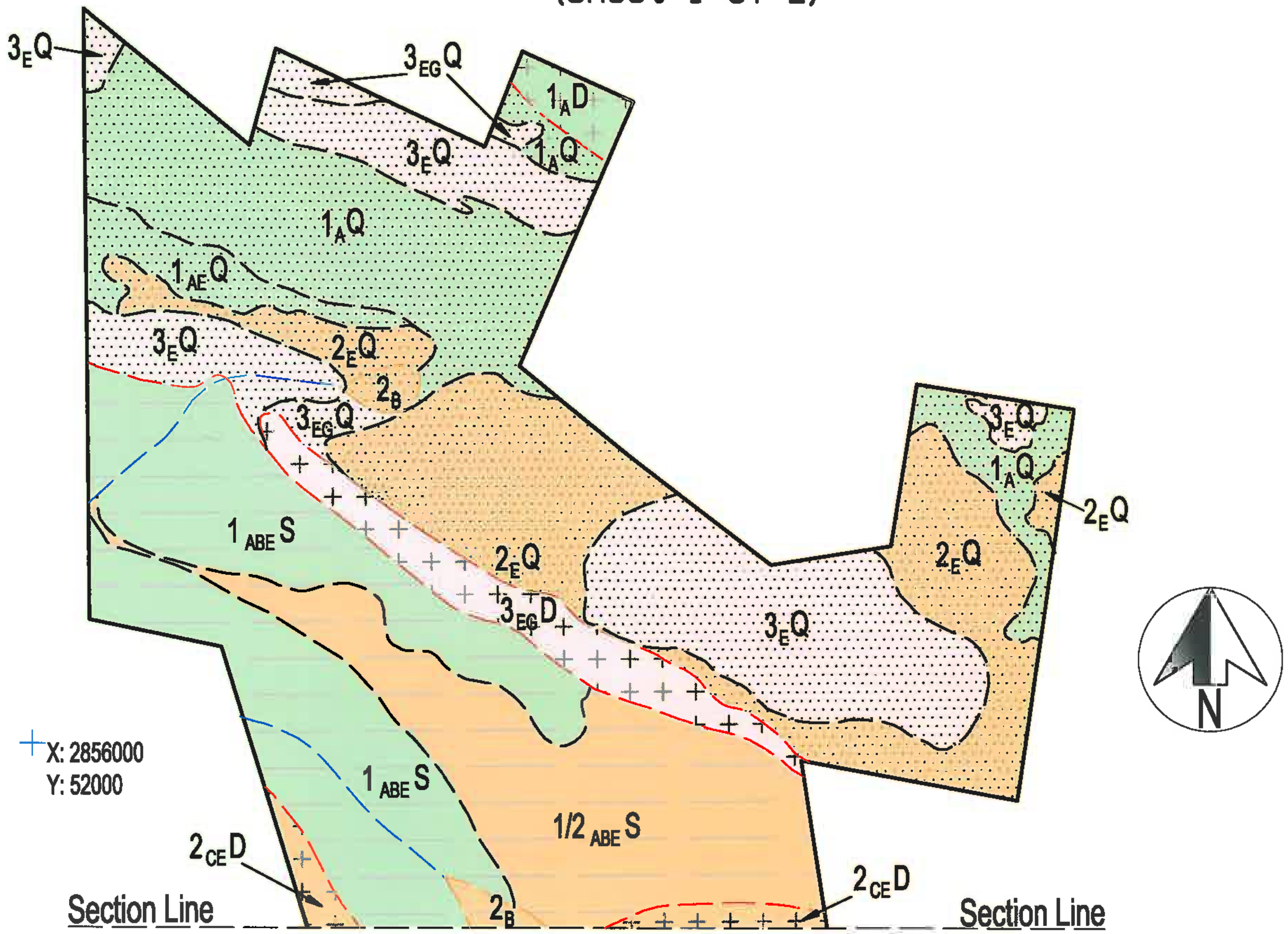
DATE: NOVEMBER 2011

DRAWING NR : 401

PORTIONS OF THE FARMS KLEINFONTEIN 368 JR & DONKERHOEK 365 JR, TSHWANE:

FIGURE 3: PHASE I (PLANNING) GEOTECHNICAL INVESTIGATION

(Sheet 1 of 2)



LEGEND	
	Site Boundary
	Inferred Geological Boundary
	Drainage Channels
	Gully Head
D	Diabase
Q	Magaliesberg Quartzite
S	Silverton Shale
	Mapping Unit
	Railway Line

DEFINITION OF GEOTECHNICAL CONSTRAINTS

Severity of constraint & cost increases from A-H

SUB-SCRIPT	GEOTECHNICAL PARAMETER	Most Favourable (1)	Intermediate (2)	Least Favourable (3)
A	Collapsible Soil	<750mm thick	>750mm thick	Any magnitude
B	Seepage	Perched water deeper then 1,5m	Perched water shallower then 1,5m	Swamps, marshes or drainage channel
C	Active Soil	Low heave	Moderate heave	High heave
D	Erodibility	Low	Intermediate	High
E	Difficulty of excavation to a depth of 1,5m	<10%	Between 10% - 50% Rock or hardpan pedocretes	>50% Rock or hardpan pedocretes
F	Instability in areas of soluble rock	Possibly unstable	Probably unstable	Known sinkholes
G	Steep slopes	Between 2° - 6°	Between 6° - 12°	>12°
H	Flooding	Does not exist	Adjacent to drainage channel	Areas in drainage channel

ZONAL DESCRIPTIONS

MAPPING UNITS	SUITABILITY FOR HOUSING DEVELOPMENT
1	Most favourable for housing development
2	Intermediate favourable for housing development
3	Least favourable for housing development

PORTIONS OF THE FARMS KLEINFONTEIN 368 JR & DONKERHOEK 365 JR, TSHWANE

FIGURE 3 : PHASE I (PLANNING) GEOTECHNICAL INVESTIGATION

(Sheet 1 of 2)

PROJECT: LM919/11 FILE NO: 919

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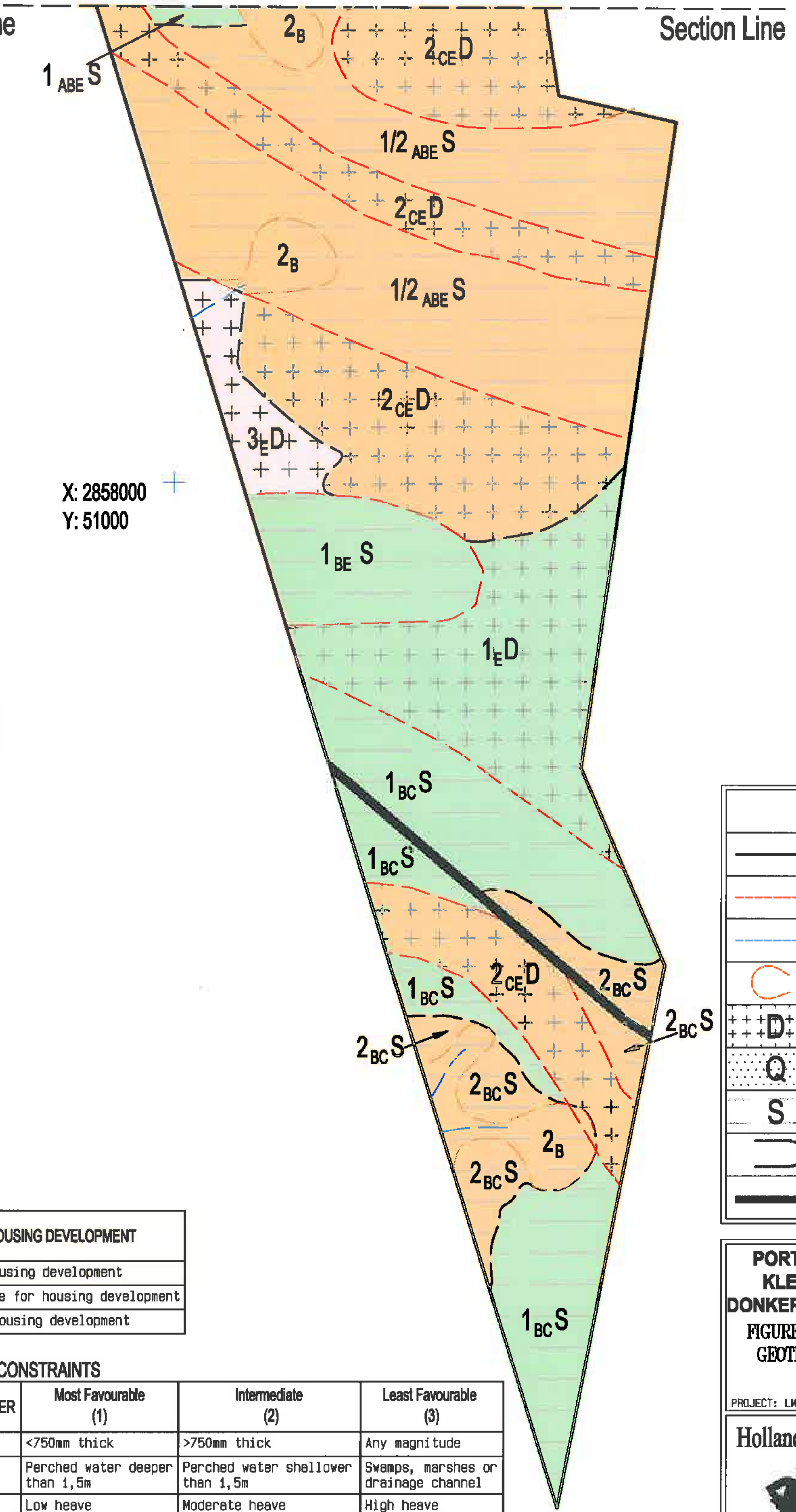
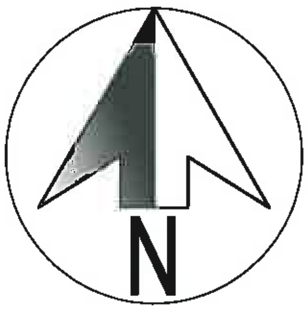
NOV. 2011	1 : 15000	KLEI_201

PORTIONS OF THE FARMS KLEINFONTEIN 368 JR & DONKERHOEK 365 JR, TSHWANE:

FIGURE 3: PHASE I (PLANNING) GEOTECHNICAL INVESTIGATION

(Sheet 2 of 2)





LEGEND	
	Site Boundary
	Inferred Geological Boundary
	Drainage Channels
	Gully Head
D	Diabase
Q	Magaliesberg Quartzite
S	Silverton Shale
	Mapping Unit
	Railway Line

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PORTIONS OF THE FARMS KLEINFONTEIN 368 JR & DONKERHOEK 365 JR, TSHWANE

FIGURE 3 : PHASE I (PLANNING) GEOTECHNICAL INVESTIGATION

(Sheet 2 of 2)

PROJECT: LM919/11 FILE NO: 919

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NOV. 2011	1 : 15000	KLEI_202

Annexure G(ii)

GEO-HYDROLOGY

GEOHYDROLOGICAL INVESTIGATION FOR THE KLEINFONTEIN TOWN DEVELOPMENT, GAUTENG PROVINCE

REPORT 106773-G2/2012

JULY 2012

Prepared for:	Kleinfontein Boerebelange Koöperatief Bpk P O Box 925 Rayton 1001
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Prepared by:	Aurecon South Africa (Pty) Ltd P O Box 74381 LYNNWOOD RIDGE 0040
Contact person:	Dr M Levin Tel No: +27 12 427 3127

Report title	Geohydrological Investigation for the Kleinfontein Town Development, Gauteng Province	
Aurecon Report No.	106773-G2/2012	
Project team	Dr M Levin	Geohydrologist
	L Stroebel	Geohydrologist
	M Terblanche	Geotechnician
Co-ordinates (WGS84)	S 25.80043º	
	E 28.49512°	
Location	Tshwane, Gauteng Province	
Signed on behalf of Africon	**L Stroebel**	**Dr M Levin**
Date	July 2012	

GEOHYDROLOGICAL INVESTIGATION FOR THE KLEINFONTEIN TOWN DEVELOPMENT, GAUTENG PROVINCE

REPORT 106773-G2/2012 JULY 2012

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ABBREVIATIONS

DWA	**Department of Water Affairs**
GQM	**Groundwater Quality Management**
GRDM	**Groundwater Reserve Determination Measures**
KBK	**Kleinfontein Boerebelange Koöperatief Bpk**
SANS	**South African National Standards**
WULA	**Water Use License Application**

EXECUTIVE SUMMARY

Aurecon was appointed by Kleinfontein Boerebelange Koöperatief Bpk to provide the geohydrological report required as part of the Water Use License Application for **Phase 1** of the town development. The objective of the geohydrological investigation is to evaluate the groundwater resources available from the existing production boreholes and spring on the property. As part of the investigation a Rapid Reserve Determination was done to support a Water Use License Application (WULA) to the Department of Water Affairs.

The following conclusions were made:

- The groundwater, with exception of the borehole *NO,* is of excellent quality and complies with the SANS 241-1 Drinking Water Standards.
- The iron content in borehole *NO* exceeds the maximum allowable drinking water standard (Class II). The manganese concentration falls within Class II standards (suitable for short term use only). This water is not presently used.
- The combined sustainable yield calculated from the pump tests conducted on the selected production boreholes is 3.8 l/s.
- The sustainable yield calculated from the fountain flow is 1.55 l/s.
- The calculated annual recharge on the property is 438 795 l/day or 5.1 l/s.
- A Water Use License for abstraction of 257 600 l/day or 2.75 l/s can be applied for.
- This is 53% of the annual recharge on the property and therefore within 60-100% of the annual recharge on the property which places the water use license in Category B.
- The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification for the study area indicate that medium level groundwater protection may be required.
- Solid waste disposal site is not required as the solid waste is disposed at the licensed Rayton waste site.
- The Sanitation Protocol study shows medium overall risk to groundwater.
- Investigation into the complaints by neighbours showed that they are located outside the Kleinfontein catchment and is unlikely to be impacted by the groundwater abstraction on the Development.

Based on the above conclusions, the following recommendations are made:

- It is recommended that borehole *NO* be rehabilitated and tested before used for production.
- All the selected production boreholes need to be registered with the Department of Water Affairs for the WULA.
- Adherence to the sustainable yields of the boreholes is crucial to ensure long-term utilisation of the groundwater resource.
- Accurate monthly monitoring of the groundwater levels in the boreholes is recommended. If any significant fluctuation in water level occurs, immediate action needs to be taken.
- Groundwater quality and especially bacteriological analyses must be done on a regular basis.

- Reasonable and sound groundwater protection measures are recommended to ensure that no cumulative pollution affects the aquifer, even in the long term.
- It is recommended that a waterborne sewage system be installed for the development to treat the raw sewage water.

1 INTRODUCTION & SCOPE OF WORK

Aurecon was appointed by Kleinfontein Boerebelange Koöperatief Bpk to provide the geohydrological report required as part of the Water Use License Application for **Phase 1** of the town development. The objective of the geohydrological investigation is to evaluate the groundwater resources available from the existing production boreholes and spring on the property. As part of the investigation a Rapid Reserve Determination was done to support a Water Use License Application (WULA) to the Department of Water Affairs.

The scope of work consisted of the following:

- Describe the groundwater resources and usage
- Pump testing of existing production boreholes on-site to determine the sustainable yield of each borehole,
- Evaluate the quality of the groundwater,
- Determine the groundwater reserve and water available for abstraction through a “Rapid Reserve Determination” which will accompany the Water Use Licence application,
- Potential impacts of the development on the groundwater resources
- Conclusions and recommendations.

2 AVAILABLE INFORMATION

The following relevant information was available and consulted prior to the investigation:

- 1:50 000 scale topographical and geological maps 2528 CD Rietvleidam.
- 1:250 000 scale geological series map 2528 Pretoria
- 1:500 000 General Hydrogeological map (Johannesburg 2526)
- 1:3 000 000 Groundwater Harvest Potential Map of South Africa .
- DWA (2003) A Protocol to Manage the Potential of Groundwater Contamination from on-site sanitation. Technical Version. Edition 2, March 2003.
- Parsons R (1995) A South African Aquifer System Management Classification. Water Research Commission Report no KV 77/95
- Barnard H C (2000) An explanation of the 1:500 000 General Hydrogeological Map Johannesburg 2526. DWAF Report.
- Vegter J R (1995) Groundwater Resources of the Republic of South Africa.
- South African National Standard: Drinking Water, SANS 241:2006 Edition 6.1. Published by Standards South Africa.

- Berrington L (2006) ‘n Verslag betreffende die vasstelling van ‘n veilige langtermyn ontrekkingskedule vir die boorgat geleë op die Noordoos hoewe deur middel van ‘n konstante lewering pomptoets. Verslag No 2006-001. April 2006
- BK (2004) Kleinfontein Boerebelange Koöperatief Beperk Dienste Verslag. Julie 2004.

3 PHYSIOGRAPHY

3.1 SITE LOCATION

The locality of the development is next to the N4 Highway and on the farm Kleinfontein 368 JR. The extent of Phase 1 of the development on Kleinfontein 368 JR is shown on the map in Appendix A. The development is situated about 10 km south of Rayton as indicated on Figure 1. The town was established in 1988 and has informally developed according to recognized standards. Recently, the decision was taken to formalize the development.

3.2 TOPOGRAPHY & SITE CHARACTERISTICS

The topography is characterised by undulating hills and meadows. A ridge at an elevation of 1577 m above mean sea level runs from east to west through the site. The topography levels out towards the south of the study area. The higher lying Magaliesberg Quartzite in the northern part of the site forms a well-defined watershed. The main drainage from Phase 1 flows to the west as a tributary to the Edendalspruit which flows into the Roodeplaat Dam. The Kleinfontein Spring is located on the higher topography on the Quartzite ridge.

Figure 1: Locality of the Kleinfontein Site

The site is located in the sub-humid, warm climate zone and receives summer rainfall. The average rainfall measured in the quaternary catchment and recorded by DWA is 689 mm per annum.

The vegetation is described as Highveld grassland and varies across the site with grassland and scattered local and alien trees. Acacia trees occur on the iron rich diabase soils with grass cover on open fields.

3.3 GEOLOGY

The site is underlain by formations belonging to the Pretoria Group of the Transvaal Sequence. As shown in Figure 2 the southern part of the site is underlain by the Silverton Formation (Vsi) consisting of shale with inter-bedded quartzite, hornfels and limestone. The Silverton Formation is intruded by diabase dykes and sills (di) shown on Figure 2.
These diabase intrusions are very prevalent at certain stratigraphic levels below the Bushveld Igneous Complex in the Pretoria Group and the majority is found in the Silverton and Strubenkop Formations. As shown on Figure 2 the Silverton Formation is overlain by the Magaliesberg Formation (Vm) in the northern part of the site. The Magaliesberg Formation consists mainly of quartzite.

3.4 GEOHYDROLOGY

The aquifers present are classified as an intergranular and fractured aquifer according to the 1:500 000 geohydrological map (Johannesburg 2526). The groundwater occurrence is associated mainly with the weathered zones, as well as fault zones and dyke or sill contact zones. The groundwater yield potential in the sedimentary rocks is good and between 0.5 and 2 l/s.
According to Vegter (1995) the probability to drill a successful borehole (between 0.5 and 2l/s) is 40% to 60%. The probability of drilling a borehole yielding more than 2 l/s is between 30% and 40%.

According to Barnard (2000) the groundwater yield potential is classed as good on the basis that 40% of the boreholes on record produce more than 2 l/s and 22% produce more than 5 l/s. Higher yielding boreholes according to Barnard occur more often in association with the surface water drainage system of the broad valley bottoms. Boreholes were drilled on the property but unfortunately no geological logs are available as only the yield and quality are recorded.

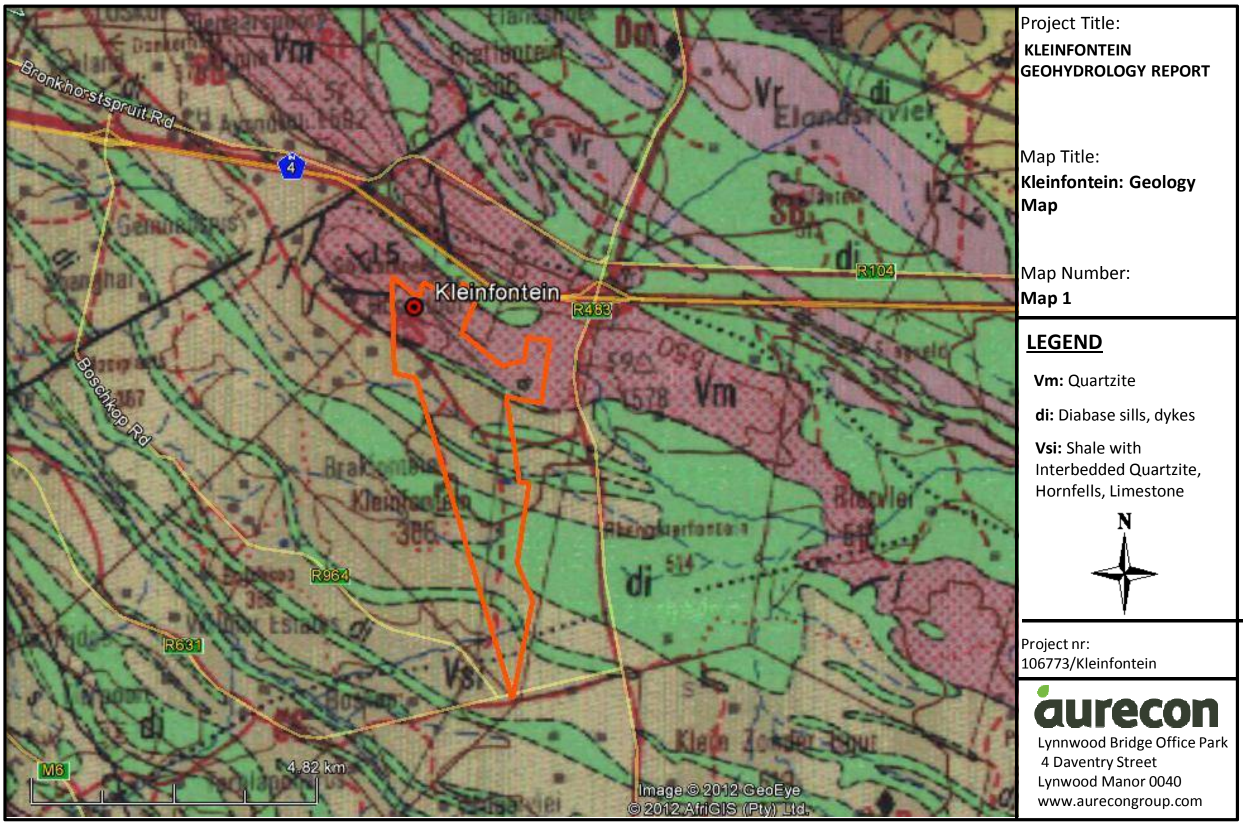


Figure 2: Geology of the Kleinfontein area as shown on the 1:50 000 2528 CD

4 WATER RESOURCES

Water supply for the Kleinfontein Development (Phase 1) consists of a fountain (natural spring) on the property and six boreholes. The coordinates as well as the sustainable yield of the boreholes and fountain are shown in Table 1.

Table 1: Coordinates and yields of the boreholes and fountain

Borehole No	WGS84 Y	WGS84 X	Sustainable Yield (l/s) 24 hrs	Depth (m)
T1	51223	55874	1.0	58
T2	51284	55919	0.8	35
T3a	51386	55874	0.8	19
T4	51431	55721	0.5	40
T5	51280	55979	0.4	21
NO	50387	54384	0.3	60
Fountain	51253	55106	2.0	~

4.1 FOUNTAIN

The fountain is located on a contact of the quartzite and diabase formations. The water originates from the quartzite aquifer, as was confirmed by the water quality. In 2005, a 90 degree V-notch weir was erected upstream of a slow sand filter installed in the flow path of the fountain, and approximately 200m downstream of the eye of the fountain. The water gravitates naturally from the eye down and through the vlei area to the sand filter. The flow of the fountain depends on the seasonal rainfall and the variation in flow is shown in the flow diagram in Appendix B. A maximum flow rate of close to 16 000 l/h during the high rainfall period in 2009 and a minimum of about 1 000l/h in 2007 during the low rainfall season was observed. The average flow calculated is approximately 9 000l/h. The water use registered at the DWA in 2001 is 49 000 kl/a on property T67550/1995 as per document No 26021581. This is approximately 1.55 l/s which correlates to the present average flow of 5 500l/h. However, at present the use is 0.75l/s or half of the average flow rate.

Production from the fountain is increased in the rainy season when flow from the fountain increased in order to reduce the production from the boreholes.

4.2 BOREHOLES

Six boreholes at Kleinfontein were test pumped by *Waterman* according to the DWA guidelines for pump testing. A stepped discharge test followed by a 24 hour constant discharge test with recovery monitoring was performed on the boreholes. The location of the boreholes is presented in the locality map in Appendix A and borehole test records giving testing and construction details of each borehole is presented in Appendix C.

The sustainable yields determined from the pump testing will be used in the WULA.

4.2.1 Description of a pumptest

The efficient operation and utilisation of a borehole requires insight into and an awareness of its productivity and that of the groundwater resource from which it draws water. This activity, which is also known as test pumping, provides a means of identifying potential constraints on the performance of a borehole and on the exploitation of the groundwater resource. It also provides data to calculate aquifer parameters such as Transmissivity (T) values.

4.2.2 Constant Discharge Test

A constant discharge test is performed to assess the productivity of the aquifer according to its response to the abstraction of water. This test entails pumping the borehole at a single pumping rate which is kept constant for an extended period of time. In this instance the boreholes were pumped for 24 hours.

4.2.3 Recovery Monitoring

This test provides an indication of the ability of a borehole and groundwater system to recover from the stress of abstraction. This ability can again be analysed to provide information with regards to the hydraulic properties of the groundwater system and arrive at an optimum yield for the medium to long term utilisation of the borehole.

4.2.4 Results & Data Processing

The data recorded during the pump tests were processed and the sustainable yield of the boreholes were calculated using the Flow Characterization Method (FC-Method) developed by the Institute for Groundwater Studies (University of the Free State). The FC Solution for the boreholes is presented in Appendix C. The calculated sustainable yield for the boreholes is presented in Table 2. Field forms used by the pump test contractor are presented in Appendix D.

4.2.5 Sustainable Yield

The FC-Method calculates the sustainable yield of a borehole by using derivatives, boundary information and error propagation. Data used for input into the software was obtained from the pumping test conducted on the boreholes. As described above a pump test basically entails continuous monitoring of the water level over a given time while pumping water from the borehole at a constant pre-determined yield.

After the pump has been switched off, continuous measuring of the recovering water level takes place. The aquifer was then modelled to obtain a sustainable pumping yield. The available drawdown is a critical parameter during this exercise and after calculating the sustainable yield, the water level should never drop beyond this level.

From Table 2, it can be concluded that a total volume of 327.69 m^3/day or 3.8 l/s (119 607 m^3/annum) can be abstracted from the existing boreholes pump tested.

It must be mentioned that borehole *NO* was drilled to 60m with the water strike at 53 m. The borehole has slowly filled with debris and is only 50m deep at present. The water strike is thus constraint and was tested at 0.5 l/s. This borehole was previously tested (72 hour test) by Berrington (2006) and the FC yield was calculated at 2.1l/s. Because of the formation stability problem it is recommended that this borehole be rehabilitated and re-tested.

Table 2: Calculated Sustainable Yield for the tested boreholes

BH nr.	Coordinates (WGS84)	Depth (m)	Static water level (mbgl)*	Sustainable Yield (l/s) Pumping 24 h/d	Volume available per day (m^3)
T1	X 51223 Y 55874	58	17.03	1.0	86.4
T2	X 51284 Y 55919	35	10.90	0.8	69.12
T3a	X 51386 Y 55874	19	9.40	0.8	69.12
T4	X 51431 Y 55721	40	11.20	0.5	43.2
T5	X 51280 Y 55979	21	9.0	0.4	34.56
NO	X 51223 Y 55874	60	9.50	0.3	25.29
			Total volume available from boreholes (m^3/day)		**327.69**

*meters below ground level

4.3 WATER USAGE

The following figures are available from the test results and the production figures were supplied by KBK.

Total available volume of water from the resources is as follows:

Source description	Yield (l/s)	Yield (m^3/day)
Fountain	1.55	133.92
6 Boreholes	3.80	328.32
Total available	**5.35**	**462.24**

Production capability at KBK:

Source description	Yield (l/s)	Yield (m^3/day)
Fountain	0.75	64.8
Boreholes	2.0	172.8
Total production capacity	**2.75**	**237.6**

The total usage for the period of 18 months from January 2011 to June 2012 is recorded as 62.930 Ml or 3496 m^3/month. **Total recorded usage is 116.537 m^3/day**

The total recorded usage of 116.537m^3/day is approximately 50% of potential production or 25% of available supply.

5 WATER QUALITY

Water samples were collected from each of the 6 boreholes at the end of the pumping tests. A sample was also collected at the fountain where it flow through the V-notch weir. The samples were submitted to an accredited laboratory (Aquatico Scientific Laboratories in Pretoria) for major inorganic analysis. The laboratory reports are presented in Appendix E.

The inorganic results were compared to the SABS drinking water standards (SANS 241:2006, edition 6.1). Water is classified according to their suitability for human consumption (**Error! Reference source not found.**):

- Class I: Recommended operational limit.
- Class 2: The maximum allowable concentration for short term use only.

From **Error! Reference source not found.**, it can be concluded that all the samples except the borehole *NO* comply with the Class I standard and is of excellent drinking water quality. Borehole *NO* was not in use for production before the pump test and shows manganese concentrations above Class I standards and high iron content exceeding the Class II standards. This borehole will be rehabilitated and water from the borehole will need aeration before storage to precipitate the iron. It is recommended that a chemical analysis be done once the borehole is rehabilitated.

No bacteriological tests were done at this stage. It is recommended that samples for microbiological analysis on the water be taken at the water reticulation system. Should microbial contamination occur, the water needs to be treated accordingly.

Table 3: Chemical parameters compared to SANS 241:2006 (edition 6.1) drinking water standards.

Sample Nr.	NO	T1	T2	T3A	T4	T5	FOUNTAIN	Class I	Class II
Ca	2.76	4.59	2.47	2.86	4.54	2.73	0.64	150	300
Mg	3.61	2.47	3.11	4.25	5.42	3.53	0.49	70	100
Na	1.65	2.58	3.67	4.13	3.94	4.10	0.64	200	400
K	1.35	0.51	1.42	1.33	1.99	1.43	0.34	50	100
Mn	0.22	0.00	0	0	0	0	0	0.1	1
Fe	3.655	-0.006	0	0.058	0	0	0	0.2	2
F	0.84	0.20	0	0	0	0.20	0.18	1	1.5
NO_3-N	0	1	0.36	0.108	0.721	0.106	0.060	10	20
NH_4-N	0.021	0.024	0.02	0	0.083	0.023	0.124	0.94	1.87
Cl	3.00	4.00	3.70	4.6	5.3	3.5	3.4	200	600
SO_4	3.67	2.79	0.73	0	0	0	0	400	600
TDS	32	30	29	34	42	31	6	1000	2400
pH	6.86	7.57	6.55	6.65	6.34	6.87	6.66	5.0 - 9.5	4.0 - 10.0
EC	7.19	6.48	5.69	7.84	9.76	7.19	1.48	150	370

Notes

Yellow = Class I

Tan = Class II

Exceeds maximum allowable drinking water standard

0 = below detection limit of analytical technique

EC values measured in mS/m, all other values measured as mg/l.

6 RAPID RESERVE DETERMINATION

6.1 INTRODUCTION

Definition of Reserve: *"The quantity and quality of water required to supply basic needs of people to be supplied with water from that resource and to protect aquatic ecosystems in order to secure ecologically sustainable development and use of water resources".*

To be able to quantify the groundwater component of the Reserve, the following relationship has to be solved:

$$GW_{allocate} = (Re + GW_{in} - GW_{out}) - BHN - GW_{Bf}$$

where:

	$GW_{allocate}$	=	groundwater allocation
	Re	=	recharge
	GW_{in}	=	groundwater inflow
	GW_{out}	=	groundwater outflow
	BHN	=	basic human needs
	GW_{Bf}	=	groundwater contribution to baseflow

Under the National Water Act (Act No. 36 of 1998) the water use at the Kleinfontein Development must be authorised. The water will be abstracted from boreholes and used as potable water in a residential development. Under these circumstances, the following (ground) water use is recognised as being relevant to the licence application:

- Section 21 (a) – taking water from a resource.

6.2 APPROACH

The assessment was done on a "rapid" level using the software GRDM version 4.0.0.0. The data used for the calculation was derived from the WRC90 dataset contained in the "GRDM" software driven by the Resource Directed Measures from the Department of Water Affairs. The local catchment falls within quaternary catchment A23A as shown on the map in Appendix F. The default values were used in the assessment in order to develop some guidance on the potential impact of the proposed abstraction on the overall groundwater use in the catchment.

6.3 DESCRIPTION OF THE STUDY AREA

The property referred to as Kleinfontein development Phase 1 has a total area of 286 ha and falls within 3 quaternary catchments namely, A23A, B20D and B31A. Groundwater abstraction however occurs only within catchment A23A. The quaternary catchment A23A has a total area of 684 km^2 of which 13 km^2 is protected (Magaliesberg, Roodeplaat and Bronberg areas), leaving an effective area of 671 km^2. The study area falls in the Crocodile (West) and Marico Water Management Area.

The dominant vegetation type is rocky Highveld grassland. The area has a sloping topography and is drained by surface runoff to the Edendalspruit, which flows alongside the southern boundary of the property from south-east to north-west.

6.4 PRESENT WATER DEMAND

A conservative projection of the planned water demand at the end of the project is 7 128 m^3/month or 85 536 m^3/annum. DWA categorises the water use licence applications in 3 categories based on the amount of recharge that is used by the applicant in relation to the specified property:

- Category A: Small scale abstractions (<60% recharge on property)
- Category B: Medium scale abstractions (60-100% recharge on property)
- Category C: Small scale abstractions (>100% recharge on property)

6.5 RDM ASSESSMENT

The following table summarises the most salient parameters relevant to this catchment (A23A):

Table 4: Most salient parameters relevant to catchment A23A.

Area km^2	Population	General Authorisation (m^3/ha/a)	Rainfall (mm/a)	Current use (Mm^3/a)
682	391615	NA	698	31.65

It is assumed that General Authorisation as a possible route can be excluded.

6.5.1 Classification

Groundwater classification is currently based on a Stress Index which relates water use to recharge. The study area is classified as category A, which indicates unstressed or low levels of stress in terms of abstraction/recharge. The resource is still being used sustainable. At this stage Classification is not directly linked to potential abstraction, but is only indicative of the current situation. A category C classification still implies that ~4.3 (Mm^3/a) can still be abstracted from the quaternary catchment before very detailed studies will be required.

6.5.2 Reserve

The following table summarizes the Reserve for the catchment.

Table 5: A summary of the Reserve for the catchment.

The allocatable portion is still relatively high (>50% of the recharge), with the greatest impact coming from current abstraction & base flow.

If this calculation is done based on the actual area of the property within the affected quaternary catchment, the following emerges:

Table 6: Recharge to Kleinfontein

Catchment	Actual area (ha) of property	Recharge in Quartenary Catchment (mm/a)	Recharge on property	
A23A	286	56	160160	m^3/a
Total	*286*		*160160*	m^3/a
			0.160	Mm^3/a
			438795	l/day
			5.1	l/second

From Table 6 it is evident that local recharge (160 160 m^3/annum) will supply in the allocatable portion (20.68 Mm^3/annum) for the quaternary catchment A23A. **The local recharge on the property will allow for abstraction of ~ 160 160 m^3/annum.** There will be applied for an abstraction of 85 536 m^3/annum (53%) from the total registered property of Phase 1 of the Kleinfontein Development. The recharge calculations (abstraction being 60-100% of the local recharge) places the property in Category B (medium scale abstraction – 60-100% abstraction of the recharge on the property) (see section 6.4).

6.5.3 Resource Quality Objectives

Maintain regional groundwater table to:

- Ensure that schedule 1 water users adjacent to the site have adequate water supply to sustain basic human need.
- Ensure that adequate water is available to maintain base flow in the Edendalspruit River.

Monitoring:

- The flow monitoring at the fountain must be done regularly to ensure that production does not exceed the flow rate in the dry season.
- Bacteriological monitoring must be done at least weekly to ensure clean healthy water.
- Inorganic analysis need to be done monthly. The iron and manganese content in borehole *NO* must be monitored.

7 AQUIFER CLASSIFICATION

The aquifer(s) underlying the subject area were classified in accordance *with "A South African Aquifer System Management Classification, December 1995"* by Parsons. Classification has been done in accordance with the following definitions for Aquifer System Management Classes:

- Sole Aquifer System: An aquifer which is used to supply 50% or more of domestic water for a given area, and for which there is no reasonably available alternative sources should the aquifer be impacted upon or depleted. Aquifer yields and natural water quality are immaterial.

- Major Aquifer System: Highly permeable formations, usually with a known or probable presence of significant fracturing. They may be highly productive and able to support large abstractions for public supply and other purposes. Water quality is generally very good (Electrical Conductivity of less than 150 mS/m).

- Minor Aquifer System: These can be fractured or potentially fractured rocks which do not have a high primary permeability, or other formations of variable permeability. Aquifer extent may be limited and water quality variable. Although these aquifers seldom produce large quantities of water, they are important for local supplies and in supplying base flow for rivers.

- Non-Aquifer System: These are formations with negligible permeability that are regarded as not containing groundwater in exploitable quantities. Water quality may also be such that it renders the aquifer unusable. However, groundwater flow through such rocks, although imperceptible, does take place, and needs to be considered when assessing the risk associated with persistent pollutants.

Table 7. Ratings for the Aquifer System Management and Second Variable Classifications:

Aquifer System Management Classification		
Class	Points	Study area
Sole Source Aquifer System:	6	6
Major Aquifer System:	4	
Minor Aquifer System:	2	
Non-Aquifer System:	0	
Special Aquifer System:	0 – 6	
Second Variable Classification (Weathering/Fracturing)		
Class	Points	Study area
High:	3	
Medium:	2	2
Low:	1	

Based on information collected during the hydrocensus it can be concluded that aquifer system in the study area can be classified as a "Sole Aquifer System". The local population and farms make use of groundwater as a source of potable water to supplement surface water use. Borehole yields and water quality are generally excellent. In order to achieve the Groundwater Quality Management Index a points scoring system as presented in Table 7 and Table 8 was used.

The occurring aquifer(s), in terms of the above definitions, is classified as a sole aquifer system.

The vulnerability, or the tendency or likelihood for contamination to reach a specified position in the groundwater system after introduction at some location above the uppermost aquifer, in terms of the above, is classified as **medium**. A moderately deep water table (9<17 mbgl) and rocks with slight weathering underlie the site. The level of groundwater protection based on the Groundwater Quality Management Classification:

Table 8. Ratings for the Groundwater Quality Management (GQM) Classification System:

Aquifer System Management Classification		
Class	Points	Study area
Sole Source Aquifer System:	6	6
Major Aquifer System:	4	
Minor Aquifer System:	2	
Non-Aquifer System:	0	
Special Aquifer System:	0 - 6	
Aquifer Vulnerability Classification		
Class	Points	Study area
High:	3	
Medium:	2	2
Low:	1	

GQM Index = Aquifer System Management x Aquifer Vulnerability
= 6 X 2 = 12

Table 9. GQM index for the study area

GQM Index	Level of Protection	Study Area
<1	Limited	
1 - 3	Low Level	
3 - 6	Medium Level	
6 - 10	High Level	
>10	Strictly Non-Degradation	12

7.1 AQUIFER SUSCEPTIBILITY

Aquifer susceptibility, a qualitative measure of the relative ease with which a groundwater body can be potentially contaminated by anthropogenic activities and which includes both aquifer vulnerability and the relative importance of the aquifer in terms of its classification, in terms of the above, is classified as **medium**.

7.2 AQUIFER PROTECTION CLASSIFICATION

The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification yield a Groundwater Quality Management Index of 12 for the study area, indicating that **"strictly non-degradation protection"** will be required.

Due to the "strictly non-degradation" GQM index calculated for this area, a high level of protection is needed to adhere to the Department of Water Affair's (DWA) water quality objectives. Reasonable and sound groundwater protection measures are recommended to ensure that no cumulative pollution affects the aquifer, even in the long term.

In terms of DWAF's overarching water quality management objectives which is (1) protection of human health and (2) the protection of the environment, the significance of this aquifer classification is that if any potential risk exist, measures must be triggered to limit the risk to the environment, which in this case is the (1) protection of the Secondary Underlying Aquifer, (2) the Edendalspruit and its tributaries which drains the subject area and (3) the external users of groundwater in the area.

8 WASTE HANDLING

8.1 Solid waste

There is no solid waste disposal site as all solid waste is collected and transported to the Rayton Landfill site for disposal.

8.2 Sanitary Systems

All stands are presently served by septic tank systems. The septic tanks conform to the SANS and CSIR standards. According to the Services Report (2004) provided by KBK, infiltration tests were done on the various soil types to ensure that the soil can accommodate the sanitary systems adequately. Application at the Department of Water Affairs to build a Waste Water Treatment Facility at Kleinfontein is planned for the near future. The site selected is shown on the map in Appendix G.

The site is located in an area away from existing boreholes and surface water resources. Monitoring boreholes will be required for the permitting of the site by DWA.

Hydrological Assessment

The hydrogeological assessment as prescribed by the Sanitation Protocol comprises an assessment of the geological formations, the major and minor groundwater aquifers, water-bearing faults and fractures, and the major surface water resources. Issues such as the thickness of the unsaturated zone, the depth to the water table the permeability of the unsaturated zone, the location of production boreholes and the impact of abstracting groundwater, are important in the assessment.

The unsaturated zone underlying the Kleinfontein development area consists mainly of a shallow to deep weathered zone. Solid rock occurs at approximately 5 to 10 m on the quartzite. The occurrence of solid rock is deeper than 15m in the shale horizons. The aquifers present in the area are mainly fractured, faulted and contact zones in the fresh un-weathered rock. The depth to the water table varies between 10 and 25 m below ground level depending on the topography.

The area has an average rainfall of about 698 mm per annum and the recharge according the Groundwater Harvest Potential Map of South Africa is in the order of 10 000 to 15 000 cubic metres per square kilometre per annum that can be abstracted. Groundwater in the area is used mainly for domestic and game or cattle supply. Groundwater protection management against contamination is therefore of utmost importance.

Surface water conditions are important as impact occurs through run-off during rain events. Surface pollution sources should be managed in such a way that run-off is not contaminated by them. Contamination introduced into the unsaturated zone will migrate into the groundwater during high rainfall events.

Assessment of risk of Contamination

Variable drainage conditions can be expected with coefficient of permeability of between 10^{-1} and 10^{-8} m/sec determined across the development during the geotechnical investigations (pers. comm. Holland-Muter) . Permeability's of between 10^{-3} and 10^{-4} cm/sec are considered to be acceptable for installation of septic tanks. As stated before the aquifer at Kleinfontein development can be regarded as a major aquifer, which requires high protection. We further need to look at the contamination as the soil indicates variable percolation into the soil and runoff to surface water during the rainy season.

Unsaturated conditions:

The following is an assessment of the reduction of contaminants in the unsaturated zone according to the DWAF Protocol:

Table 10: Assessment of the reduction of contaminants in the unsaturated zone

Description	Rate
Rate of flow in the unsaturated zone:	**Slow to medium: 1-10 m/d**
Capacity of media to absorb contaminants:	**Medium**
Capacity to create an effective barrier to contaminants:	**Medium**
Reduction of bacteria and viruses	**High**
Reduction of nitrates and phosphates	**Minimal**
Reduction of chlorides	**Minimal**

From Table 10, it can be concluded the unsaturated zone is a **fair barrier** to the movements of **biological contaminants, but with little reduction in chemical contaminants.**

With the high density development and the variable thickness of the unsaturated zone in the Kleinfontein development area, the aquifer vulnerability is considered medium for the contaminant load that can be expected from septic tanks that are installed. A **medium overall risk** to the groundwater is estimated if precautionary measures are not taken due to the retention and overflow that may occur in septic tank pits.

It is recommended that a water borne sewage treatment system (such as the *activated sequential batch reactor* proposed), be utilised for the development to treat raw sewage. The treated effluent must be of the required DWA quality standard for release into the drainage system or for irrigation use.

8.3 Cemetery Site

There are two cemetery sites on the property located in the game park as shown in Appendix G. One site is historical and dates back to 1860 with graves of the original inhabitants as well as graves from the Anglo-Boer War in 1902. The cemetery presently in use is located adjacent to the historical cemetery and houses 25 graves of the Kleinfontein community. A record is kept of all funerals and the cemetery is well maintained and is in line with the standards of the National Cemetery Association (INCA). The cemetery is approximately 575 m upstream from the nearest borehole and no impact on the groundwater is envisaged.

9 POTENTIAL IMPACT ON OTHER USERS

The management of water resources at Kleinfontein focuses on protecting the resources and the environment. Homeowners are requested to use water efficiently and reduce water use during the rainy season. The production system is set to increase production from the fountain in the rainy season and reduce the production from the boreholes. During the pump testing the drawdown was monitored on observation boreholes in the vicinity but no impacts were recorded. This means that the drawdown in 24 hours testing did not impact on surrounding boreholes. It must be noted that the boreholes are shallow and available drawdown is restricted.

A number of complaints regarding reduction in water resources were received from neighbours. Details regarding their names and property localities are shown in Table 11. The complaints were concerning the reduction in their groundwater resources. Their usage as a percentage of the annual recharge on their properties was not considered but could be confirmed. It must be understood that groundwater is recharged by annual rainfall which fluctuates and therefore a reduction in resources is experienced by all users.

In order to investigate the potential impact on these properties the locality with respect to the boreholes pumped were plotted and are shown in Appendix H. Based on the localities the topographic profiles that exist between the localities were evaluated. The profiles are included in Appendix H with Profile A-A’ showing the topography between borehole *NO* tested and the Donkerhoek localities. Profile B-B’ shows the topography between the remaining 5 boreholes tested and the Donkerhoek localities. Both profiles show a watershed between the sites and it is therefore unlikely that the boreholes at Kleinfontein can impact on the properties in Table 11. Both the reduction in rainfall as well as other potential impacts on their groundwater should be investigated.

Table 11: Details of neighbours from which complaints were received.

Neighbour	Donkerhoek 365JR	Lattitude (WGS84)	Longitude (WGS84)
Adrian Roslee	Plot 13	na	na
Erik Pretorius	Plot 23 & 24	na	na
Jakkie Pieterse	Plot 69	25° 46' 58.88"	28° 27' 55.00 "
Lex Middelberg	na	25° 47' 10.25 "	28° 28' 16.76 "
Johan Thom	Plot 124	na	na

10 CONCLUSIONS AND RECOMMENDATIONS

Based on all the available information, test pumping data, analytical results and reserve determination, the following can be concluded:

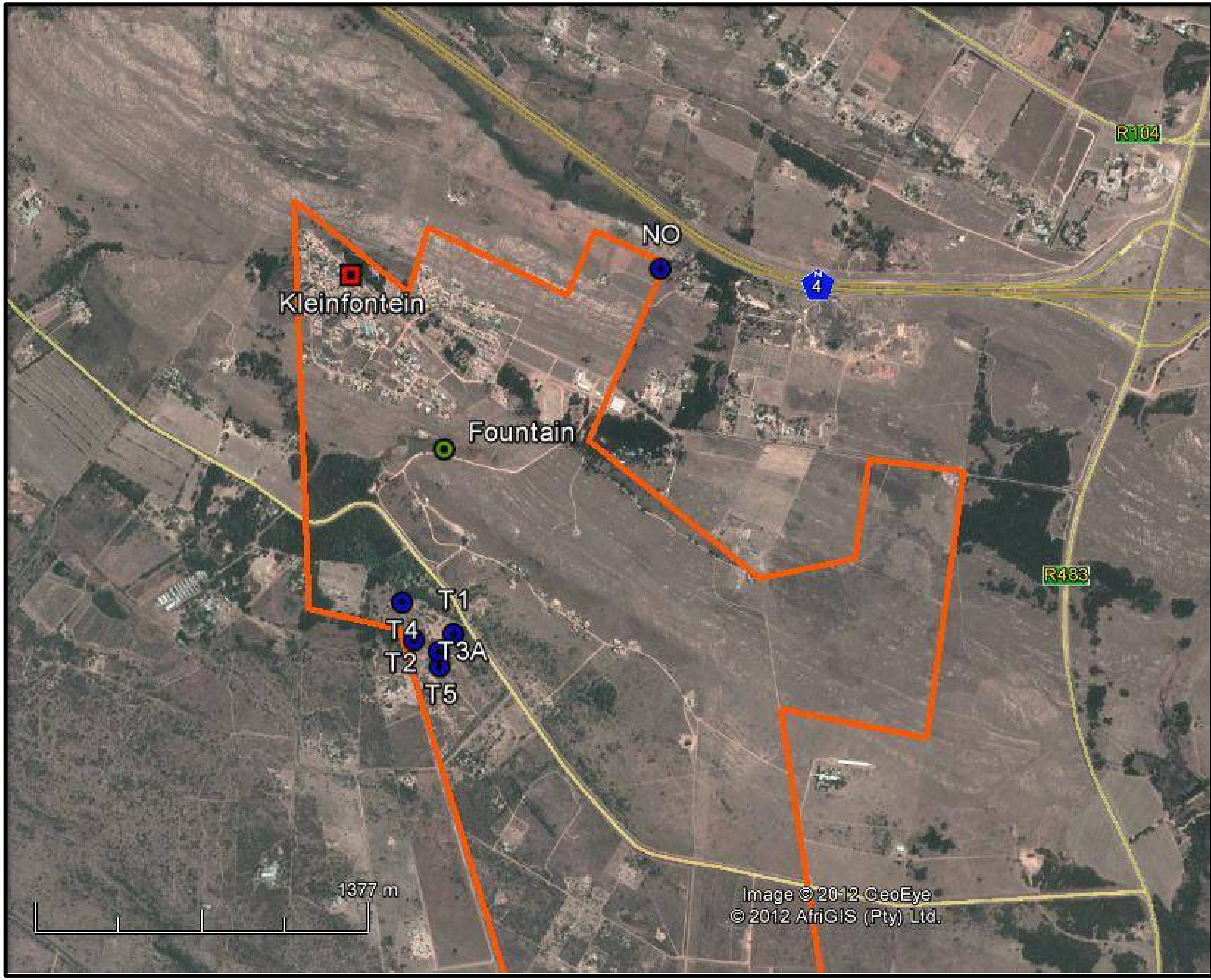
- The groundwater, with exception of the borehole *NO,* is of excellent quality and complies with the SANS 241-1 Drinking Water Standards.
- The iron content in borehole *NO* exceeds the maximum allowable drinking water standard (Class II). The manganese concentration falls within Class II standards (suitable for short term use only). This water is not presently used.
- The combined sustainable yield calculated from the pump tests conducted on the selected production boreholes is 3.8 l/s.
- The sustainable yield calculated from the fountain flow is 1.55 l/s.
- The calculated annual recharge on the property is 438 795 l/day or 5.1 l/s.
- A Water Use License for abstraction of 257 600 l/day or 2.75 l/s can be applied for.
- This is 53% of the annual recharge on the property and therefore within 60-100% of the annual recharge on the property which places the water use license in Category B.
- The ratings for the Aquifer System Management Classification and Aquifer Vulnerability Classification for the study area indicate that medium level groundwater protection may be required.
- Solid waste disposal site is not required as the solid waste is disposed at the licensed Rayton waste site.
- The Sanitation Protocol study shows medium overall risk to groundwater.
- Investigation into the complaints by neighbours showed that they are located outside the Kleinfontein catchment and is unlikely to be impacted by the groundwater abstraction on the Development.

Based on the above conclusions, the following recommendations are made:

- It is recommended that borehole *NO* be rehabilitated and tested before used for production.
- All the selected production boreholes need to be registered with the Department of Water Affairs for the WULA.
- Adherence to the sustainable yields of the boreholes is crucial to ensure long-term utilisation of the groundwater resource.
- Accurate monthly monitoring of the groundwater levels in the boreholes is recommended. If any significant fluctuation in water level occurs, immediate action needs to be taken.
- Groundwater quality and especially bacteriological analyses must be done on a regular basis.
- Reasonable and sound groundwater protection measures are recommended to ensure that no cumulative pollution affects the aquifer, even in the long term.
- It is recommended that a waterborne sewage system be installed for the development to treat the raw sewage water.

Appendix A

Borehole Locality Map



Project Title:
KLEINFONTEIN GEOHYDROLOGY REPORT

Map Title:
Kleinfontein: BH Locations

Map Number:
Map 1

LEGEND

Boreholes

Fountain

Kleinfontein Town

N

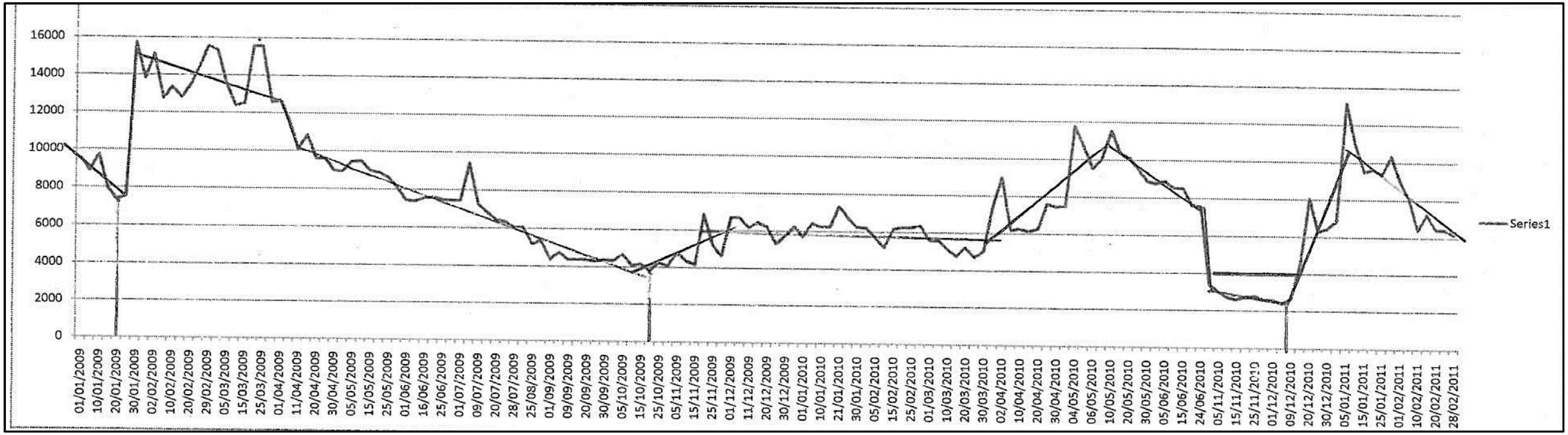
Project nr:
106773/Kleinfontein

aurecon

Lynnwood Bridge Office Park
4 Daventry Street
Lynnwood Manor 0040
www.aurecongroup.com

Appendix B

Fountain flow record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10000
8000
6000
4000
2000
0
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10/01/2009
20/01/2009
30/01/2009
02/02/2009
10/02/2009
20/02/2009
29/02/2009
05/03/2009
15/03/2009
25/03/2009
01/04/2009
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25/11/2010
01/12/2010
09/12/2010
20/12/2010
30/12/2010
05/01/2011
15/01/2011
25/01/2011
01/02/2011
10/02/2011
20/02/2011
28/02/2011
Series1

Appendix C

FC-Method Solution

FC-METHOD : Estimation of the sustainable yield of a borehole

T1

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	#NUM! ←	#NUM! ←	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	1	0.00E+00 ←	S-late ←	Change r_e
s_a (available drawdown), sigma_s = (enter)	5.0	←	Sigma_s from risk	
Annual effective recharge (mm) =	20	9.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	6.17	End time and drawdown of test	
Average maximum derivative = (enter)	0.2 ←	0.2	Estimate of average of max deriv	
Average second derivative = (enter)	0.0 ←	0.0	Estimate of average second deriv	
Derivative at radial flow period = (enter)	#NUM! ←	#NUM!	Read from derivative graph	
	T-early[m^2/d] =	#NUM!	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	70.16	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

		Maximum influence of boundaries at long time		
	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	6.72	7.36	8.01	9.94
Q_sust (l/s) =	1.34	1.22	1.12	0.91
	Best case	→		**Worst case**

Average Q_sust (l/s) = **1.14** — WARNING!! Est. Q_sust > Q during pumping test

with standard deviation= 0.18 — Suggestion:check available drawdown and rech

(If no information exists about boundaries skip advanced solution and go to final recommendation)

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

(Late T-and S-values a priori + distance to boundary)

T-late [m^2/d] = (enter) → 70.16

S-late = (enter) → 5.00E-03

1. BOUNDARY INFORMATION (choose a or b) — (Code =9999 = dummy value if not applicable)

(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	9999	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	0.00

(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	0.00

2. INFLUENCE OF OTHER BOREHOLES →	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	#NUM!	#NUM!

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter) →		Sigma_s =	0.000	

(Go to Risk sheet and perform risk analysis from which sigma_s will be estimated : only for barrier boundaries)

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	1.00
Total amount of water allowed to be abstracted per month (m^3) =	2592

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

FC-METHOD : Estimation of the sustainable yield of a borehole

T2

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	#NUM! ←	#NUM! ←	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	0.8	0.00E+00 ←	S-late ←	Change r_e
s_a (available drawdown), sigma_s = (enter)	12.0	23 ←	Sigma_s from risk	
Annual effective recharge (mm) =	20	16.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	6.36	End time and drawdown of test	
Average maximum derivative = (enter)	2.4 ←	2.4	Estimate of average of max deriv	
Average second derivative = (enter)	0.0 ←	0.0	Estimate of average second deriv	
Derivative at radial flow period = (enter)	#NUM! ←	#NUM!	Read from derivative graph	
	T-early[m^2/d] =	#NUM!	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	5.26	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
		Maximum influence of boundaries at long time		
sWell (Extrapol.time) =	13.25	20.14	27.03	47.70
Q_sust (l/s) =	0.97	0.64	0.47	0.27
	Best case	→	→	**Worst case**
Average Q_sust (l/s) =	**0.53**			
with standard deviation=	0.29			

(If no information exists about boundaries skip advanced solution and go to final recommendation)

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

(Late T-and S-values a priori + distance to boundary)

T-late [m^2/d] = (enter) →	5.26			
S-late = (enter) →	5.00E-03			
1. BOUNDARY INFORMATION (choose a or b)	(Code =9999 = dummy value if not applicable)			
(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	9999	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	#NUM!
(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	#NUM!
2. INFLUENCE OF OTHER BOREHOLES →	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	#NUM!	#NUM!
SOLUTION INCLUDING BOUNDS AND BH's				
Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter) →		Sigma_s =	0.000	

(Go to Risk sheet and perform risk analysis from which sigma_s will be estimated : only for barrier boundaries)

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.80
Total amount of water allowed to be abstracted per month (m^3) =	2074

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

FC-METHOD : Estimation of the sustainable yield of a borehole

T3A

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	#NUM! ←	#NUM! ←	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	1.2	0.00E+00 ←	S-late ←	Change r_e
s_a (available drawdown), sigma_s = (enter)	10.0	0 ←	Sigma_s from risk	
Annual effective recharge (mm) =	20	14.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	5.3	End time and drawdown of test	
Average maximum derivative = (enter)	5.4 ←	5.4	Estimate of average of max deriv	
Average second derivative = (enter)	0.0 ←	0.0	Estimate of average second deriv	
Derivative at radial flow period = (enter)	#NUM! ←	#NUM!	Read from derivative graph	
	T-early[m^2/d] =	#NUM!	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	3.52	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	20.93	36.37	51.81	98.13
Q_sust (l/s) =	0.80	0.46	0.32	0.17
	Best case	→		**Worst case**

Average Q_sust (l/s) = **0.38**

with standard deviation= 0.27

(If no information exists about boundaries skip advanced solution and go to final recommendation)

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

(Late T-and S-values a priori + distance to boundary)

T-late [m^2/d] = (enter) → 3.52

S-late = (enter) → 5.00E-03

1. BOUNDARY INFORMATION (choose a or b)

(Code =9999 = dummy value if not applicable)

(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	9999	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	#NUM!

(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	#NUM!

2. INFLUENCE OF OTHER BOREHOLES →	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	#NUM!	#NUM!

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter) →		Sigma_s =	0.000	

(Go to Risk sheet and perform risk analysis from which sigma_s will be estimated : only for barrier boundaries)

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.80
Total amount of water allowed to be abstracted per month (m^3) =	2074

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

FC-METHOD : Estimation of the sustainable yield of a borehole

T4

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	#NUM! ←	#NUM! ←	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	0.7	0.00E+00 ←	S-late ←	Change r_e
s_a (available drawdown), sigma_s = (enter)	6.0	0 ←	Sigma_s from risk	
Annual effective recharge (mm) =	20	10.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	2.68	End time and drawdown of test	
Average maximum derivative = (enter)	1.1 ←	1.1	Estimate of average of max deriv	
Average second derivative = (enter)	0.0 ←	0.0	Estimate of average second deriv	
Derivative at radial flow period = (enter)	#NUM! ←	#NUM!	Read from derivative graph	
	T-early[m^2/d] =	#NUM!	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	10.10	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	5.88	9.02	12.15	21.57
Q_sust (l/s) =	1.19	0.78	0.58	0.32
	Best case	→	→	**Worst case**
Average Q_sust (l/s) =	**0.64**			
with standard deviation=	0.37			

(If no information exists about boundaries skip advanced solution and go to final recommendation)

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

(Late T-and S-values a priori + distance to boundary)

T-late [m^2/d] = (enter) →	10.10			
S-late = (enter) →	5.00E-03			
1. BOUNDARY INFORMATION (choose a or b)	(Code =9999 = dummy value if not applicable)			
(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	9999	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	#NUM!
(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	0.00	0.00	0.00	0.00
2. INFLUENCE OF OTHER BOREHOLES →	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	#NUM!	#NUM!
SOLUTION INCLUDING BOUNDS AND BH's				
Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter) →		Sigma_s =	0.000	

(Go to Risk sheet and perform risk analysis from which sigma_s will be estimated : only for barrier boundaries)

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.50
Total amount of water allowed to be abstracted per month (m^3) =	1296

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

FC-METHOD : Estimation of the sustainable yield of a borehole

T5

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	#NUM!	#NUM!	Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	1	0.00E+00	S-late	Change r_e
s_a (available drawdown), sigma_s = (enter)	10.0	0	Sigma_s from risk	
Annual effective recharge (mm) =	20	14.00	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	7.6	End time and drawdown of test	
Average maximum derivative = (enter)	10.3	10.3	Estimate of average of max deriv	
Average second derivative = (enter)	0.1	0.1	Estimate of average second deriv	
Derivative at radial flow period = (enter)	#NUM!	#NUM!	Read from derivative graph	
	T-early[m^2/d] =	#NUM!	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	1.54	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

Maximum influence of boundaries at long time

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
sWell (Extrapol.time) =	37.26	66.61	95.97	184.02
Q_sust (l/s) =	0.38	0.21	0.15	0.08
	Best case			**Worst case**

Average Q_sust (l/s) = **0.17**

with standard deviation= 0.13

(If no information exists about boundaries skip advanced solution and go to final recommendation)

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

(Late T-and S-values a priori + distance to boundary)

T-late [m^2/d] = (enter)	1.54			
S-late = (enter)	5.00E-03			
1. BOUNDARY INFORMATION (choose a or b)	(Code =9999 = dummy value if not applicable)			
(a) Barrier (no-flow) boundaries	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	9999	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	#NUM!	0.00	#NUM!	#NUM!
(b) Fix head boundary + no-flow	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	#NUM!	0.00	#NUM!	#NUM!
2. INFLUENCE OF OTHER BOREHOLES	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	#NUM!	#NUM!

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter)		Sigma_s =	0.000	

(Go to Risk sheet and perform risk analysis from which sigma_s will be estimated : only for barrier boundaries)

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.40
Total amount of water allowed to be abstracted per month (m^3) =	1037

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

FC-METHOD : Estimation of the sustainable yield of a borehole

NO

Extrapolation time in years = (enter)	2	1051200	Extrapol.time in minutes	
Effective borehole radius (r_e) = (enter)	26.52 ←	26.52	← Est. r_e	From r(e) sheet
Q (l/s) from pumping test =	0.5	1.38E-06	← S-late	← Change r_e
s_a (available drawdown), sigma_s = (enter)	31.7	←	Sigma_s from risk	
Annual effective recharge (mm) =	20	35.66	s_available working drawdown(m)	
t(end) and s(end) of pumping test =	1440	31.33	End time and drawdown of test	
Average maximum derivative = (enter)	4.7 ←	4.7	Estimate of average of max deriv	
Average second derivative = (enter)	0.0 ←	0.0	Estimate of average second deriv	
Derivative at radial flow period = (enter)	6.95 ←	6.95	Read from derivative graph	
	T-early[m^2/d] =	1.14	Aqui. thick (m)	20
T and S estimates from derivatives	T-late [m^2/d] =	1.69	Est. S-late =	1.10E-03
(To obtain correct S-value, use program RPTSOLV)	S-late =	5.00E-03	S-estimate could be wrong	

BASIC SOLUTION

(Using derivatives + subjective information about boundaries)

(No values of T and S are necessary)

	No boundaries	1 no-flow	2 no-flow	Closed no-flow
		Maximum influence of boundaries at long time		
sWell (Extrapol.time) =	44.75	58.16	71.58	111.83
Q_sust (l/s) =	0.40	0.31	0.25	0.16
	Best case	→	→	**Worst case**

Average Q_sust (l/s) = **0.26**

with standard deviation= 0.10

(If no information exists about boundaries skip advanced solution and go to final recommendation)

ADVANCED SOLUTION

(Using derivatives+ knowledge on boundaries and other boreholes)

(Late T-and S-values a priori + distance to boundary)

T-late [m^2/d] = (enter) → 1.69

S-late = (enter) → 5.00E-03

1. BOUNDARY INFORMATION (choose a or b) (Code =9999 = dummy value if not applicable)

(a) Barrier (no-flow) boundaries →	Closed Square	Single Barrier	Intersect. 90°	2 Parallel Barriers
Bound. distance a[meter] : (enter)	9999	9999	9999	9999
Bound. distance b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	#NUM!	0.00	#NUM!	#NUM!
(b) Fix head boundary + no-flow →	Closed Fix	Single Fix	90°Fix+no-flow	// Fix+no-flow
Bound. distance to fix head a[meter] : (enter)	9999	9999	9999	9999
Bound. distance to no-flow b[meter] : (enter)			9999	9999
s_Bound(t = Extrapol.time) [m] =	#NUM!	0.00	#NUM!	#NUM!

2. INFLUENCE OF OTHER BOREHOLES →	Q (l/s)	r (m)	u_r	W(u,r)
BH1			0.00E+00	#NUM!
BH2			0.00E+00	#NUM!
s_(influence of BH1,BH2) =	0.00	0.00	7.14E-04	6.67

SOLUTION INCLUDING BOUNDS AND BH's

Fix head + No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
No-flow : Q_sust (l/s) =	9999.00	9999.00	9999.00	9999.00
Enter selected Q for risk analysis = (enter) →		Sigma_s =	0.000	

(Go to Risk sheet and perform risk analysis from which sigma_s will be estimated : only for barrier boundaries)

FINAL RECOMMENDED ABSTRACTION RATE

Abstraction rate (l/s) for 24 hr/d = (enter)	0.30
Total amount of water allowed to be abstracted per month (m^3) =	778

COMMENTS

Q_sust with 68% safety =

Q_sust with 95% safety =

Appendix D

Field Testing Records

WATER SOURCE EVALUATION REPORT

BH Number	NO

Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Map Ref Number	WGS84
Lat	50387
Long	54384
Altitude (mamsl)	1540
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0
BH Depth (m)	51.2

Status	
No info	
Destroyed	
In use	x
Unused	

Consumer	
No info	
Water disposed	
Farm	x
No urban	
Urban	

Toposetting	
Alluvial Fan	
Dry river bed	
Dunes	
Ephemeral stream	
Flat surface, plain	
In or along sinkhole	
Irrigated field	
Along dam, lake or swamp	
On mountain or hill	
At or in opencast mine	
In or along pan	
In or along river	
Hillside (slope)	
Terrace	
Valley	x
At or in waste disposal	

Purpose	
Drainage	
Exploration	
Mine drainage	
Observation	
Production (water supply)	x
Recharge	
Standby	
Waste disposal	
Other	

Equipment installed	
Airlift	
Centrifugal pump	
Gravity suction	
Handpump	
Jet	
Mono-type pump	
No equipment	
Observation tube	
Piston pump	
Powerhead	
Recorder	
Submersible pump	x
Turbine	
Windpump	
Windpump with powerhead	
Other:	

Site Type	
Stormwater	
Borehole	x
Canal or trench	
Dug well	
Effluent	
Fountain/Spring	
Gauging weir	
Sinkhole	
Drainage well	
Cattle dip	
Sewage	
Pit latrine, VIP, UDP	
Multiple borehole	
Meteorological Station	
Seepage from opencast mine	
Pan, dam, lake	
River or stream	
Seepage pond	
Tunnel, shaft or drain	
Flow from underground mine	
Rainwater harvesting station	
Wellpoint	
Reservoir	
Graveyard	
Other:	

Application	
No info	
Agriculture & domestic	x
Agriculture - irrigation only	
Agriculture - stock watering only	
Domestic - all purposes	
Domestic - garden only	
Nature conservation	
Public	
Industrial - commercial	
Industrial & mining - evaporate	
Industrial - industrial	
Industrial - mining	
Industrial - power generation	

TEST RECORD:

Date Started:	16/06/2012	**Test pump used:**	SP8-30	**Logger depth (m):**		**CD Date started:**	16/06/2012
Time Started:	08H00	**Pump depth (m):**	45.4	**SWL (mbgl):**	9.50	**CD Time started:**	10:30
						Waterlevel before constant started (m):	13.7

STEP TEST & RECOVERY

ep 1 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	16.42	0.38	
2	17.38		
3	18.34	0.38	
5	19.30		
7	20.10		
10	20.56	0.37	
15	21.50		
20	22.42	0.38	
30	22.96		
40	23.80	0.37	
50	25.64		
60	26.48	0.37	
70			
80			
90			
100			
110			
120			

Step 2 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	31.97	0.9	
2	33.15		
3	34.18	0.85	
5	36.44		
7	38.00		
10	40.12	0.83	
15	42.12		
20	45.12	0.81	
30	PI	0.57	
40			
50			
60			
70			
80			
90			
100			
110			
120			

Recovery

Time (min)	Waterlevel (m)
1	41.16
2	39.45
3	37.9
5	35.46
7	33.09
10	30.06
15	25.29
20	22.74
30	17.9
40	13.77
60	
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

Step 3 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1			
2			
3			
5			
7			
10			
15			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			

Step 4 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1			
2			
3			
5			
7			
10			
15			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			

CONSTANT DISCHARGE TEST

Constant Discharge Test RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Rec Time (min)	Recovery (m)
1	20.64	0.56	1	
2	20.9		2	
3	21.5		3	
5	22.3	0.55	5	
7	23.4		7	
10	24.19		10	
15	25.8		15	
20	28.32		20	
30	30.74	0.55	30	
40	32.27		40	
60	36.63	0.55	60	
90	37.75		90	
120	38.4	0.53	120	
150	38.68	0.52	150	
180	38.76	0.52	180	
210	38.78		210	
240	38.8	0.51	240	
300	38.78	0.52	300	
360	38.89	0.52	360	
420	39.08	0.52	420	
480	39.08		480	
540	39.18	0.51	540	
600	39.25		600	
720	39.59	0.51	720	
840	39.6		840	
960	39.69	0.5	960	
1080	39.92	0.5	1080	
1200	40.21	0.51	1200	
1320	40.47	0.52	1320	
1440	40.83	0.52	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH

BH no:

Distance:

Waterlevel:

Lat:

Long:

	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

WATER SOURCE EVALUATION REPORT

BH Number	T1

Map Ref Number	WGS84
Lat	51284
Long	55919
Altitude (mamsl)	1514
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0.12
BH Depth (m)	58

Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Status

Status	
No info	
Destroyed	
In use	x
Unused	

Consumer

Consumer	
No info	
Water disposed	
Farm	x
No urban	
Urban	

Toposetting

Toposetting	
Alluvial Fan	
Dry river bed	
Dunes	
Ephemeral stream	
Flat surface, plain	
In or along sinkhole	
Irrigated field	
Along dam, lake or swamp	
On mountain or hill	
At or in opencast mine	
In or along pan	
In or along river	
Hillside (slope)	
Terrace	
Valley	x
At or in waste disposal	

Purpose

Purpose	
Drainage	
Exploration	
Mine drainage	
Observation	
Production (water supply)	x
Recharge	
Standby	
Waste disposal	
Other	

Equipment installed

Equipment installed	
Airlift	
Centrifugal pump	
Gravity suction	
Handpump	
Jet	
Mono-type pump	
No equipment	
Observation tube	
Piston pump	
Powerhead	
Recorder	
Submersible pump	x
Turbine	
Windpump	
Windpump with powerhead	
Other:	

Site Type

Site Type	
Stormwater	
Borehole	x
Canal or trench	
Dug well	
Effluent	
Fountain/Spring	
Gauging weir	
Sinkhole	
Drainage well	
Cattle dip	
Sewage	
Pit latrine, VIP, UDP	
Multiple borehole	
Meteorological Station	
Seepage from opencast mine	
Pan, dam, lake	
River or stream	
Seepage pond	
Tunnel, shaft or drain	
Flow from underground mine	
Rainwater harvesting station	
Wellpoint	
Reservoir	
Graveyard	
Other:	

Application

Application	
No info	
Agriculture & domestic	x
Agriculture - irrigation only	
Agriculture - stock watering only	
Domestic - all purposes	
Domestic - garden only	
Nature conservation	
Public	
Industrial - commercial	
Industrial & mining - evaporate	
Industrial - industrial	
Industrial - mining	
Industrial - power generation	

TEST RECORD:

Date Started:	14/06/2012	**Test pump used:**	SP8-30	**Logger depth (m):**		**CD Date started:**	14/06/2012
Time Started:	08:04	**Pump depth (m):**	36.26	**SWL (mbgl):**	17.00	**CD Time started:**	13:02:00 AM
						Waterlevel before constant started (m):	17.8

STEP TEST & RECOVERY

ep 1 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	18.30		
2	18.40	0.31	
3	18.30		
5	18.28		
7	18.27	0.31	
10	18.25		
15	18.28		
20	18.27	0.37	
30	18.85	0.4	
40	18.85	0.4	
50	18.95		
60	18.97	0.4	
70			
80			
90			
100			
110			
120			

Step 2 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	21.00		
2	20.37	0.77	
3	20.42		
5	20.54		
7	20.53		
10	20.55		
15	20.42	0.77	
20	20.40		
30	20.49		
40	20.53	0.75	
50	20.53		
60	20.52	0.75	
70			
80			
90			
100			
110			
120			

Step 3 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	22.12	1.06	
2	22.04		
3	22.04		
5	22.12	1.06	
7	22.30		
10	22.27	1.03	
15	22.24		
20	22.28	1.02	
30	22.36	1.02	
40	22.42		
50	22.47	1.02	
60	22.44		
70			
80			
90			
100			
110			
120			

Step 4 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	25.15	1.75	
2	25.26		
3	25.65		
5	26		
7	26.27	1.75	
10	26.73		
15	27.62		
20	28.34		
30	30.8	1.69	
40	32.94		
50	35.21		
60	36.12	1.69	
70	PI	1.02	
80			
90			
100			
110			
120			

Recovery

Time (min)	Waterlevel (m)
1	25.6
2	22.5
3	20.8
5	20.07
7	19
10	18.25
15	17.8
20	
30	
40	
60	
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

CONSTANT DISCHARGE TEST

Constant Discharge Test RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Rec Time (min)	Recovery (m)
1	22.86	0.97	1	
2	22.9		2	
3	22.93		3	
5	22.95	0.97	5	
7	22.97		7	
10	22.98		10	
15	23	0.97	15	
20	23.02		20	
30	23.04		30	
40	23.05	0.97	40	
60	23.06		60	
90	23.06	0.97	90	
120	23.08	0.98	120	
150	23.11		150	
180	23.13	0.98	180	
210	23.15		210	
240	23.15	0.98	240	
300	23.15		300	
360	23.15		360	
420	23.17		420	
480	23.13		480	
540	23.09		540	
600	23.12		600	
720	23.09	0.95	720	
840	23.08		840	
960	23.08		960	
1080	23	0.95	1080	
1200	23.06		1200	
1320	23.1	0.97	1320	
1440	23.11	0.97	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH

BH no:
Distance:
Waterlevel:
Lat:
Long:

	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

WATER SOURCE EVALUATION REPORT

BH Number	T2

Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Map Ref Number	WGS84
Lat	51284
Long	55919
Altitude (mamsl)	1512
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0.12
BH Depth (m)	37

Status	
No info	
Destroyed	
In use	X
Unused	

Consumer	
No info	
Water disposed	
Farm	X
No urban	
Urban	

Toposetting	
Alluvial Fan	
Dry river bed	
Dunes	
Ephemeral stream	
Flat surface, plain	
In or along sinkhole	
Irrigated field	
Along dam, lake or swamp	
On mountain or hill	
At or in opencast mine	
In or along pan	
In or along river	
Hillside (slope)	
Terrace	
Valley	X
At or in waste disposal	

Purpose	
Drainage	
Exploration	
Mine drainage	
Observation	
Production (water supply)	X
Recharge	
Standby	
Waste disposal	
Other	

Equipment installed	
Airlift	
Centrifugal pump	
Gravity suction	
Handpump	
Jet	
Mono-type pump	
No equipment	
Observation tube	
Piston pump	
Powerhead	
Recorder	
Submersible pump	X
Turbine	
Windpump	
Windpump with powerhead	
Other:	

Site Type	
Stormwater	
Borehole	X
Canal or trench	
Dug well	
Effluent	
Fountain/Spring	
Gauging weir	
Sinkhole	
Drainage well	
Cattle dip	
Sewage	
Pit latrine, VIP, UDP	
Multiple borehole	
Meteorological Station	
Seepage from opencast mine	
Pan, dam, lake	
River or stream	
Seepage pond	
Tunnel, shaft or drain	
Flow from underground mine	
Rainwater harvesting station	
Wellpoint	
Reservoir	
Graveyard	
Other:	

Application	
No info	
Agriculture & domestic	X
Agriculture - irrigation only	
Agriculture - stock watering only	
Domestic - all purposes	
Domestic - garden only	
Nature conservation	
Public	
Industrial - commercial	
Industrial & mining - evaporate	
Industrial - industrial	
Industrial - mining	
Industrial - power generation	

TEST RECORD:

Date Started:	19/06/2012	**Test pump used:**		**Logger depth (m):**		**CD Date started:**	19/06/2012
Time Started:	08:15	**Pump depth (m):**	34.8	**SWL (mbgl):**	11	**CD Time started:**	11:02
						Waterlevel before constant started (m):	

STEP TEST & RECOVERY

ep 1 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	12.80	0.45	
2	12.80	0.45	
3	12.73	0.45	
5	12.70		
7	12.67	0.43	
10	12.69		
15	12.67	0.44	
20	12.66		
30	12.70		
40	12.72	0.45	
50	12.73	0.44	
60	12.70		
70			
80			
90			
100			
110			
120			

Step 2 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	13.85	0.72	
2	14.57		
3	15.35		
5	15.73	0.8	
7	15.05		
10	14.95	0.79	
15	15.00		
20	15.03		
30	15.10	0.8	
40	15.23		
50	15.23		
60	15.47		
70			
80			
90			
100			
110			
120			

Recovery

Time (min)	Waterlevel (m)
1	34.65
2	29.13
3	23.7
5	19.68
7	14.1
10	13.4
15	
20	
30	
40	
60	
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

Step 3 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	17.85	1.09	
2	18.30		
3	18.93	1.1	
5	20.07		
7	20.87	1.1	
10	21.00		
15	27.21		
20	30.50	1.09	
30	33.96		
40	PI	0.82	
50			
60			
70			
80			
90			
100			
110			
120			

Step 4 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1			
2			
3			
5			
7			
10			
15			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			

CONSTANT DISCHARGE TEST

Constant Discharge Test RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Rec Time (min)	Recovery (m)
1	15.59	0.76	1	
2	15.89		2	
3	17.02		3	
5	17.1	0.8	5	
7	16.86		7	
10	16.7		10	
15	16.7		15	
20	16.99	0.75	20	
30	16.95		30	
40	16.99		40	
60	17.05		60	
90	17.09	0.74	90	
120	17.1		120	
150	17.08	0.75	150	
180	17.06		180	
210	16.88	0.73	210	
240	16.85		240	
300	16.78		300	
360	16.8	0.76	360	
420	16.71		420	
480	17.28	0.76	480	
540	16.71		540	
600	16.78		600	
720	16.72	0.74	720	
840	17.31		840	
960	17.29		960	
1080	17.36	0.75	1080	
1200	17.27	0.76	1200	
1320	17.31	0.77	1320	
1440	17.35	0.77	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH

BH no:
Distance:
Waterlevel:
Lat:
Long:

	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

WATER SOURCE EVALUATION REPORT

BH Number	T3A

Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Map Ref Number	WGS84
Lat	51386
Long	55874
Altitude (mamsl)	
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0.12
BH Depth (m)	19

Status	
No info	
Destroyed	
In use	x
Unused	

Consumer	
No info	
Water disposed	
Farm	x
No urban	
Urban	

Toposetting	
Alluvial Fan	
Dry river bed	
Dunes	
Ephemeral stream	
Flat surface, plain	
In or along sinkhole	
Irrigated field	
Along dam, lake or swamp	
On mountain or hill	
At or in opencast mine	
In or along pan	
In or along river	
Hillside (slope)	
Terrace	
Valley	x
At or in waste disposal	

Purpose	
Drainage	
Exploration	
Mine drainage	
Observation	
Production (water supply)	x
Recharge	
Standby	
Waste disposal	
Other	

Equipment installed	
Airlift	
Centrifugal pump	
Gravity suction	
Handpump	
Jet	
Mono-type pump	
No equipment	
Observation tube	
Piston pump	
Powerhead	
Recorder	
Submersible pump	x
Turbine	
Windpump	
Windpump with powerhead	
Other:	

Site Type	
Stormwater	
Borehole	x
Canal or trench	
Dug well	
Effluent	
Fountain/Spring	
Gauging weir	
Sinkhole	
Drainage well	
Cattle dip	
Sewage	
Pit latrine, VIP, UDP	
Multiple borehole	
Meteorological Station	
Seepage from opencast mine	
Pan, dam, lake	
River or stream	
Seepage pond	
Tunnel, shaft or drain	
Flow from underground mine	
Rainwater harvesting station	
Wellpoint	
Reservoir	
Graveyard	
Other:	

Application	
No info	
Agriculture & domestic	x
Agriculture - irrigation only	
Agriculture - stock watering only	
Domestic - all purposes	
Domestic - garden only	
Nature conservation	
Public	
Industrial - commercial	
Industrial & mining - evaporate	
Industrial - industrial	
Industrial - mining	
Industrial - power generation	

TEST RECORD:

Date Started:	27/06/2012	Test pump used:		Logger depth (m):		CD Date started:	27/06/2012
Time Started:	08:30	Pump depth (m):	18.5	SWL (mbgl):	9.4	CD Time started:	14:20:00 AM
						Waterlevel before constant started (m):	10.42

STEP TEST & RECOVERY

ep 1 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	9.81	0.38	
2	9.75		
3	9.65		
5	9.70	0.38	
7	9.69		
10	9.68		
15	9.67	0.39	
20	9.67		
30	9.70		
40	9.73	0.37	
50	9.71		
60	9.73	0.37	
70			
80			
90			
100			
110			
120			

Step 2 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	9.90	0.6	
2	9.92		
3	9.94		
5	9.96	0.59	
7	9.97		
10	9.99		
15	9.99	0.55	
20	9.99		
30	9.98	0.56	
40	10.00	0.56	
50	10.03		
60	10.05		
70			
80			
90			
100			
110			
120			

Step 3 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	10.35	0.85	
2	10.33		
3	10.35		
5	10.38	0.83	
7	10.40		
10	10.43		
15	10.49	0.83	
20	10.48		
30	10.46	0.84	
40	10.5		
50	10.53		
60	10.57	0.83	
70			
80			
90			
100			
110			
120			

Step 4 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	10.94	1.7	
2	11.15		
3	11.43	1.7	
5	11.57		
7	11.64		
10	11.77	1.68	
15	11.96		
20	12.35		
30	13.89	1.67	
40	14.1		
50	14.16		
60	14.42	1.67	
70			
80			
90			
100			
110			
120			

Recovery

Time (min)	Waterlevel (m)
1	15.8
2	13.3
3	12.95
5	11.99
7	11.9
10	11.74
15	11.49
20	11.2
30	10.42
40	10.16
60	
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

CONSTANT DISCHARGE TEST

Constant Discharge Test RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Rec Time (min)	Recovery (m)
1	11	1.18	1	12.06
2	11.15		2	11.97
3	11.23		3	11.96
5	11.4	1.15	5	11.95
7	11.67		7	11.83
10	11.9		10	11.67
15	12.09	1.14	15	11.46
20	12.6		20	11.23
30	12.57		30	10.59
40	12.57		40	10.35
60	12.73		60	9.99
90	12.8	1.14	90	
120	12.78	1.15	120	
150	12.99		150	
180	12.79		180	
210	12.74	1.14	210	
240	12.69		240	
300	12.68	1.13	300	
360	12.74		360	
420	12.81	1.14	420	
480	13.02		480	
540	13.45	1.13	540	
600	13.6		600	
720	14.7	1.13	720	
840	13.78		840	
960	13.76	1.14	960	
1080	13.75		1080	
1200	13.65	1.14	1200	
1320	13.66	1.14	1320	
1440	13.59	1.13	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH

BH no:
Distance:
Waterlevel:
Lat:
Long:

	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

WATER SOURCE EVALUATION REPORT

BH Number	T4

Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Map Ref Number	WGS84
Lat	51431
Long	55721
Altitude (mamsl)	1512
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0.12
BH Depth (m)	39.4

Status	
No info	
Destroyed	
In use	X
Unused	

Consumer	
No info	
Water disposed	
Farm	X
No urban	
Urban	

Toposetting	
Alluvial Fan	
Dry river bed	
Dunes	
Ephemeral stream	
Flat surface, plain	
In or along sinkhole	
Irrigated field	
Along dam, lake or swamp	
On mountain or hill	
At or in opencast mine	
In or along pan	
In or along river	
Hillside (slope)	
Terrace	
Valley	X
At or in waste disposal	

Purpose	
Drainage	
Exploration	
Mine drainage	
Observation	
Production (water supply)	X
Recharge	
Standby	
Waste disposal	
Other	

Equipment installed	
Airlift	
Centrifugal pump	
Gravity suction	
Handpump	
Jet	
Mono-type pump	
No equipment	
Observation tube	
Piston pump	
Powerhead	
Recorder	
Submersible pump	X
Turbine	
Windpump	
Windpump with powerhead	
Other:	

Site Type	
Stormwater	
Borehole	X
Canal or trench	
Dug well	
Effluent	
Fountain/Spring	
Gauging weir	
Sinkhole	
Drainage well	
Cattle dip	
Sewage	
Pit latrine, VIP, UDP	
Multiple borehole	
Meteorological Station	
Seepage from opencast mine	
Pan, dam, lake	
River or stream	
Seepage pond	
Tunnel, shaft or drain	
Flow from underground mine	
Rainwater harvesting station	
Wellpoint	
Reservoir	
Graveyard	
Other:	

Application	
No info	
Agriculture & domestic	X
Agriculture - irrigation only	
Agriculture - stock watering only	
Domestic - all purposes	
Domestic - garden only	
Nature conservation	
Public	
Industrial - commercial	
Industrial & mining - evaporate	
Industrial - industrial	
Industrial - mining	
Industrial - power generation	

TEST RECORD:

Date Started:	2001/07/12	**Test pump used:**		**Logger depth (m):**		**CD Date started:**	01/07/2012
Time Started:	08:25	**Pump depth (m):**	17.5	**SWL (mbgl):**	11.2	**CD Time started:**	13:00
						Waterlevel before constant started (m):	12.22

STEP TEST & RECOVERY

ep 1 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	11.90	0.13	
2	11.90		
3	11.89	0.13	
5	11.91		
7	11.89	0.14	
10	11.88		
15	11.89	0.13	
20	11.89		
30	11.88	0.13	
40	11.89		
50	11.91	0.13	
60	11.90		
70			
80			
90			
100			
110			
120			

Step 2 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	12.01	0.28	
2	12.11		
3	12.14	0.28	
5	12.16		
7	12.16	0.27	
10	12.15		
15	12.16	0.28	
20	12.18		
30	12.20	0.27	
40	12.19		
50	12.20	0.28	
60	12.22		
70			
80			
90			
100			
110			
120			

Step 3 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	12.47	0.53	
2	12.60		
3	12.57	0.53	
5	12.60		
7	12.63	0.51	
10	12.67	0.51	
15	12.67		
20	12.72		
30	12.76	0.52	
40	12.79		
50	12.8	0.51	
60	12.82		
70			
80			
90			
100			
110			
120			

Step 4 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	12.99	1.16	
2	13.14		
3	13.32	1.15	
5	13.55		
7	13.7	1.14	
10	13.86		
15	14.52		
20	14.8	1.16	
30	15.07		
40	15.15	1.15	
50	15.65		
60	16	1.16	
70			
80			
90			
100			
110			
120			

Recovery

Time (min)	Waterlevel (m)
1	14.72
2	14.04
3	13.83
5	13.09
7	12.98
10	12.85
15	12.6
20	12.37
30	12.24
40	12.15
60	11.96
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

CONSTANT DISCHARGE TEST

Constant Discharge Test RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Rec Time (min)	Recovery (m)
1	12.73	0.66	1	12.88
2	12.92		2	12.84
3	12.99		3	12.8
5	13.08	0.67	5	12.74
7	13.11		7	12.67
10	13.14	0.64	10	12.57
15	13.27		15	12.4
20	13.34	0.64	20	12.31
30	13.38		30	12.23
40	13.52		40	12.2
60	13.51		60	12.12
90	13.52		90	12.02
120	13.55		120	
150	13.6		150	
180	13.6	0.65	180	
210	13.62		210	
240	13.63		240	
300	13.62		300	
360	13.7	0.65	360	
420	13.74		420	
480	13.73		480	
540	13.75	0.66	540	
600	13.61		600	
720	13.72		720	
840	13.64	0.66	840	
960	13.66		960	
1080	13.84		1080	
1200	13.86		1200	
1320	13.88	0.64	1320	
1440	13.84	0.64	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH

BH no:
Distance:
Waterlevel:
Lat:
Long:

	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

WATER SOURCE EVALUATION REPORT

BH Number	T5

Project No:	
Province	
District	
Municipality	
Farm name & No.	
Village/Site name	

Map Ref Number	WGS84
Lat	51280
Long	55979
Altitude (mamsl)	
Drainage Region	
BH Diameter (mm)	165
Collar height (m)	0.25
BH Depth (m)	21

Status	
No info	
Destroyed	
In use	X
Unused	

Consumer	
No info	
Water disposed	
Farm	X
No urban	
Urban	

Toposetting	
Alluvial Fan	
Dry river bed	
Dunes	
Ephemeral stream	
Flat surface, plain	
In or along sinkhole	
Irrigated field	
Along dam, lake or swamp	
On mountain or hill	
At or in opencast mine	
In or along pan	
In or along river	
Hillside (slope)	
Terrace	
Valley	X
At or in waste disposal	

Purpose	
Drainage	
Exploration	
Mine drainage	
Observation	
Production (water supply)	X
Recharge	
Standby	
Waste disposal	
Other	

Equipment installed	
Airlift	
Centrifugal pump	
Gravity suction	
Handpump	
Jet	
Mono-type pump	
No equipment	
Observation tube	
Piston pump	
Powerhead	
Recorder	
Submersible pump	X
Turbine	
Windpump	
Windpump with powerhead	
Other:	

Site Type	
Stormwater	
Borehole	X
Canal or trench	
Dug well	
Effluent	
Fountain/Spring	
Gauging weir	
Sinkhole	
Drainage well	
Cattle dip	
Sewage	
Pit latrine, VIP, UDP	
Multiple borehole	
Meteorological Station	
Seepage from opencast mine	
Pan, dam, lake	
River or stream	
Seepage pond	
Tunnel, shaft or drain	
Flow from underground mine	
Rainwater harvesting station	
Wellpoint	
Reservoir	
Graveyard	
Other:	

Application	
No info	
Agriculture & domestic	X
Agriculture - irrigation only	
Agriculture - stock watering only	
Domestic - all purposes	
Domestic - garden only	
Nature conservation	
Public	
Industrial - commercial	
Industrial & mining - evaporate	
Industrial - industrial	
Industrial - mining	
Industrial - power generation	

TEST RECORD:

Date Started:	23/06/2012	**Test pump used:**		**Logger depth (m):**		**CD Date started:**	23/06/2012
Time Started:	07:45	**Pump depth (m):**	19	**SWL (mbgl):**	9	**CD Time started:**	12:00
						Waterlevel before constant started (m):	10.05

STEP TEST & RECOVERY

ep 1 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	9.50	0.59	
2	9.46		
3	9.43	0.58	
5	9.43		
7	9.45	0.58	
10	9.46		
15	9.47	0.57	
20	9.50		
30	9.51	5.7	
40	9.52		
50	9.55	0.57	
60	9.57		
70			
80			
90			
100			
110			
120			

Step 2 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	9.61	1.18	
2	9.64		
3	9.63	1.18	
5	9.67		
7	9.68	1.19	
10	9.70		
15	9.75	1.24	
20	9.76		
30	9.82	1.25	
40	9.90		
50	9.91	1.25	
60	9.97		
70			
80			
90			
100			
110			
120			

Step 3 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	10.10	1.78	
2	10.09		
3	10.10	1.81	
5	10.10		
7	10.15	1.81	
10	10.20		
15	10.26	1.8	
20	10.47		
30	10.50	1.79	
40	10.62		
50	10.81	1.8	
60	10.92		
70			
80			
90			
100			
110			
120			

Step 4 RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Recovery (m)
1	11.3	2.72	
2	11.49		
3	11.84	2.63	
5	12.23		
7	13.14	2.54	
10	14.97		
15	17.25	2.36	
20	PI	1.04	
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			

Recovery

Time (min)	Waterlevel (m)
1	13.25
2	12.2
3	11.65
5	11.2
7	10.91
10	10.63
15	10.42
20	10.32
30	10.1
40	10.05
60	
90	
120	
150	
180	
210	
240	
300	
360	
420	
480	
540	
600	
720	
840	
960	
1080	
1200	
1320	
1440	
2280	
2880	
3480	
3900	
4320	
4920	
5760	

CONSTANT DISCHARGE TEST

Constant Discharge Test RPM:

Time (min)	Drawdown (m)	Yield (L/s)	Rec Time (min)	Recovery (m)
1	10.33	1	1	11.07
2	10.42		2	10.98
3	10.52		3	10.88
5	10.86	1	5	10.75
7	11.23		7	10.64
10	11.63		10	10.52
15	11.99	0.99	15	10.34
20	12.21		20	10.29
30	12.44		30	10.16
40	12.68	1	40	10.07
60	13.71		60	9.94
90	12.79		90	9.81
120	12.85	0.98	120	9.7
150	12.89		150	
180	12.97		180	
210	13.03	0.97	210	
240	13.1		240	
300	13.13		300	
360	13.14	0.98	360	
420	14.06		420	
480	14.7		480	
540	14.67		540	
600	16.6	0.97	600	
720	15.6		720	
840	15.8		840	
960	14.68		960	
1080	13.9		1080	
1200	12.23	0.96	1200	
1320	11.67	0.97	1320	
1440	11.49	0.97	1440	
2280			2280	
2880			2880	
3480			3480	
3900			3900	
4320			4320	
4920			4920	
5760			5760	

Observation BH

BH no:
Distance:
Waterlevel:
Lat:
Long:

	Drawdown	Recovery
1		
2		
3		
5		
7		
10		
15		
20		
30		
40		
60		
90		
120		
150		
180		
210		
240		
300		
360		
420		
480		
540		
600		
720		
840		
960		
1080		
1200		
1320		
1440		
2280		
2880		
3480		
3900		
4320		

Appendix E

Laboratory Reports

CLEAN STREAM
Scientific Services (Pty.) Ltd.
489 Jacqueline Drive, Garsfontein, Pretoria, 0042
P.O. Box 905008, Garsfontein, 0042
Tel (012) 348 2813/4, **Fax** 012 348 8575

Specialists in environmental monitoring

Test Report

Client: Aurecon
Address: 1040 Burnett Street, Hatfield, 0083
Report No: 8551 **Project:** Aurecon

Date of certificate: 26 Jun 2012
Date accepted: 20 Jun 2012
Date completed: 26 Jun 2012

Lab no:			91849	91850	91851
Date sampled:			20 Jun 2012	20 Jun 2012	20 Jun 2012
Sample type:			Water	Water	Water
Locality description			T1	NO	T2
Analyses:		**Method**			
A	pH	CSM 20	7.57	6.86	6.55
A	Electrical conductivity (EC) mS/m	CSM 20	6.48	7.19	5.69
A	Total dissolved solids (TDS) mg/l	CSM 26	30	32	29
A	Total alkalinity mg/l	CSM 01	20.7	26.6	21.9
A	Chloride (Cl) mg/l	CSM 02	4.0	3.0	3.7
A	Sulphate (SO4) mg/l	CSM 03	2.79	3.67	0.73
A	Nitrate (NO3) mg/l as N	CSM 06	0.596	<0.057	0.361
A	Ammonium(NH4) mg/l as N	CSM 05	0.024	0.021	0.023
A	Orthophosphate (PO4) mg/l as P	CSM 04	0.078	0.060	<0.025
A	Fluoride (F) mg/l	CSM 08	0.198	0.844	<0.183
A	Calcium (Ca) mg/l	CSM 30	4.587	2.757	2.472
A	Magnesium (Mg) mg/l	CSM 30	2.465	3.613	3.105
A	Sodium (Na) mg/l	CSM 30	2.58	1.65	3.67
A	Potassium (K) mg/l	CSM 30	0.509	1.350	1.420
A	Aluminium (Al) mg/l	CSM 31	<0.006	<0.006	0.052
A	Iron (Fe) mg/l	CSM 31	<0.006	3.655	<0.006
A	Manganese (Mn) mg/l	CSM 31	<0.001	0.220	<0.001
A	Total hardness mg/l	CSM 26	22	22	19

A = Accredited (Included in the SANAS Schedule of Accreditation); N = Not accredited (Excluded from the SANAS Schedule of Accreditation)
OSD = Outsourced; S = Sub-contracted; NR = Not requested; RTF = Results to follow; TNTC = To numerous to count; ND = Not detected
NATD = Not able to determine

sanas Testing Laboratory
T0374

Report checked by: H. Holtzhausen (Laboratory Manager) HHausen

aquatico Laboratories (Pty). Ltd.
489 Jacqueline Drive, Garsfontein, Pretoria, 0042
P.O. Box 905008, Garsfontein, 0042
Tel (012) 348 2813/4, **Fax** 012 348 8575

Specialists in environmental monitoring

Test Report

Client: Aurecon
Address: 1040 Burnett Street, Hatfield, 0083
Report No: 8622 **Project:** Aurecon

Date of certificate: 04 Jul 2012
Date accepted: 29 Jun 2012
Date completed: 03 Jul 2012

Lab no:			92509	92510
Date sampled:			28 Jun 2012	28 Jun 2012
Sample type:			Water	Water
Locality description			T3A	T5
Analyses:		**Method**		
A	pH	CSM 20	6.65	6.87
A	Electrical conductivity (EC) mS/m	CSM 20	7.84	7.19
A	Total dissolved solids (TDS) mg/l	CSM 26	34	31
A	Total alkalinity mg/l	CSM 01	28.0	25.2
A	Chloride (Cl) mg/l	CSM 02	4.6	3.5
A	Sulphate (SO4) mg/l	CSM 03	<0.132	<0.132
A	Nitrate (NO3) mg/l as N	CSM 06	0.108	0.106
A	Ammonium(NH4) mg/l as N	CSM 05	<0.015	0.023
A	Orthophosphate (PO4) mg/l as P	CSM 04	<0.025	<0.025
A	Fluoride (F) mg/l	CSM 08	<0.183	0.196
A	Calcium (Ca) mg/l	CSM 30	2.857	2.726
A	Magnesium (Mg) mg/l	CSM 30	4.246	3.533
A	Sodium (Na) mg/l	CSM 30	4.13	4.10
A	Potassium (K) mg/l	CSM 30	1.333	1.426
A	Aluminium (Al) mg/l	CSM 31	0.494	0.102
A	Iron (Fe) mg/l	CSM 31	0.058	<0.006
A	Manganese (Mn) mg/l	CSM 31	<0.001	<0.001
A	Total hardness mg/l	CSM 26	25	21

A = Accredited (Included in the SANAS Schedule of Accreditation); N = Not accredited (Excluded from the SANAS Schedule of Accreditation); OSD = Outsourced; S = Sub-contracted; NR = Not requested; RTF = Results to follow; TNTC = To numerous to count; ND = Not detected; NATD = Not able to determine

Report checked by: H. Holtzhausen (Laboratory Manager) HHausen

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aquatico Laboratories (Pty). Ltd.

489 Jacqueline Drive, Garsfontein, Pretoria, 0042
P.O. Box 905008, Garsfontein, 0042
Tel (012) 348 2813/4, **Fax** 012 348 8575

Specialists in environmental monitoring

Test Report

Client: **Aurecon**
Address: 1040 Burnett Street, Hatfield, 0083
Report No: 8634 **Project:** Aurecon

Date of certificate: 06 Jul 2012
Date accepted: 02 Jul 2012
Date completed: 05 Jul 2012

Lab no:			92578
Date sampled:			02 Jul 2012
Sample type:			Water
Locality description			T4
Analyses:		**Method**	
A	pH	CSM 20	6.34
A	Electrical conductivity (EC) mS/m	CSM 20	9.76
A	Total dissolved solids (TDS) mg/l	CSM 26	42
A	Total alkalinity mg/l	CSM 01	34.0
A	Chloride (Cl) mg/l	CSM 02	5.3
A	Sulphate (SO4) mg/l	CSM 03	<0.132
A	Nitrate (NO3) mg/l as N	CSM 06	0.721
A	Ammonium(NH4) mg/l as N	CSM 05	0.083
A	Orthophosphate (PO4) mg/l as P	CSM 04	<0.025
A	Fluoride (F) mg/l	CSM 08	<0.183
A	Calcium (Ca) mg/l	CSM 30	4.535
A	Magnesium (Mg) mg/l	CSM 30	5.419
A	Sodium (Na) mg/l	CSM 30	3.94
A	Potassium (K) mg/l	CSM 30	1.987
A	Aluminium (Al) mg/l	CSM 31	<0.006
A	Iron (Fe) mg/l	CSM 31	<0.006
A	Manganese (Mn) mg/l	CSM 31	<0.001
A	Total hardness mg/l	CSM 26	34

A = Accredited (Included in the SANAS Schedule of Accreditation); N = Not accredited (Excluded from the SANAS Schedule of Accreditation); OSD = Outsourced; S = Sub-contracted; NR = Not requested; RTF = Results to follow; TNTC = To numerous to count; ND = Not detected; NATD = Not able to determine

Aquatico Laboratories does not accept responsibility for any matters arising from the further use of these results.
Measurement of uncertainty available on request. This report only relates to the above samples and variables analysed.

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T0374

Report checked by: H. Holtzhausen (Laboratory Manager) HHausen

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ilac-MRA sanas Testing Laboratory T0374

Test Report

Client: Aurecon
Address: 1040 Burnett Street, Hatfield, 0083
Report no: 8783
Project: Aurecon

Date of certificate: 17 July 2012
Date accepted: 12 July 2012
Date completed: 17 July 2012
Revision: 0

Lab no:				93951
Date sampled:				12-Jul-12
Sample type:				Water
Locality description:				Fountain
	Analyses	**Unit**	**Method**	
A	pH	pH	CSM 20	6.66
A	Electrical conductivity (EC)	mS/m	CSM 20	1.48
A	Total dissolved solids (TDS)	mg/l	CSM 26	6
A	Total alkalinity	mg/l	CSM 01	<8.26
A	Chloride (Cl)	mg/l	CSM 02	3.35
A	Sulphate (SO_4)	mg/l	CSM 03	<0.13
A	Fluoride (F)	mg/l	CSM 08	<0.18
A	Orthophosphate (PO_4) as P	mg/l	CSM 04	<0.03
A	Ammonium (NH4) as N	mg/l	CSM 05	0.124
A	Nitrate (NO3) as N	mg/l	CSM 06	<0.057
A	Calcium (Ca)	mg/l	CSM 30	0.64
A	Magnesium (Mg)	mg/l	CSM 30	0.49
A	Sodium (Na)	mg/l	CSM 30	0.64
A	Potassium (K)	mg/l	CSM 30	0.34
A	Aluminium (Al)	mg/l	CSM 31	0.01
A	Iron (Fe)	mg/l	CSM 31	<0.01
A	Manganese (Mn)	mg/l	CSM 31	<0.001
A	Total hardness	mg/l	CSM 26	4

A = Accredited N= Not accredited O = Outsourced S = Sub-contracted NR = Not requested RTF = Results to follow NATD = Not able to determine
Results marked 'Not SANAS Accredited' in this report are not included in the SANAS Schedule of Accreditation for this laboratory.
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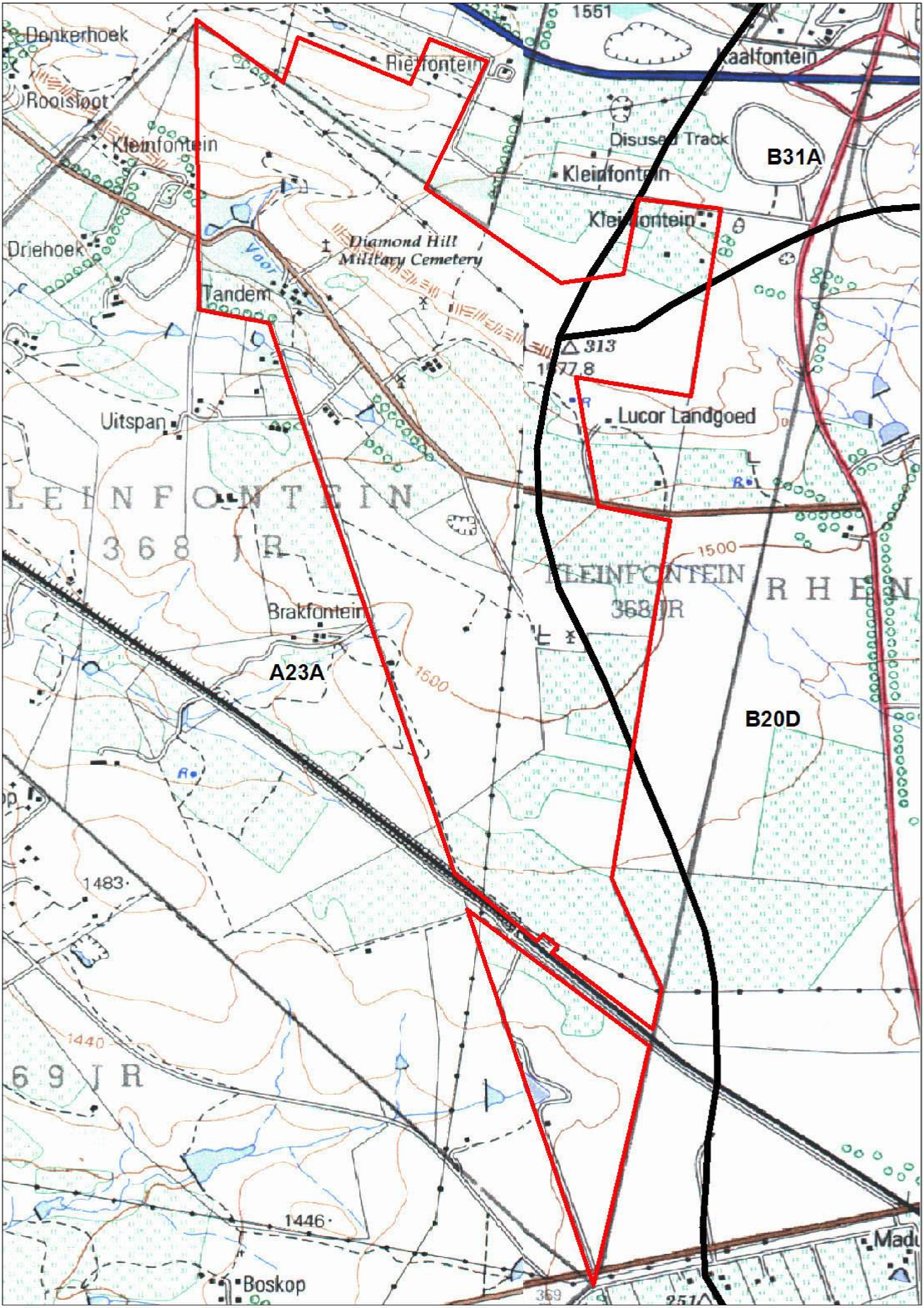
Measurement of uncertainty available on request for all methods included in the SANAS Schedule of Accreditation.
Results reported against the limit of quantification.

HHausen
Laboratory Manager: H. Holtzhausen

Appendix F

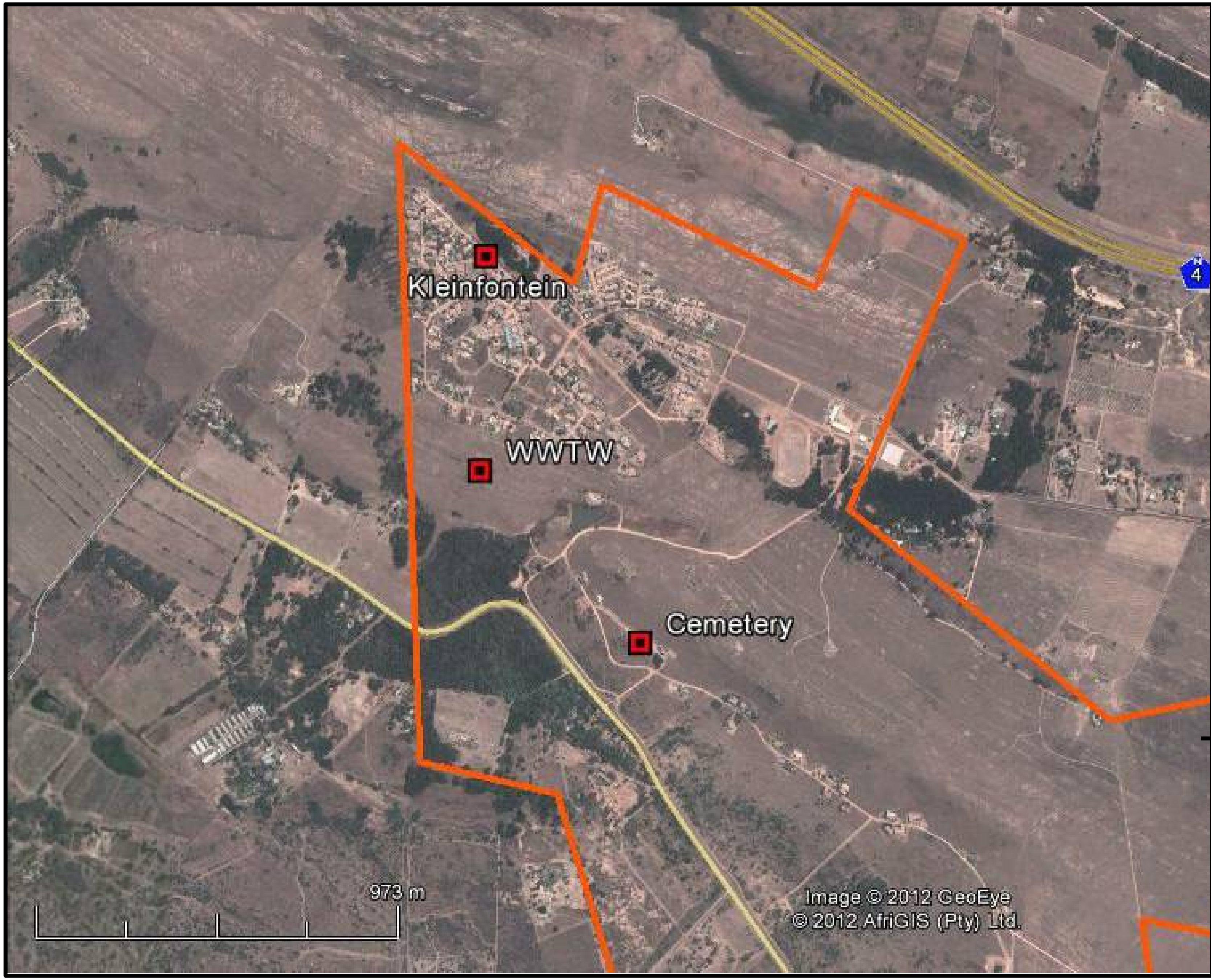
Catchment Map



Donkerhoek
Rooisloot
Kleinfontein
Driehoek
Rietfontein
Diamond Hill
Military Cemetery
Tandem
Uitspan
Voor
Kaalfontein
Disused Track
Kleinfontein
Kleinfontein
B31A
313
1577.8
Lucor Landgoed
KLEINFONTEIN
368 JR
KLEINFONTEIN
368 JR
RHEN
1500
Brakfontein
A23A
B20D
1500
1551
1483
1440
69 JR
1446
Boskop
Madu
369

Appendix G

Location of Cemetery and Planned Waste Water Plant Sites



Project Title:

KLEINFONTEIN GEOHYDROLOGY REPORT

Map Title:

Kleinfontein: Locality Map

Map Number:

Map 4

LEGEND

N

Project nr:
106773/Kleinfontein

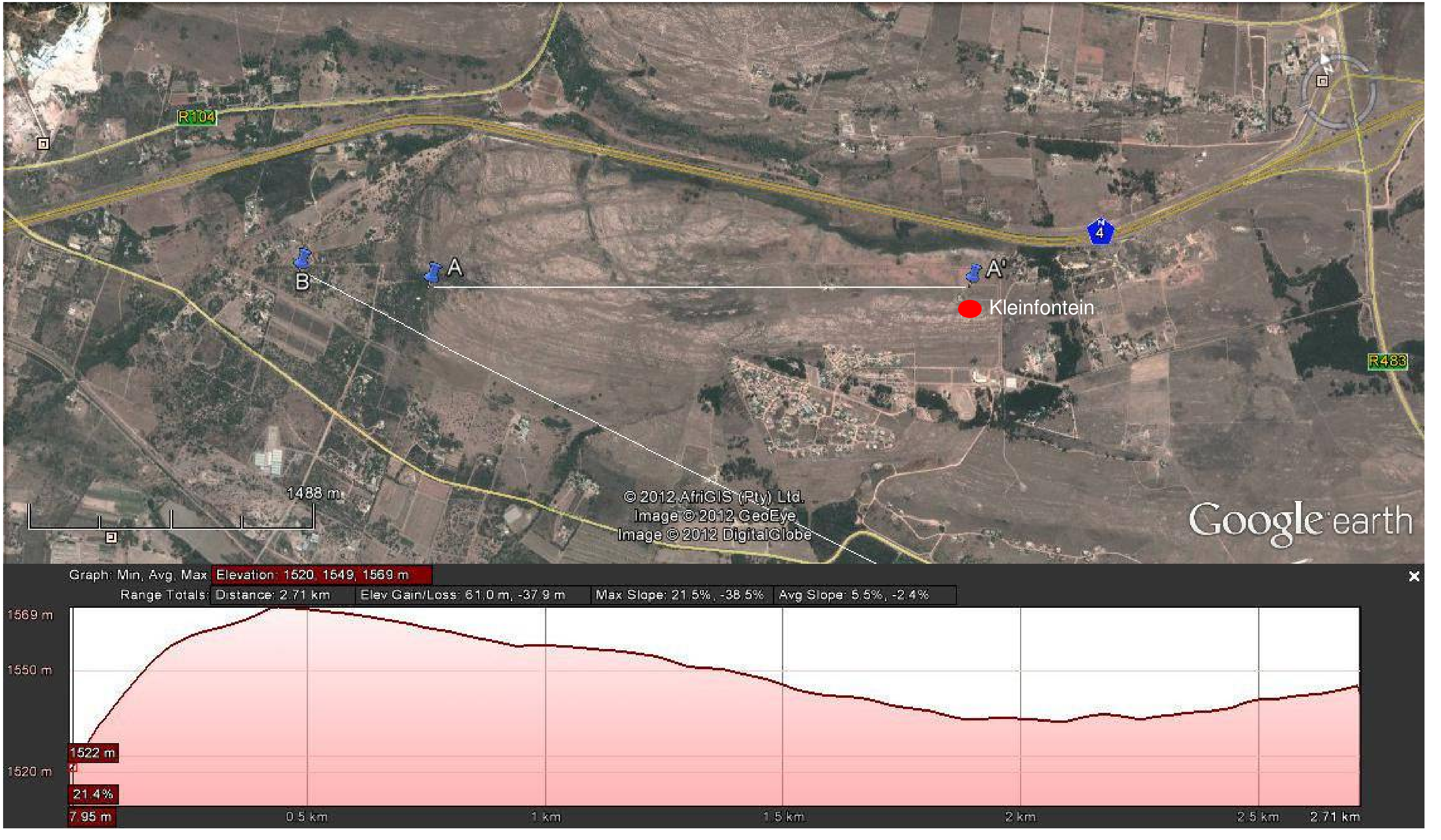
aurecon

Lynnwood Bridge Office Park
4 Daventry Street
Lynnwood Manor 0040
www.aurecongroup.com

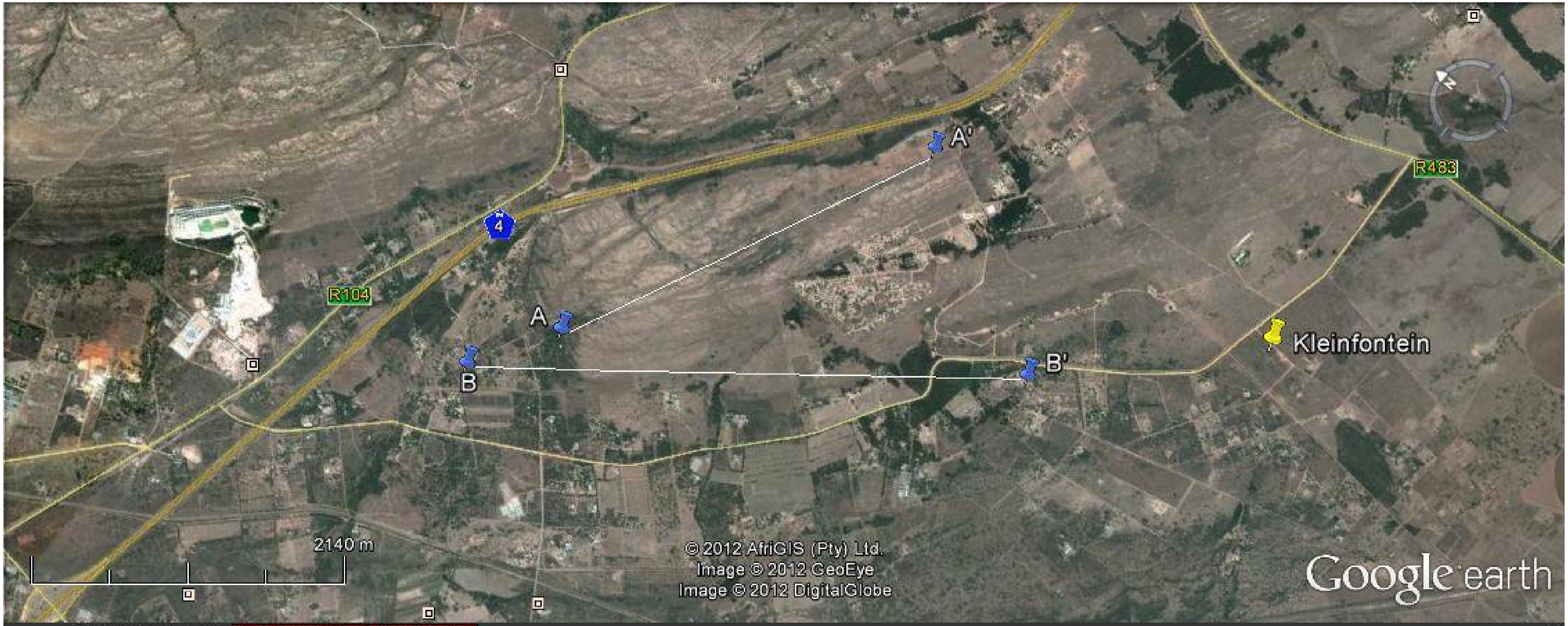
Appendix H

Profiles between Kleinfontein and Neighbours

Profile A-A'


R104
A
A'
B
4
Kleinfontein
R483
1488 m
© 2012 AfriGIS (Pty) Ltd.
Image © 2012 GeoEye
Image © 2012 DigitalGlobe
Google earth
Graph: Min, Avg, Max
Elevation: 1520, 1549, 1569 m
Range Totals:
Distance: 2.71 km
Elev Gain/Loss: 61.0 m, -37.9 m
Max Slope: 21.5%, -38.5%
Avg Slope: 5.5%, -2.4%
1569 m
1550 m
1520 m
1522 m
21.4%
7.95 m
0.5 km
1 km
1.5 km
2 km
2.5 km
2.71 km

Profile B-B'



A
A'
B
B'
4
R104
R483
Kleinfontein
2140 m
© 2012 AfriGIS (Pty) Ltd.
Image © 2012 GeoEye
Image © 2012 DigitalGlobe
Google earth

Graph: Min, Avg, Max
Elevation: 1434, 1519, 1560 m
Range Totals:
Distance: 3.74 km
Elev Gain/Loss: 151 m, -93.7 m
Max Slope: 33.2%, -91.4%
Avg Slope: 7.7%, -4.8%
1560 m
1500 m
1450 m
1434 m
1434 m
6.0%
0 m
0.5 km
1 km
1.5 km
2 km
2.5 km
3 km
3.74 km

Annexure G(iii)

WETLAND DELINEATION

THE PROPOSED DEVELOPMENT ON PORTIONS OF THE FARM KLEINFONTEIN 368 JR, GAUTENG

Wetland Delineation and Functional Assessment Report
August 2011

Drafted by Antoinette Bootsma
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Drafted for Bokamoso Landscape Architects
& Environmental Consultants
Tel: (012) 346 3810
Fax: 086 570 5659
Email: lizelleg@mweb.co.za

Declaration of Independence

I, **Antoinette Bootsma**, in my capacity as a specialist consultant, hereby declare that I -

- Act as an independent consultant;
- Do not have any financial interest in the undertaking of the activity, other than remuneration for the work performed in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- Undertake to disclose, to the competent authority, any material information that has or may have the potential to influence the decision of the competent authority or the objectivity of any report, plan or document required in terms of the National Environmental Management Act, 1998 (Act 107 of 1998);
- As a registered member of the South African Council for Natural Scientific Professions, will undertake my profession in accordance with the Code of Conduct of the Council, as well as any other societies to which I am a member; and
- Based on information provided to me by the project proponent, and in addition to information obtained during the course of this study, have presented the results and conclusion within the associated document to the best of my professional judgement.

AB Bootsma	2011.08.25
Antoinette Bootsma (PrSciNat)	Date
Ecologist/Botanist	
SACNASP Reg. No. 400222-09	

EXECUTIVE SUMMARY

Limosella Consulting was appointed by Bokamoso Environmental Consultants and Landscape Architects to undertake an independent assessment of potential wetland conditions that could potentially be affected by the proposed development on the portions of the farm Kleinfontein 368 JR, Gauteng.

Five wetland areas were identified during the current assessment. One large wetland system was recorded on the northern part of the site and includes two dams. This valley bottom wetland is found at the bottom of two steep ridges and is fed by water runoff from the ridges. Three wetland areas were identified on the southern section of the site. A low laying pan was found to the north of the southern section with *Typha capensis* (Bullrushes) and a variety of different sedges. At the eastern boundary a small valley bottom wetland was found dominated by *Imperata cylindrica* (Cottonwool Grass), a third wetland area was found on the southernmost portion of the site. This area was fenced and access could not be gained for soil samples. A visual inspection was conducted and the delineation was consequently based on vegetation gradients visible on aerial imagery. The southernmost section of the site has a low level of impact as can be seen by the absence of *Seriphuim plumosum* (Bankrotbossie), although in some areas the presence of *Tagetes minuta* (Khakiweed) was recorded. The relative importance of wetland habitat to bird and animal species should be verified by suitable qualified avifauna, herpetofauna and fauna specialists.

An artificial seepage wetland was recorded adjacent to a road. This wetland is not sensitive in a local or regional context, and although all wetlands are protected by various aspects of legislation, the current study finds that the contribution to local biodiversity and hydrological function can be mitigated by a variety of interventions, including for example bioswales that trap runoff from the road. The remaining four wetlands should be demarcated and (together with their associated 50m buffer zones) retained as natural open spaces in the development. The cumulative loss of habitat by increased urbanisation enhances the value of remaining areas of natural vegetation as refuges to many species. Apart from the generic mitigation measures that control the degradation of wetlands through alien vegetation encroachment, sedimentation, erosion and pollution, it is important to ensure that a continuum of natural open spaces should be included in the development layout that allows for linkages between wetland areas and smaller, intervening patches of surviving habitat that can also serve as "stepping stones" that link fragmented ecosystems by ensuring that primary ecological processes are maintained within and between groups of habitat fragments.

The approximate size of the wetland areas identified on site together with their associated 50m buffer zone is 33.44 Ha, (4.09% of the site).

Table of Contents

Figures

Tables

1 INTRODUCTION

Limosella Consulting was appointed by Bokamoso Environmental Consultants and Landscape Architects to undertake an independent assessment of potential wetland conditions that could potentially be affected by the proposed development on the portions of the farm Kleinfontein 368 JR, Gauteng. Fieldwork was conducted on the 17th of August 2011.

1.1 Locality of the Study Site

The study site is located south of Cullinan, just south of the N4 and west of the R515 in the Kungwini Municipality. The study area is divided into two sections, the northern living area and the southern small holding area. A gravel road divides these two areas. The northern part of the site is home to various wild game such as Zebra, Wildebeest and other antelope. Steep rocky outcrops and areas of ecological importance characterize the area. Approximate central coordinates are 25°48'54.52"and 28°29'43.97" (Figure 1).

1.2 Terms of Reference

The terms of reference for the current study were as follows:

- Conclusively identify the presence or absence of wetland conditions as prescribed by the DWAF (2005) delineation guideline;
- Identify the outer edge of the wetland temporary zone, or edge of the riparian zone;
- Classify the wetland or riparian areas according to the system proposed in the national wetlands inventory if relevant,
- Indicate the relative functional importance of the wetland or riparian areas;
- Discuss wetland buffer zones;
- Indicate possible impacts on the wetland or riparian areas; and
- Recommend mitigation measures in order to limit the impact of the proposed development on the wetland or riparian areas.

1.3 Assumptions and Limitations

The GPSmap 76CSx used for wetland delineations is accurate to within five meters. Therefore, the wetland delineation plotted digitally may be offset by at least five meters to either side. Furthermore, it is important to note that, during the course of converting spatial data to final drawings, several steps in the process may affect the accuracy of areas delineated in the current report. It is therefore suggested that the no-go areas identified in the current report be pegged in the field in collaboration with the surveyor for precise boundaries.

The site visit was conducted before the onset of the growing season. Although vegetation was suitably visible to provide clear wetland indicators, a full contingent of the species composition could not be provided. A Red Data scan, fauna and flora assessments were not included in the current study.

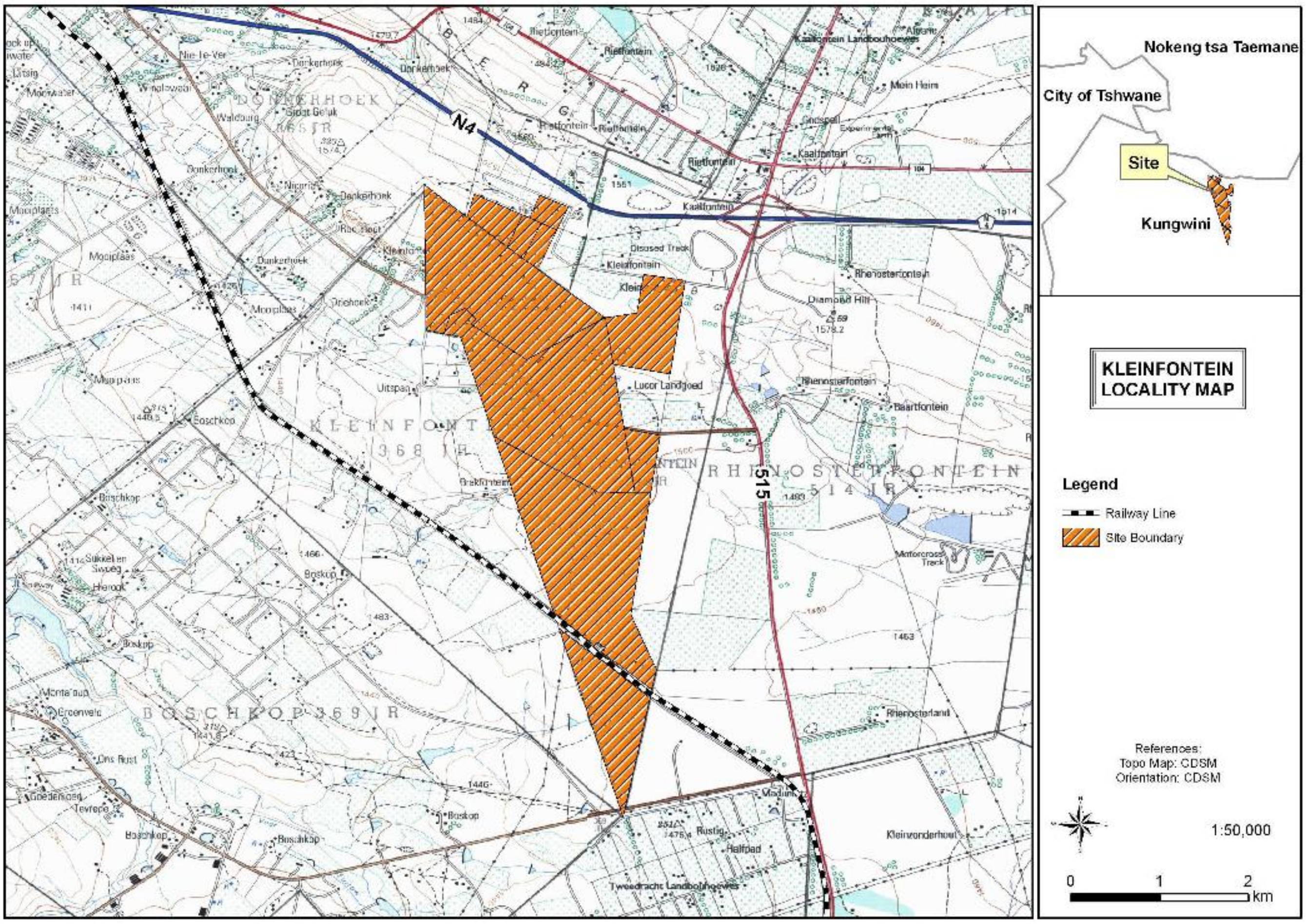


Figure 1: Location of the study site

1.4 Definitions and Legal Framework

In a South African legal context, the term watercourse is often used rather than the terms wetland, or river. The National Water Act (NWA) (1998) includes wetlands and rivers into the definition of the term watercourse in the following definition.

Watercourse means:

a) A river or spring;
b) A natural channel in which water flows regularly or intermittently;
c) A wetland, lake or dam into which, or from which, water flows, and
d) Any collection of water which the Minister may, by notice in the Gazette, declare to be a watercourse, and a reference to a watercourse includes, where relevant, its bed and banks.

Riparian habitat is the accepted indicator used to delineate the extent of a river's footprint (DWAF, 2005). The National Water Act, 1998 (Act No. 36 of 1998), defines a riparian habitat as follows: "Riparian habitat includes the physical structure and associated vegetation of the areas associated with a watercourse, which are commonly characterised by alluvial soils, and which are inundated or flooded to an extent and with a frequency sufficient to support vegetation of species with a composition and physical structure distinct from those of adjacent land areas.”.

In contrast, the National Water Act, 1998 (Act 36 of 1998) defines a wetland as “land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil.”

Authoritative legislation that lists impacts and activities on wetlands and riparian areas that requires authorisation includes (Armstrong, 2009):

- Conservation of Agriculture Resources Act, 1983 (Act 43 of 1983);
- Environment Conservation Act, 1989 (Act 73 of 1989);
- National Water Act, 1998 (Act 36 of 1998);
- National Forests Act, 1998 (Act 84 of 1998);
- National Environmental Management Act, 1998 (Act No. 107 of 1998);
- National Environmental Management: Biodiversity Act, 2004 (Act 10 of 2004).
- GNR 1182 and 1183 of 5 September 1997, as amended (ECA);
- GNR 385, 386 and 387 of 21 April 2006 (NEMA);
- GNR 392, 393, 394 and 396 of 4 May 2007 (NEMA);
- GNR 398 of 24 March 2004 (NEMA); and
- GNR 544, 545 and 546 of 18 June 2010 (NEMA).

1.5 Description of the Receiving Environment

A review of literature and spatial data formed the basis of a characterisation of the biophysical environment in its theoretically undisturbed state and consequently an analysis of the degree of impact to the ecology of the study site in its current state. The northern part of the study area falls into two regional vegetation units *sensu* Mucina and Rutherford (2006) namely; Rand Highveld Grassland and Gold Reef Mountain Bushveld. The northern section of the site is home to various game such as Zebra, Wildebeest and other antelope. Steep rocky outcrops and areas of ecological importance characterize the area. Common invader species of this area include *Acacia mearnsii* (Black wattle), *Tagetes minuta* (Blackjack) and *Seriphium plumosum* (Bankrotbossie). The southern smallholding area of the site falls within the Rand Highveld Grassland vegetation unit. This area is used on a small scale for grazing. *Acacia caffra* (Common hookthorn) and *Acacia karroo* (Sweet Thorn) dominate this landscape. Common grasses of this area are *Themeda triandra, Heteropogon contortus,* and *Elionurus muticus*.

A surface water spatial layer reflected the presence of several non-perennial rivers associated with the site, although only two watercourses appear to cross onto the site boundary (CDSM, 1996) (Figure 2).

Avalon and Mispah soil forms are associated with the wetland areas identified in the current report (GDACE, 2002). Mispah soil is a relatively young shallow soil underlain by hard rock or silcrete. Penetration of roots and water is typically non-uniform and restricted to spaces between fragments of rock or saprolite (Fey, 2005). This soil form is not a recognized wetland soil (DWAF, 2005), however, particularly where anthropogenic disturbances such as agricultural practices have altered the landscape, the relative impermeable quality of the substrate together with the shallow soils layer may result in water being retained in the landscape to form wetland conditions.

Avalon soils are recognised as potential seasonal or temporary wetland soils (DWAF, 2005). Avalon soils are associated with hard or soft plinthic horizons which dam water within the lower part of the section. The strongest expression occurs in middle to lower slope positions in the landscape. Manganese is associated with iron in some plinthic materials in this soil form (Fey, 2005).

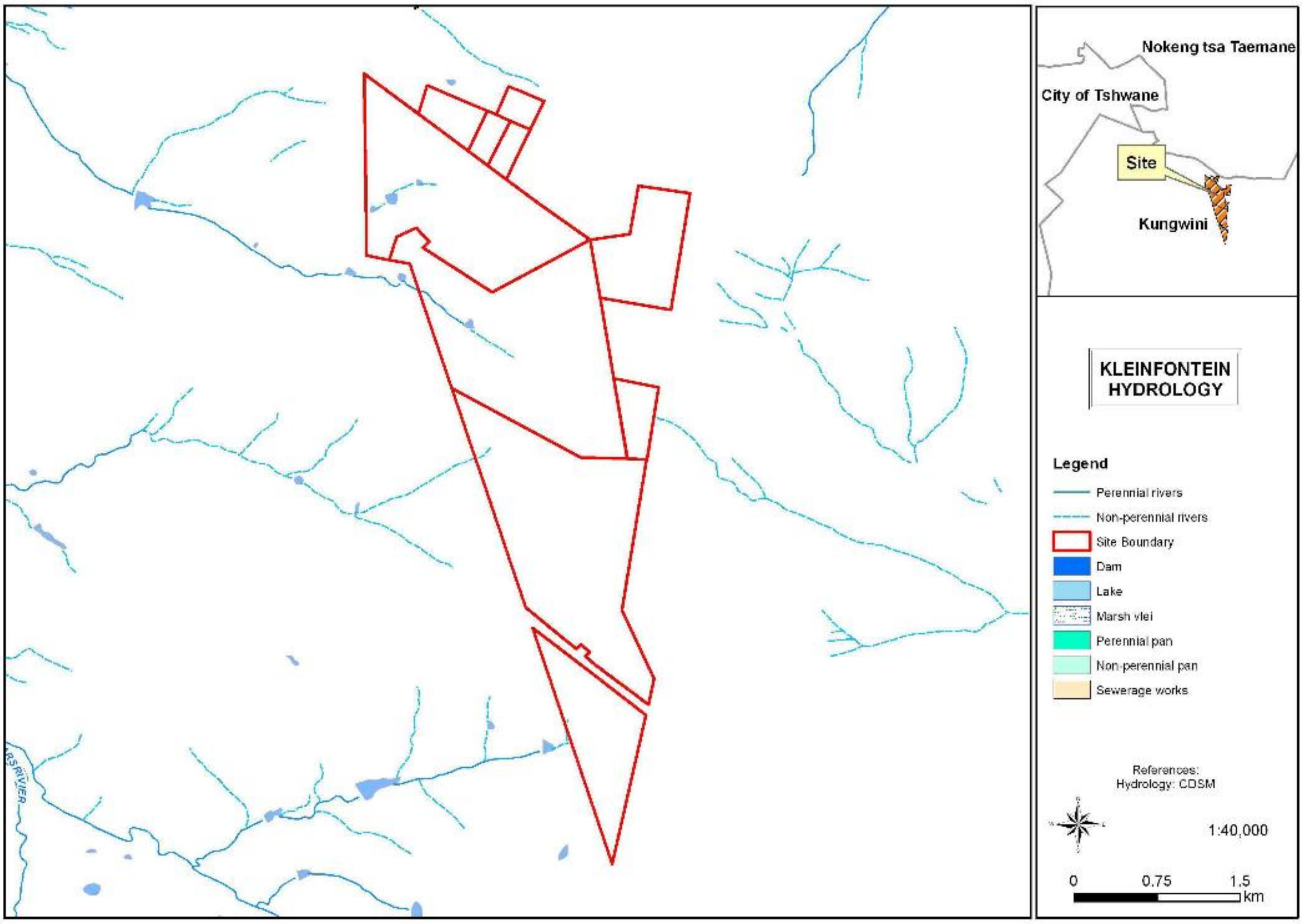


Figure 2: Hydrology of the region

2 RESULTS

2.1 Wetland Delineation

Wetlands are identified based on the following characteristic attributes (DWAF, 2005):

- The presence of plants adapted to or tolerant of saturated soils (hydrophytes);
- Wetland (hydromorphic) soils that display characteristics resulting from prolonged saturation; and
- A high water table that results in saturation at or near the surface, leading to anaerobic conditions developing within 50cm of the soil surface.

Thirty (30) points were sampled during the course of the field investigation to determine compliance with the definition of wetland and riparian conditions. One large wetland system was recorded on the northern part of the site and includes two dams. This valley bottom wetland is found at the bottom of two steep ridges and is fed by water runoff from the ridges. Two artificial structures were found in this system, including a 10m high dam wall. At the bottom of the system the water forms a small stream, which runs through a riparian area characterized by *Eucyluptus* sp. trees (Bluegums). The stream ends in a dam surrounded by the latter trees. Various bird species were found nesting in *Typha capensis* (Bullrushes) patches, animal tracks were also found in the muddy areas near the wetland edge.

Although some wetland indicators were found next to the gravel roads, soil samples proved negative for conclusive wetland conditions. A single seepage wetland associated by road runoff was delineated and is included in the wetland map below (Figure 3). Three wetland areas were identified on the southern section of the site. A low laying pan was found to the north of the southern section with *Typha capensis* (Bullrushes) and an array of different sedges. At the eastern boundary a small valley bottom wetland was found dominated by *Imperata cylindrica* (Cottonwool Grass). A third wetland area was found on the southernmost portion of the site. This area was fenced and access could not be gained for soil samples. A visual inspection was conducted and the delineation was consequently based on vegetation gradients visible on aerial imagery. The southernmost section of the site has a low level of impact as can be reflected by the absence of *Seriphium plumosum* (Bankrotbossie), although in some areas the presence of *Tagetes minuta* (Khakiweed) was recorded. The approximate sizes of the wetlands are provided in Table 1.

Table 1: Approximate sizes of the wetlands recorded on site

Wetland Number	Size (Ha)	Size as a percentage of the site (%)
1	3.37	0.42
2	0.04	0.01
3	0.74	0.09
4	0.09	0.01
5	4.10	0.52
Total size of the site	793.13	100.00

The higher laying areas were mostly dominated by shallow shale, while the lower laying areas were mostly dominated by dark organic soils.

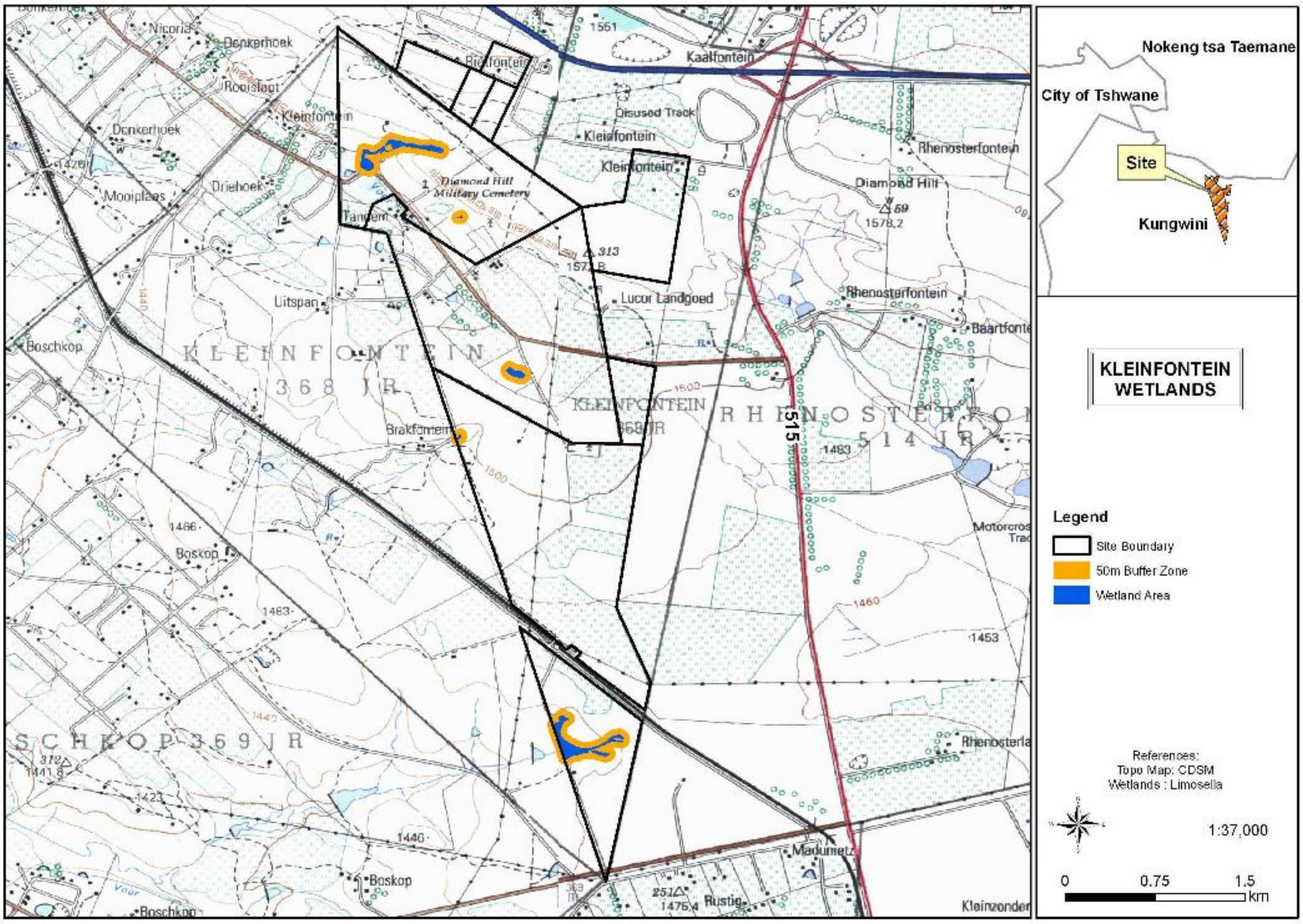


Figure 3: An overview of wetland areas recorded on the study site

Details of plant and soil characteristics recorded are discussed below and are presented in Appendix A. Five wetland areas were identified. A summary of their dominant characteristics is presented in Table 2 and Figures 4 to 6 below.

Table 2: Summary of dominant characteristics of the wetlands identified on site

Wetland Number	Approximate central coordinate	Dominant vegetation	Soil description and notes	Figure
1	25°48'10.64"S and 28°29'14.93"E	• *Eucalyptus* sp. • *Typha capensis* • *Zantedeschia aethiopica* • *Typha capensis* • *Verbena bonariensis* • *Plantago lanceolata*	The soil profile of this area is mostly orange sandy to clay soils with shallow shale. Slow moving water forms a small stream that moves into a riparian area Iron oxidation is visible on the water surface	Figure 4

2	25°48'30.23"S and 28°29'32.65"E	• *Typha capensis* • *Amaranthus hybridus* • *Pennesitum clandestinum* • *Tagetes minuta* • *Verbena bonariensis*	Small area of wetland vegetation formed by surface runoff from adjacent road	Figure 4
3	25°49'12.51"S and 28°29'47.62"E	• *Typha capensis* • *Imperata cylindrica* • Sedge species	Pan with shallow shale	Figure 5
4	25°49'29.78"S and 28°29'32.24"E	• *Imperata cylindrica* • *Verbena bonariensis*	Bottom of a valley where soils are dark, organic and damp	Figure 5
5	25°50'52.93"S and 28°30'0.39"E	Grass and sedge dominated wetland	This wetland was not accessible for sampling	Figure 6

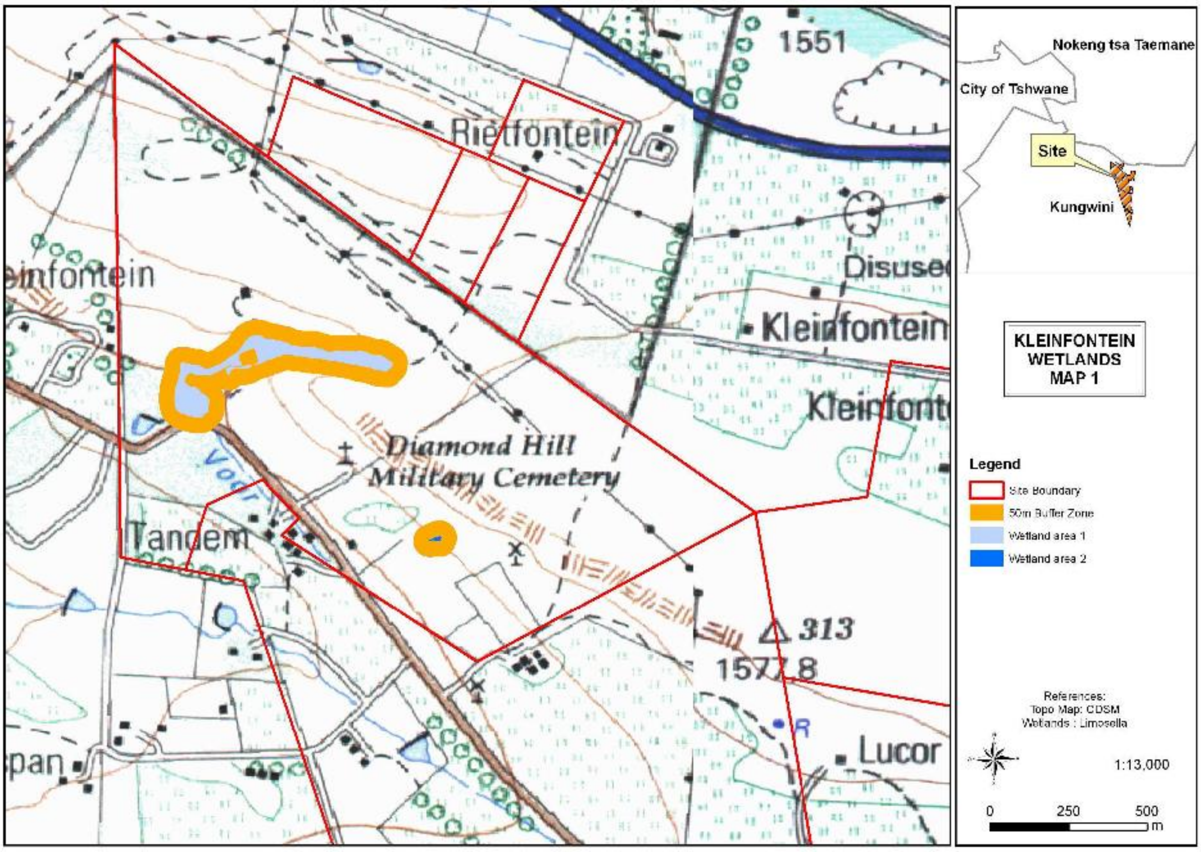


Figure 4: Wetlands one and two

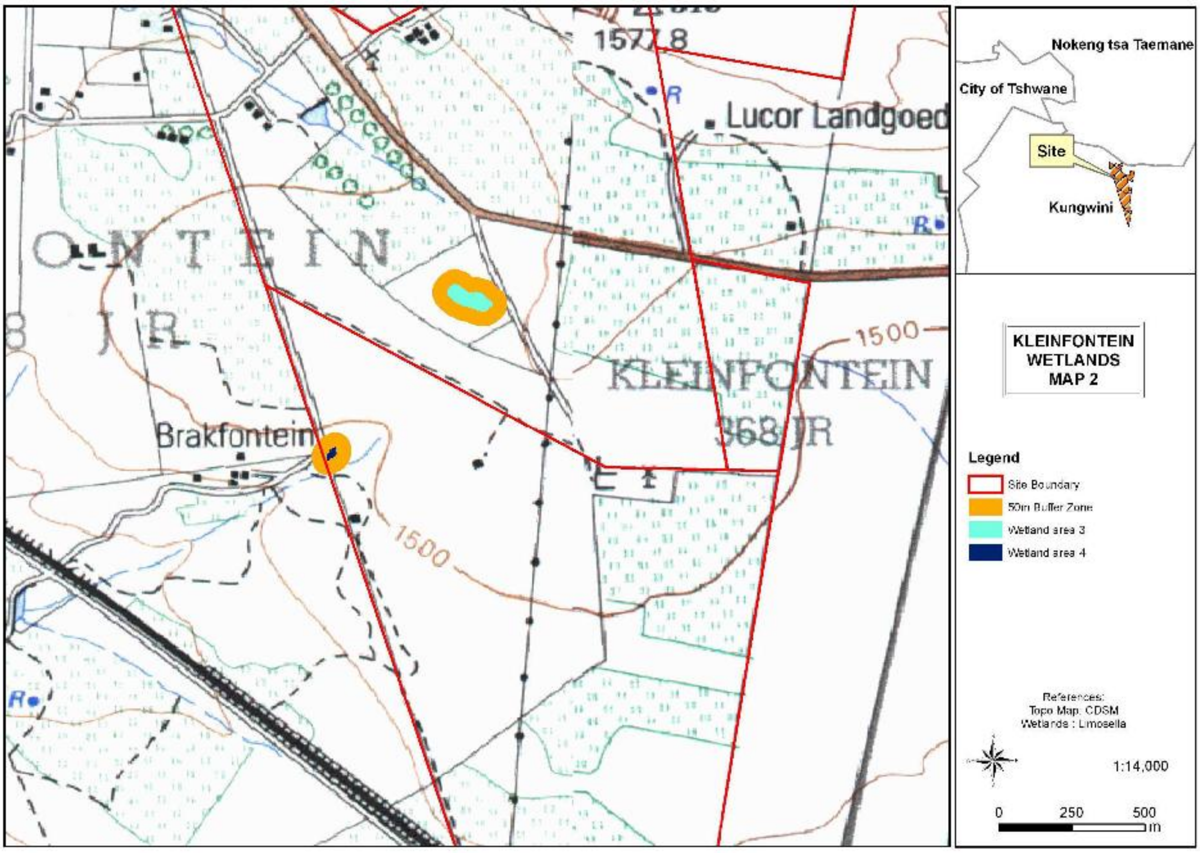


Figure 5: Wetlands three and four

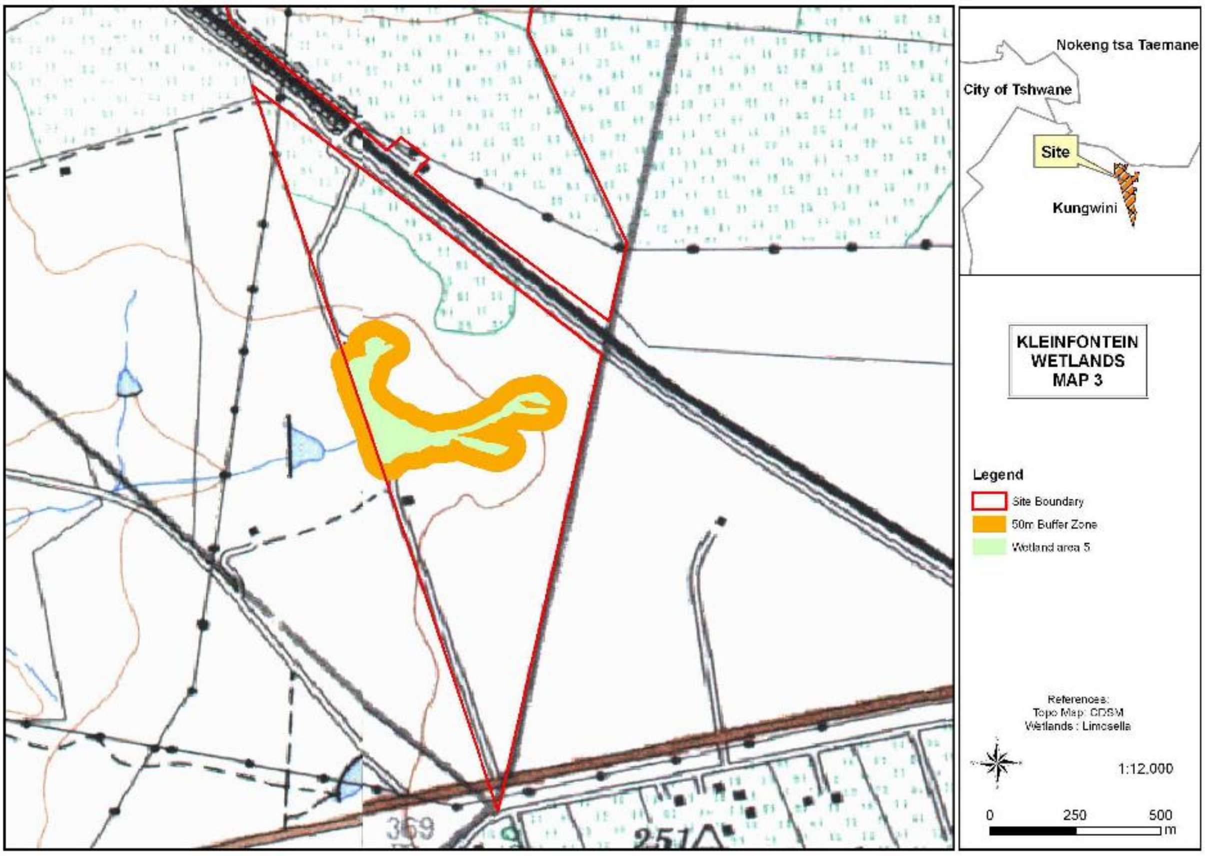


Figure 6: Wetland five

2.2 Classification

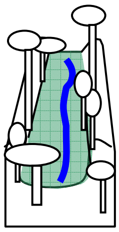
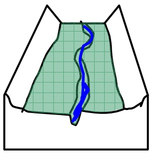
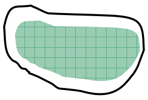
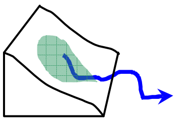
Differential weathering of geological formations may create steep slopes with shallow soils. In this instance, water is expected to flow in well defined channels at a high velocity. These conditions are conducive to the deposition of alluvial soils and the formation of channelled valley bottom wetlands and rivers. Where gentle slopes allow sediments to be accumulated and vegetation attenuates water flow velocity, waterlogging may occur. This in turn, leads to the formation of anaerobic conditions in the soil and unchannelled wetlands and floodplains are often the result. The reasoning follows that wetlands (particularly valley bottom wetlands) are most likely to occur at the lowest point of gravity in the landscape.

The classification system developed for the National Wetlands Inventory is based on the principles of the hydro-geomorphic (HGM) approach to wetland classification (Ewart-Smith *et al*, 2006). The current wetland study follows the same approach by classifying wetlands in terms of a functional unit in line with a level three category recognised in the classification system proposed in Ewart-Smith et al (2006). HGM units take into consideration factors that determine the nature of water movement into, through and out of the wetland system. HGM units encompass three key elements (Kotze *et al*, 2005):

a) Geomorphic setting - This refers to the landform, its position in the landscape and how it evolved (e.g. through the deposition of river borne sediment);
b) Water source - There are usually several sources, although their relative contributions will vary amongst wetlands, including precipitation, groundwater flow, stream flow, etc.; and
c) Hydrodynamics - This refers to how water moves through the wetland.

The northernmost wetland on site is classified as a valley bottom wetland with a riparian component which is probably of a secondary nature. Wetland two is formed by surface water runoff and is therefore also considered as an artificial wetland consistent with the characteristics of a seepage wetland as defined below. Wetland three (located below the gravel road dividing the northern and southern sections of the site) is classified as an inward draining pan wetland possibly formed by trampling of animals or wind erosion. Wetlands four and five are classified as valley bottom wetlands (Table 3).

Table 3: Classification of wetland and riparian areas (adapted from Brinson, 1993; Kotze, 1999, Marneweck and Batchelor, 2002 and DWAF, 2005). The highlighted section refers to the classification of the wetland on the study site

Hydro-geomorphic types	Description
Riparian habitat 	Riparian areas commonly reflect the high energy conditions associated with water flowing in a channel. Wetlands generally display more diffuse flows and are low energy environments. Due to water availability and rich alluvial soils, riparian areas are usually very productive. Tree growth is high and the vegetation under the trees is usually lush.
Valley bottom with a channel 	*Valley bottom areas with a well defined stream channel lack characteristic floodplain features. The may be gently sloped and characterized by the net accumulation of alluvial deposits or may have steeper slopes and be characterized by the net loss of sediment. Water inputs from main channel (when channel banks overspill) and from adjacent slopes.*
Depression (includes Pans) 	A basin shaped area with a closed elevation contour that allows for the accumulation of surface water (i.e. it is inward draining). It may also receive sub-surface water. An outlet is usually absent.
Hillslope seepage 	Slopes on hillsides, which are characterized by the colluvial (transported by gravity) movement of materials. Water inputs are mainly from sub-surface flow and outflow is usually via a well defined stream channel connecting the area directly to a watercourse. Where seepage wetlands are not associated with a stream, water inputs mainly from sub-surface flow and outflow is either very limited or through diffuse sub-surface and/or surface flow

2.3 Buffer Zones

A buffer zone is defined as a strip of land surrounding a wetland or riparian area in which activities are controlled or restricted (DWAF, 2005). A development has several impacts on the surrounding environment and on a wetland or riparian area. The development changes habitats, the ecological environment, infiltration rate, amount of runoff and runoff intensity of the site, and therefore the water regime of the entire site.

Buffer zones have been shown to perform a wide range of functions and have therefore been widely proposed as a standard measure to protect water resources and their associated biodiversity. These include (i) maintaining basic hydrological processes; (ii) reducing impacts on water resources from upstream activities and adjoining landuses; (iii) providing habitat for various aspects of biodiversity. A brief description of each of the functions and associated services is outlined in Table 4 below.

Table 4: Generic functions of buffer zones relevant to the study site (adapted from Macfarlane *et al*, 2010)

Primary Role	Buffer Functions
Maintaining basic aquatic processes, services and values.	• Groundwater recharge: Seasonal flooding into wetland areas allows infiltration to the water table and replenishment of groundwater. This groundwater will often discharge during the dry season providing the base flow for streams, rivers, and wetlands. • Flood attenuation: Wetland vegetation increases the roughness of stream margins, slowing down flood-flows. This may therefore reduce flood damage in downstream areas. Vegetated buffers have therefore been promoted as providing cost-effective alternatives to highly engineered structures to reduce erosion and control flooding, particularly in urban settings.
Reducing impacts from upstream activities and adjoining landuses	• Storm water attenuation: Flooding into the buffer zone increases the area and reduces the velocity of storm flow. Roots, braches and leaves of plants provide direct resistance to water flowing through the buffer, decreasing its velocity and thereby reducing its erosion potential. More water is exchanged in this area with soil moisture and groundwater, rather than simply transferring out of the area via overland flow. • Sediment removal: Surface roughness provided by vegetation, or litter, reduces the velocity of overland flow, enhancing settling of particles. Buffer zones can therefore act as effective sediment traps, removing sediment from runoff water from adjoining lands thus reducing the sediment load of surface waters. • Removal of toxics: Buffer zones can remove toxic pollutants, such hydrocarbons that would otherwise affect the quality of water resources and thus their suitability for aquatic biota and for human use. • Nutrient removal: Wetland vegetation and vegetation in terrestrial buffer zones may significantly reduce the amount of nutrients (N & P), entering a water body reducing the potential for excessive outbreaks of microalgae that can have an adverse effect on both freshwater and estuarine environments. • Removal of pathogens: By slowing water contaminated with faecal material, buffer zones encourage deposition of pathogens, which soon die when exposed to the elements.

Despite limitations, buffer zones are well suited to perform functions such as sediment trapping, erosion control and nutrient retention which can significantly reduce the impact of activities taking place adjacent to water resources. Buffer zones are therefore proposed as a standard mitigation measure to reduce impacts of landuses / activities planned adjacent to water resources. These must however be considered in conjunction with other mitigation measures.

Local government policies require that protective wetland buffer zones be calculated from the outer edge of the temporary zone of a wetland and river buffer zones be calculated from the outer edge of the riparian zone (KZN DAEA, 2002; CoCT, 2008; CoJ, 2008b; GDACE, 2009). Although research is underway to provide further guidance on appropriate defensible buffer zones, there is no current standard other than the generic recommendation of 100m for rivers, and 50m for wetlands outside the urban edge.

2.4 Wetland Functionality, Status and Sensitivity

Wetland functionality is defined as a measure of the deviation of wetland structure and function from its natural reference condition. The hydrological, geomorphological and vegetation integrity was assessed for each wetland unit associated with the study site to provide a Present Ecological Status (PES) score (Macfarlane *et al*, 2007) and an Environmental Importance and Sensitivity category (EIS) (DWAF, 1999) and summarised in the tables below. The ecosystem services are also discussed in broad terms below.

2.4.1 Provision of Goods and Services - WET-Ecoservices

Hydro-geomorphic units are per definition characterised by physical and hydrological features that allow them to perform specific ecosystem services (Table 5). The degree of disturbance and modification of wetlands results in a decrease in the ability to which they are able to perform these ecosystem services. The ecosystem services provided by each wetland unit is summarised in Table 6.

Table 5: Preliminary rating of the hydrological benefits likely to be provided by a channelled valley bottom wetland given its particular hydro-geomorphic type (Kotze *et al*, 2005)

WETLAND HYDRO-GEOMORPHIC TYPE	GENERIC HYDROLOGICAL BENEFITS PROVIDED BY THE WETLAND							
	Flood attenuation		Stream flow regulation	Erosion control	Enhancement of water quality			
	Early wet season	Late wet season			Sediment trapping	Phosphates	Nitrates	Toxicants[1]
Valley bottom - channelled	+	0	0	+	+	+	+	+
Hillslope seepage not feeding a stream	+	0	0	++	0	0	++	+
Pan/ Depression	+	+	0	0	0	0	+	+

Note: [1]Toxicants are taken to include heavy metals and biocides

Rating: 0 Benefit unlikely to be provided to any significant extent

\+ Benefit likely to be present at least to some degree

++ Benefit very likely to be present (and often supplied to a high level)

Table 6: A summary of ecosystem services provided by the wetlands on site

Wetland Number	Classification	Ecosystem Service (Kotze *et al,* 2005)
1	Valley bottom wetland with a channel, with riparian element	This wetland contributes to regional flood attenuation and sediment trapping to a certain extent especially from surface water flowing from adjacent ridges. The dams in the system further assist with sediment trapping. Some nitrate and toxicant removal potential is expected, particularly from the water delivered from the adjacent hillslopes. The habitat provided by the open water sections (dams) and riparian element is expected to be utilised by various bird and animal species. The relative importance of this habitat should be verified by suitable qualified avifauna, herpetofauna and fauna specialists.
2	Seepage wetland not linked to the stream channel	This small artificial wetland primarily functions to trap toxicants from the road. Since this is a small and seldom used road the amount of toxicants that are input into the wetland are not expected to be significant.
3	Inward draining pan	The pan is expected to contribute to trapping nitrates and phosphates from the surrounding agricultural areas. It may provide an important habitat to various bird and animal species. The relative importance of this habitat should be verified by suitable qualified avifauna, herpetofauna and fauna specialists.
4	Valley bottom wetland	This wetland is a small section of a larger system that is largely cut off by a dirt road. It contributes to regional flood attenuation early in the wet season and trapping of sediments and erosion control. The wetland traps nitrates and phosphates from the surrounding agricultural areas although this does not appear to be a significant land-use.
5	Valley bottom wetland	This wetland also forms a small section of a larger system that is cut off by a road. However, it's larger size, and the relative undisturbed adjacent grassland elevate its ability to provide ecosystem services such as flood attenuation, sediment trapping and erosion control. The biodiversity element of this wetland is expected to be significant and should be verified by

		suitable qualified avifauna, herpetofauna and fauna specialists.

2.4.2 Present Ecological Status (PES) – WET-Health

Table 7 provides an overview of the descriptions of the various PES categories to give a context for the scores obtained for each wetland presented in Table 8. As expected, wetland five scored the highest PES score although it remained in class C which describes moderately modified wetlands. No score could be obtained for the artificial seepage wetland as the fact that it presents wetland conditions is a derived condition. Wetland 4 obtained the lowest PES score, primarily due to its small size and the presence of the road which removes it to a large degree from the wetland system adjacent to the study site.

Table 7: Health categories used by WET-Health for describing the integrity of wetlands (Macfarlane *et al*, 2007)

DESCRIPTION	PES SCORE
Unmodified, natural.	A
Largely natural with few modifications. A slight change in ecosystem processes is discernable and a small loss of natural habitats and biota may have taken place.	B
Moderately modified. A moderate change in ecosystem processes and loss of natural habitats has taken place but the natural habitat remains predominantly intact.	C
Largely modified. A large change in ecosystem processes and loss of natural habitat and biota has occurred.	D
The change in ecosystem processes and loss of natural habitat and biota is great but some remaining natural habitat features are still recognizable.	E
Modifications have reached a critical level and the ecosystem processes have been modified completely with an almost complete loss of natural habitat and biota.	F

Table 8: A summary of the components of the PES scores obtained for each wetland on the site

Wetland Number	Hydrology	Geomorphology	Vegetation	Final PES Score
1	Alien vegetation abstracts water from the wetland diminishing the extent of seasonal and temporary zones. Changes to natural hydrology has been effected by the dams built in the wetland although water abstraction is not expected to be very large. Water distribution and retention patterns in the wetland have been largely altered by the dams and canalisation and the impact of the adjacent road. The impact of the modifications is clearly detrimental to the hydrological integrity. The PES score of this component of wetland integrity is 5, equivalent to class D	Stream straitening has occurred in the system of which this wetland area is part. A large degree of infilling and compaction was caused by the road constructed adjacent to, and across the wetland. The residential area in the wetland's catchment has changed runoff characteristics and therefore patterns of floodpeaks. Dirt roads and a borrow pit contribute to sediment input. The geomorphology has been moderately modified. That is to say that a moderate change in geomorphic processes has taken place but the system remains predominantly intact. The PES score of this component of wetland integrity is 3.2, equivalent to a class C	Deep flooding excludes emergent vegetation, dense patches of alien plants exclude natural wetland habitat. Vegetation composition has been substantially altered but some characteristic species remain, although the vegetation consists mainly of introduced, alien and/or ruderal species. This aspect of wetland integrity is likely to deteriorate with time if no steps are taken to actively rehabilitate the wetland. The PES score for this component of wetland integrity is 7.5, equivalent to class E	5.2 Class D

2	Since this wetland is predominantly artificial, no PES score can be derived for it as this involves the degree of change from a hypothetical natural reference condition			
3	Little modification to the hydrological component of the pan is evident although alien trees in the catchment contribute to a loss of water available to the wetland. This is also an inherent feature of a closed hydrological system that does not have upstream or downstream components. The PES score of this component of wetland integrity is 1.6, equivalent to class B	A large contribution to sediment input is provided by the numerous roads and tracks around the pan. A low degree of vegetation roughness in the catchment further contributes to sedimentation and ultimately deterioration of the geomorphological component of the wetland. The PES score of this component of wetland integrity is 3.4, equivalent to class C	Vegetation in and around the pan is largely natural although no sensitive or rare species were recorded. The PES score of this component of wetland integrity is 3.4, equivalent to class C	2.8 Class C
4	Clumps of alien trees abstract water from the wetland diminishing the extent of seasonal and temporary zones. Water distribution and retention patterns in the wetland have been largely altered by the road that bisects the wetland. The PES score of this component of wetland integrity is 5.9, equivalent to class D	Infilling and compaction of wetland soils has occurred due to the road constructed adjacent to, and across the wetland. The dirt road and tracks contribute to sediment input. The PES score of this component of wetland integrity is 6.2, equivalent to class E	Vegetation composition has been substantially altered but some characteristic species remain, although the vegetation consists mainly of introduced, alien and/or ruderal species. This aspect of wetland integrity is likely to deteriorate with time if no steps are taken to actively rehabilitate the wetland. The PES score of this component of wetland integrity is 7.1, equivalent to class E	6.4 Class E
5	Changes to natural hydrology has been effected by the dam resulting from the road built through the wetland. The PES score of this component of wetland integrity is 2.1, equivalent to class C	Infilling and compaction of wetland soils has occurred due to the road constructed adjacent to, and across the wetland. The dirt road and tracks contribute to sediment input. The low degree of alteration of the natural vegetation surrounding the wetland provides some mitigation by trapping sediments. The PES score of this component of wetland integrity is 2.4, equivalent to class C	Largely unmodified, vegetation roughness of the wetland and its catchment is impacted to some degree by grazing. Deep flooding by the dam has resulted in the loss of some emergent species and temporary and seasonal zonation. The PES score of this component of wetland integrity is 1.8, equivalent to class B	2.1 Class C

2.4.3 Ecological Importance and Sensitivity (EIS)

Ecological importance is an expression of a wetland's importance to the maintenance of ecological diversity and functioning on local and wider spatial scales. Ecological sensitivity refers to the system's ability to tolerate disturbance and its capacity to recover from disturbance once it has occurred (DWAF, 1999). This classification of water resources allows for an appropriate management class to be allocated to the water resource and includes the following:

- Ecological Importance in terms of ecosystems and biodiversity;
- Ecological functions; and
- Basic human needs.

The EIS scores for the five wetlands all fall within class C or D. Wetland 5 is the least impacted and scores the highest sensitivity although it also falls in class C (Table 9) The reason for the relatively low scores is primarily the relatively small sizes of the wetlands and the presence of the road that intersects most of them. Table 10 provides an overview of the EIS rating scale used with an explanation of the relative status of wetlands in each category.

Table 9: EIS scores obtained for the western section of the wetland (DWAF, 1999)

WETLAND IMPORTANCE AND SENSITIVITY	Importance Score Wetland 1	Importance Score Wetland 2	Importance Score Wetland 3	Importance Score Wetland 4	Importance Score Wetland 5
Ecological importance & sensitivity	2.7	0.6	1.6	1.0	2.8
Hydro-functional importance	1.3	0.4	0.6	0.9	2.0
Direct human benefits	0.5	0	0.7	0.5	0.5
Overall score	**1.5**	**0.3**	**1.0**	**0.8**	1.8
Class	**C**	**D**	**C**	**D**	C

Table 10: Environmental Importance and Sensitivity rating scale used for calculation of EIS scores (DWAF, 1999)

Ecological Importance and Sensitivity Categories	Rating	Recommended Ecological Management Class
Very High Wetlands that are considered ecologically important and sensitive on a national or even international level. The biodiversity of these wetlands is usually very sensitive to flow and habitat modifications. They play a major role in moderating the quantity and quality of water in major rivers	>3 and <=4	A
High Wetlands that are considered to be ecologically important and sensitive. The biodiversity of these wetlands may be sensitive to flow and habitat modifications. They play a role in moderating the quantity and quality of water of major rivers	>2 and <=3	B
Moderate Wetlands that are considered to be ecologically important and sensitive on a provincial or local scale. The biodiversity of these wetlands is not usually sensitive to flow and habitat modifications. They play a small role in moderating the quantity and quality of water in major rivers	>1 and <=2	C
Low/Marginal Wetlands that are not ecologically important and sensitive at any scale. The biodiversity of these wetlands is ubiquitous and not sensitive to flow and habitat modifications. They play an insignificant role in moderating the quantity and quality of water in major rivers	>0 and <=1	D

2.5 Impacts and Mitigation

Activities associated with the proposed development may have an impact on the wetland and their buffer zones unless measures are put in place to prevent this. A first line of defence is to demarcate the wetland and buffer zone areas and prevent access of construction vehicles and crew. Ideally a rehabilitation plan should be put into place that will address any erosion, alien vegetation encroachment or pollution of the wetlands resulting from the proposed activities. Prevention of sedimentation, pollution from crew camps or input of hydrocarbons from construction vehicles should be prioritised during the construction phase of the development. Following completion of the construction activities, trapping of oils and pollutants from parking areas and roads can be achieved by vegetated buffers and swales that direct polluted water into appropriate settling areas before release into the system.

In order to minimize artificially generated surface stormwater runoff, total sealing of paved areas such as parking lots, driveways, pavements and walkways should not be permitted. Permeable material should rather be utilized for these purposes (GDACE, 2008). An ecologically-sensitive stormwater management plan should be implemented that includes not allowing stormwater to be discharged directly into the identified buffer zone of the wetland areas. A continuum of natural open spaces should be included in the development layout that allows for linkages between wetland areas and smaller, intervening patches of natural habitat can also serve as "stepping stones" that link fragmented ecosystems by ensuring that certain ecological processes are maintained within and between groups of habitat fragments. Palisade fencing should be used to allow for the continued natural movement of fauna.

Although the wetland habitat recorded on the study site is in a relatively impacted condition, it remains a functional component within the ecological landscape. Vegetation clearing associated with the proposed activities are likely to result in the encroachment of alien invasive plant species. Revegetation of cleared areas with suitable indigenous species as soon as possible after the disturbance, together with an alien species monitoring and eradication program should prevent encroachment of these problem plants. Details regarding the identification and legislation associated with alien invasive species can be obtained from http://www.agis.agric.za.

3 CONCLUSION

Five wetland areas were identified during the current assessment. An artificial seepage wetland was recorded adjacent to a road. This wetland is not sensitive in a local or regional context, and although all wetlands are protected by various aspects of legislation, the current study finds that the contribution to local biodiversity and hydrological function can be mitigated by a variety of interventions, including for example bioswales that trap runoff from the road. The remaining four wetlands should be demarcated and (together with their associated 50m buffer zones) retained as natural open spaces in the development. The cumulative loss of habitat by increased urbanisation enhances the value of remaining areas of natural vegetation as refuges to many species. Apart from the generic mitigation measures that prohibit the degradation of wetlands through alien vegetation encroachment, sedimentation, erosion and pollution, it is important to ensure that a continuum of natural open spaces should be included in the development layout that allows for linkages between wetland areas and smaller, intervening patches of natural habitat that can also serve as "stepping stones" that link fragmented ecosystems by ensuring that primary ecological processes are maintained within and between groups of habitat fragments.

4 METHODOLOGY

The delineation method documented by the Department of Water affairs and Forestry in their document “A practical field procedure for identification and delineation of wetlands and riparian areas” (DWAF, 2005), and the Minimum Requirements for Biodiversity Assessments (GDACE, 2009) was followed throughout the field survey. These guidelines describe the use of indicators to determine the outer edge of the wetland and riparian areas such as soil and vegetation forms as well as the terrain unit indicator.

A hand held GPSmap 76CSx was used to capture GPS co-ordinates in the field. 1:50 000 cadastral maps and available GIS data were used as reference material for the mapping of the preliminary wetland boundaries. These were converted to digital image backdrops and delineation lines and boundaries were imposed accordingly after the field survey.

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Appendix A: Survey Data

Table 11: Survey Data

Survey point	Coordinates	Notes and important plant species	Area description
1	25°48'3.80"S and 28°29'31.80"E	• *Acacia mearnsii* wood	Invader species occurring in grasslands, open plains, next to roads and waterways.
2	25°47'55.90"S and 28°29'14.20"E	• *Aristida congesta* subsp. *Congesta* • Sandy soils • Rocky layer at 10cm	Disturbed area
3	25°47'50.60"S and 28°29'28.20"E	• *Themeda triandra* • *Elionurus muticus* • High mountainous area with rocky outcrops	Mountainous area
4	25°48'13.00"S and 28°29'32.20"E	• Low laying area sloped towards dam • Rocky • Sandy soil	Mountainous area
5	25°48'13.10"S and 28°29'27.50"E	• *Hypparhenia hirta* • *Verbena bonariensis* • *Eragrostis lehmeniana* • *Seriphium plumosum* • *Sedges* • Iron coloured clay soils • Various animal prints	Permanent to seasonal wetland area
6	25°48'12.90"S and 28°29'28.20"E	• High number of bird species • Dark clay soils	Edge of temporary zone
7	25°48'12.00"S and 28°29'28.00"E	• *Seriphuim plumosus* • Sedges	Edge of temporary zone
8	25°48'12.00"S and 28°29'26.80"E	• +- 3 meter high ridge with wetland conditions on both sides • *Verbena bonariensis* • *Amaranthus hybridus*	Ridge
9	25°48'11.30"S and 28°29'27.10"E	• *Imperata cylindrical* • *Sporobolus fimbriantus* • *Seriphium plumosum* • Beginning of stream that leads to dam	Temporary to permanent wet zone
10	25°48'12.40"S and 28°29'23.40"E	• Wetland from next to road	Temporary to permanent wet zone
11	25°48'11.00"S and 28°29'19.20"E	• *Zantedeschia aethiopica* • *Typha capensis* • *Verbena bonariensis* • *Plantago lanceolata*	Stream
12	25°48'10.90"S and 28°29'20.40"E	• Water channelled away, with excess water flowing into dam • *Plantago lanceolata*	Area of water channelling

13	25°48'12.20"S and 28°29'14.90"E	• *Amaranthus hybridus* • *Imperata cylindrica* • *Typha capensis*	Edge of dam
14	25°48'10.70"S and 28°29'14.40"E	• Dam wall covered in short grass • Edge of dam, with water flowing over to form a valley bottom wetland +-10m below • *Zantedeschia aethiopica*	Dam wall, with valley bottom wetland next to it.
15	25°48'12.30"S and 28°29'10.60"E	• Slow moving water that forms a small river that moves into a riparian area surrounded by *Eucyluptus* trees • Iron oxidation on water surface • *Typha capensis*	Valley bottom wetland and beginning of riparian area
16	25°48'16.30"S and 28°29'9.40"E	• Dug out area next to dam area, where previously mentioned stream leads into • Clay soils with shale • Dam surrounded by *Acacia mearnsii,* and *Eucyluptus* trees	Disturbed area next to dam
17	25°48'24.10"S and 28°29'23.20"E	• *Heteropogon contortus* • Sloped area	Shrubby grassland
18	25°48'30.40"S and 28°29'32.40"E	• Small area of wetland vegetation due to surface run off from adjacent road • *Typha capensis* • *Amaranthus hybridus* • *Pennesitum clandestinum* • *Tagetes minuta* • *Verbena bonariensis*	Temporary wet zone
19	25°48'39.00"S and 28°29'50.90"E	• Large number of *Seriphium plumosum* • *Hypparhenia hirta* • *Tagetes minuta*	Grassland
20	25°48'55.00"S and 28°29'40.60"E	• *Acacia karroo* • *Heteropogon contortus* • *Cymbopogon excuvatus* • Dry rocky soils •	*Acacia karroo* shrubland
21	25°48'19.00"S and 28°29'25.60"E	• Mountainous area with associated mountain vegetation • Rocky, with large boulders • *Eragrostis plana*	Top of mountain
22	25°49'36.20"S and 28°30'8.10"E	• Grassland dominated by tall grasses such as *Heteropogon contortus, Cymbopogon excavatus,* and *Hypparhenia hirta* • A small amount of trees can be observed, but is mostly limited to the western area near the boundary • Small animals such as hares and mongoose was observed	Smallholding area, mostly grassland.
23	25°49'39.60"S and 28°30'7.50"E	• Some wetland vegetation observed next to road but soil samples prove negative for evidence of wetland conditions • *Imperata cylindrica*	Road

24	25°50'26.10"S and 28°30'19.40"E	• Grassland next to argricultural land • *Heteropogon contortus*	Grazing grassland
25	25°50'33.20"S and 28°30'8.80"E	• Typical grassland area	Grassland
26	25°49'29.30"S and 28°29'53.70"E	• *Hypparhenia hirta* grassland with *Acacia* trees	Savannah area
27	25°49'12.30"S and 28°29'45.20"E	• Large pan dominated by large sedges and *Typha capensis* • Pan +-3,5m deep • Shale prevalent on surface	Pan wetland
28	25°49'13.90"S and 28°29'48.70"E	• Wetland edge • *Typha capensis* • *Imperata cylindrica* • Sedges	Edge of wetland
29	25°48'53.10"S and 28°29'36.30"E	• Low laying area • *Seriphium plumosum* • *Hypparhenia hirta*	Grassland
30	25°49'30.10"S and 28°29'31.80"E	• Bottom of a valley • Soils organic and damp • *Imperata cylindrica* • *Verbena bonariensis*	Temporary to seasonal wet zone

Appendix B: Glossary of Terms

Anaerobic	not having molecular oxygen (O_2) present
Buffer	A strip of land surrounding a wetland or riparian area in which activities are controlled or restricted, in order to reduce the impact of adjacent land uses on the wetland or riparian area
Gley	soil material that has developed under anaerobic conditions as a result of prolonged saturation with water. Grey and sometimes blue or green colours predominate but mottles (yellow, red, brown and black) may be present and indicate localised areas of better aeration
Hydrophyte	any plant that grows in water or on a substratum that is at least periodically deficient in oxygen as a result of soil saturation or flooding; plants typically found in wet habitats
Hydromorphic soil	soil that in its undrained condition is saturated or flooded long enough during the growing season to develop anaerobic conditions favouring the growth and regeneration of hydrophytic vegetation (vegetation adapted to living in anaerobic soils)
Mottles	soils with variegated colour patters are described as being mottled, with the "background colour" referred to as the matrix and the spots or blotches of colour referred to as mottles
Seepage	A type of wetland occurring on slopes, usually characterised by diffuse (i.e. unchannelled, and often subsurface) flows
Perched water table	the upper limit of a zone of saturation in soil, separated by a relatively impermeable unsaturated zone from the main body of groundwater
Permanently wet soil	soil which is flooded or waterlogged to the soil surface throughout the year, in most years
Sedges	Grass-like plants belonging to the family Cyperaceae, sometimes referred to as nutgrasses. Papyrus is a member of this family.
Soil horizons	layers of soil that have fairly uniform characteristics and have developed through pedogenic processes; they are bound by air, hard rock or other horizons (i.e. soil material that has different characteristics).
Soil profile	the vertically sectioned sample through the soil mantle, usually consisting of two or three horizons (Soil Classification Working Group, 1991)
Soil saturation	the soil is considered saturated if the water table or capillary fringe reaches the soil surface
Temporarily	The soil close to the soil surface (i.e. within 50 cm) is wet for periods > 2 weeks

wet soil	during the wet season in most years. However, it is seldom flooded or saturated at the surface for longer than a month.
Temporary zone of wetness	the outer zone of a wetland characterised by saturation within 50cm of the soil surface for less than three months in a year
Wetland:	"*land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil*." (National Water Act; Act 36 of 1998).
Wetland delineation	the determination and marking of the boundary of a wetland on a map using the DWAF (2005) methodology. This assessment includes identification of suggested buffer zones and is usually done in conjunction with a wetland functional assessment. The impact of the proposed development, together with appropriate mitigation measures are included in impact assessment tables

Appendix C: Abridged Curriculum Vitae of the Specialist

Name:	**ANTOINETTE BOOTSMA nee van Wyk**
Name of Company:	Limosella Consulting
Position:	Wetland Specialist
SACNASP Status:	Professional Natural Scientist # 400222-09

EDUCATIONAL QUALIFICATIONS

- B. Sc (Botany & Zoology), University of South Africa (1997 - 2001)
- B. Sc (Hons) Botany, University of Pretoria (2003-2005)
- Short course in wetland delineation, legislation and rehabilitation, University of Pretoria (2007)
- Short course in Wetland Soils, Terrasoil Science, (2009)
- MSc (Ecology), University of South Africa (2010 – ongoing)

KEY QUALIFICATIONS

- **Principal Specialist**

This entailed the management of wetland vegetation and rehabilitation related projects in terms of developing proposals, project management, technical investigation (delineation and functional assessment of wetlands and riparian areas in order to advise proposed development layouts) and quality control through the following:

- More than 90 fine scale wetland and ecological assessments in Gauteng, Mpumalanga, KwaZulu Natal, Limpopo and the Western Cape and Eastern Cape. Liaison with clients, and all facets of project management. April 2007, ongoing.
- Reviewing of specialist reports, including faunal and floral assessments, aquatic, wetland and rehabilitation reports;
- An assessment of wetlands in Tatu, Kenya in order to inform the proposed development of a residential estate. August 2009
- Riparian Management Plan for Mixed-Use developments in Kagiso, Gauteng. August 2009;
- Rehabilitation Plan for the wetland associated with Heroes Bridge in Soweto. Technical investigation as well as management of a team of specialist, integration of information into a final report. The technical investigation for this project also included an investigation into the occurrence of Red Data vegetation. June 2009;

- Input into the wetland component of the Green Star SA rating system. April 2009;
- Strategic analysis of wetlands in Thohyandou in conjunction with a strategic vegetation assessment of the area, March 2009;
- Strategic analysis of wetlands in Gauteng for the GDACE Regional Management Framework, August 2008;
- Successful completion of an audit of the wetlands in the City of Johannesburg. Specialist studies as well as project management and integration of independent datasets into a final report. July 2008.
- An assessment of wetlands in southern Mozambique. This involved a detailed analysis of the vegetation composition and sensitivity associated with wetlands and swamp forest in order to inform the development layout of a proposed resort. May 2008.
- An assessment of three wetlands in the Highlands of Lesotho. This involved a detailed assessment of the value of the study sites in terms of functionality and rehabilitation opportunities. Integration of the specialist reports socio economic, aquatic, terrestrial and wetland ecology studies into a final synthesis. May 2007.
- Ecological investigation on a strategic scale to inform an Environmental Management Framework for the Emakazeni Municipality and an Integrated Environmental Management Program for the Emalahleni Municipality. May and June 2007

Conservation ecology

The implementation and management of projects related to long and short term studies on impacts and rehabilitation in a mining environment.

- Principal investigator. Species assemblages in the woody vegetation communities of coastal dune forests between the Umfolozi and Umlalazi rivers. This relates to colonisation trends across disturbance and rehabilitation age gradients, including aspects such as seed ecology and phenology. 2006/7
- Principal investigator. Biodiversity of the coastal dune forests and associated habitats in Richards Bay, particularly on the epiphytic orchids and ferns found on the mineral lease area of Richards Bay Minerals. 2006
- Technical assistant. Biodiversity of the coastal dune forests and associated habitats in Richards Bay, particularly on the herpetofauna found on the mineral lease area of Richards Bay Minerals. 2006
- Principal investigator. Baseline vegetation, and topsoil maps for Richards Bay Minerals' Zulti South lease area. 2005/6
- Technical assistant. A species list of woody and herbaceous plants of the Sekhukhune area. 2005

Phytosociology

A technical investigation as part of academic research

- Principal investigator. A phytosociological study of vegetation associated with the wetlands of Lake Chrissie, Mpumalanga. 2004

Annexure G(iv)

Fauna and Flora Report

GALAGO ENVIRONMENTAL

Biodiversity & Aquatic Specialists

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Biodiversity Assessment

of

Portion 4 of the farm Kleinfontein 368-JR

February 2013

GDARD reference number: GAUT 002/12-13/EO122

Report Compiled and edited by:	Ms. Vanessa Marais of Galago Environmental
Report authors:	Dr. I.L. Rautenbach (Pri. Sci. Nat: Ph.D, T.H.E.D.), Mrs. P. Lemmer (Cert. Sci. Nat: B.Sc.) Mr. R.F. Geyser Mr. A.J. Fourie (B. Tech)
Avifauna Report verified by:	Dr. Alan C. Kemp (Pri.Sci. Nat.)
Ridges Report verified by:	Dr. Alan C. Kemp (Pri.Sci. Nat.)
Botany Report verified by:	Dr L.A. Coetzer (D.Sc., Pri. Sci. Nat.)

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FIGURES:

1. Introduction:

Galago Environmental was appointed to conduct a vegetation, mammal, avifauna, reptile and amphibian survey including a study on the ecological conditions of the ridge on Portion 4 of the farm Kleinfontein 368-JR, scheduled for low density residential development.

2. Location of the study site:

The 89,9888 ha study site lies near the northwestern boundary of the farm Kleinfontein 368-JR and almost entirely between gravel road D1342 and the Sentra Rand railway line with the railway line cutting through the southern tip of the site.

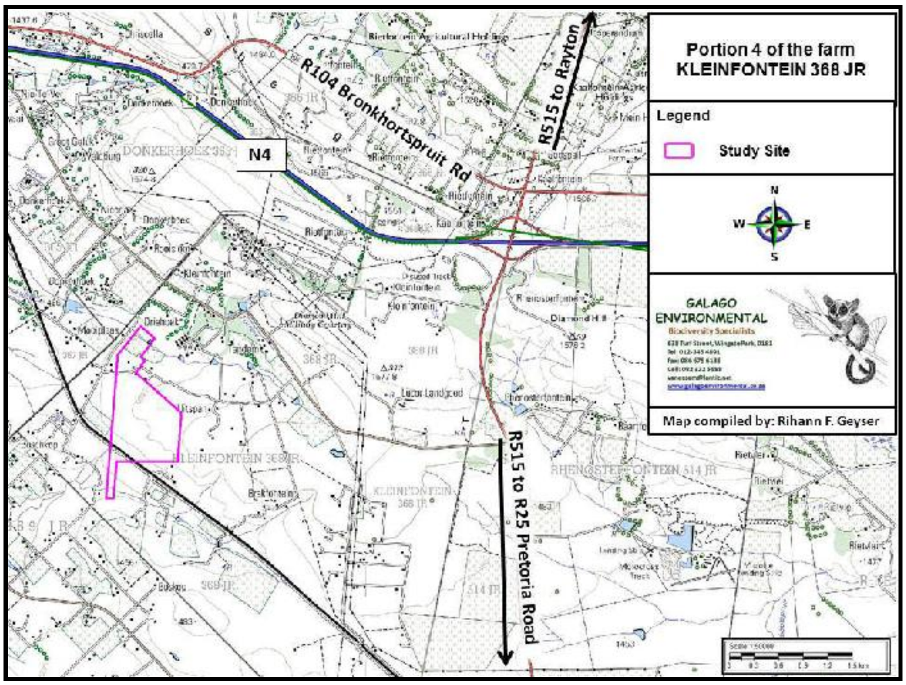

Figure 1: Locality map of the study area

3. Participating Specialists

This investigation was conducted by the following specialists:

Specialists	Aspect Investigated	Qualifications	Prof. Registration	Date of Field Survey
Rautenbach, I.L.	Mammalogy	Ph.D., T.H.E.D.	Pr. Nat. Sci.	29 December 2012
Lemmer, P	Botany	B. Sc	Cert. Sci. Nat	6 & 29 December 2012
Geyser, R.	Avifauna		Pending	6 December 2013
Coetzer, L.A.	Botany review	D.Sc.	Pr. Nat. Sci.	
Fourie, A.J.	Ridges	B. Tech		2 March 2013
Kemp, A.C.	Avifauna & Ridge review	Ph.D.	Pr. Nat. Sci.	
Marais, V.	Environmental Impacts and maps	BL Landscape Architecture		6 December 2012

5. Vegetation assessment:

According to Mucina & Rutherford (2006) the study site falls within two vegetation units, Marikana Thornveld, that comprised the western, and largest, part of the site and Rand Highveld Grassland that occurred in the eastern part of the site. Marikana Thornveld is characterised by open *Acacia karroo* woodland occurring in valleys and by slightly undulating plains and lowland hills. The Marikana Tornveld vegetation unit is considered endangered. Rand Highveld Grassland on the other hand is a highly variable landscape with extensive sloping plains and a series of slightly elevated ridges. The Rand Highveld Grassland vegetation unit is considered endangered.

Five vegetation study units were identified on the study site:

- *Acacia – Euclea crispa* woodland;
- *Lippia – Microchloa* rocky outcrop vegetation;
- Drainage line vegetation;
- *Ziziphus – Diospyros whyteana* ridge vegetation; and
- Cultivated fields.

The *Lippia – Microchloa* rocky outcrop vegetation, the *Ziziphus – Diospyros whyteana* ridge vegetation and the Drainage line vegetation were considered sensitive and should be excluded from development. Where possible, these areas must be connected to other natural vegetation areas on the neighbouring properties to facilitate connectivity. To lessen the impact of the development on the vegetation of the site, great care should be taken to group residences on smaller lots in certain areas, rather than spreading them out over large areas. Roads, footpaths, services etc. should be constructed with great care.

It was required that the specialist focused on *Argyrolobium campicola, Brachycorythis conica* subsp *transvaalensis, Ceropegia decidua* subsp*. pretoriensis, Habenaria bicolor, Habenaria kraenzliniana* and *Trachyandra erythrorrhiza.* A second site visit to cover the flowering times of all species concerned was carried out on 27 February 2013, but these species were not found. **See Appendix A for the Flora report.**

6. Fauna assessment:

The **mammal** study found that the conservation condition of the site in terms of mammals is ranked as below average. It is recommended that eradicating obnoxious alien plants (viz. Queen of the Night) should be a priority on the site. The highest aspects of the andesite outcrops are considered marginally sensitive and justify conservation justification. No threatened mammal species is singled out that require special consideration in considering the application to develop the site. Habitat types represented on the site are inclined to be sub-optimal. **See Appendix B for the Mammal report.**

The **avifaunal** study found that the habitat on the study site will not favour any Red Data avifaunal species, however the woodland and drainage line vegetation will favour a variety of typical bushveld avifaunal species as well as some of the more common aquatic avifaunal species. Development will result is habitat loss for these avifaunal species and areas should be left undisturbed and undeveloped to ensure future avifaunal diversity on the study site. **See Appendix C for the Avifauna report.**

The **study on the ecological conditions of the ridge** found that the ridge identified on the study site must be conserved and since **the ridge is classified as a Class 1 ridge, a buffer area of 200 meters** must be incorporated around the identified boundaries of the ridge – as in line with the GDARD minimum requirements, 2012. The corridor as outlined by GDARD in the Conservation Plan (C-Plan 3.3, 2011) should also be conserved as far as possible as the connectivity areas between the ridges are important movement and pollinator areas to preserve biodiversity in the area. Since the site would only be subdivided into small holdings, the connectivity in the corridor area should continue. The proposed mitigation measures will need to be implemented where indigenous vegetation is planted and alien invasive species eradicated. **See Appendix E for the Riparian delineation study report.**

7. Mitigation:

- Where possible, trees naturally growing on the site should be retained as part of the landscaping. Measures to ensure that these trees survive the physical disturbance from the development should be implemented. A tree surgeon should be consulted in this regard.
- Dumping of builders' rubble and other waste in the areas earmarked for exclusion must be prevented, through fencing or other management measures. These areas must be properly managed throughout the lifespan of the project in terms of fire, eradication of exotics etc. to ensure continuous biodiversity.
- All Declared Weeds and invaders and other alien species must be removed from the site.
- Areas with natural woodland vegetation should be left undisturbed as far as possible to ensure future avifaunal biodiversity on the study site.
- It is recommended that no fences be erected on the borders of the various lots to allow free movement of fauna species through the area.
- Where possible, **work should be restricted to one area at a time**, as this will give the smaller birds, mammals and reptiles a chance to weather the disturbance in an undisturbed zone close to their natural territories.
- **No vehicles should be allowed to move in or across the wet areas or drainage lines and possibly get stuck.** This leaves visible scars and destroys habitat, and it is important to conserve areas where there are tall reeds or grass, or areas where there is short grass and mud.
- With proper cultivation of specific indigenous plant species, the bird numbers and species in the area could even increase. Indigenous plant species that attract birds to gardens or that are natural to the area could be obtained from the local nurseries surrounding the area. The area must however be kept as natural as possible.
- It is important to note that birds inhabiting one of the named microhabitats on site will not move, in most cases, into a different habitat. In other words, birds found in the open woodland will not now, with the development, move into the grassland areas or the wetland area. If the objective is to keep these species on site, suitable open woodland must be kept for these species.
- The contractor must ensure that no fauna is disturbed, trapped, hunted or killed during the construction phase. Conservation-orientated clauses should be built into contracts for construction personnel, complete with penalty clauses for non-compliance.

- It is suggested that where work is to be done close to the drainage lines, these areas **be fenced off during construction,** to prevent heavy machines and trucks from trampling the plants, compacting the soil and dumping in the system.
- During the construction phase, noise must be kept to a minimum to reduce the impact of the development on the fauna residing on the site.
- Should hedgehogs be encountered during the construction phase of the development, these should be relocated to natural grassland areas in the vicinity.
- The open space system (highest aspects of the rocky outcrop outliers of the easterly randjie) should be fenced off prior to selling adjoining properties or construction commencing (including site clearing and pegging). All construction-related impacts (including service roads, temporary housing, temporary ablution, disturbance of natural habitat, storing of equipment/building materials/vehicles or any other activity) should be excluded from the open space system. Access of vehicles to the open space system should be prevented and access of people should be controlled, both during the construction and operational phases. Movement of indigenous fauna should however be allowed (i.e. no solid walls, e.g. through the erection of palisade fencing).
- Ecological management plans developed for the study site should include management recommendations for neighbouring land, especially where correct management on adjacent land within 500 meters from the proposed development is crucial for the long-term persistence of sensitive species present on the development.

Please see the specialist reports for more mitigation measures.

8. Environmental sensitivity:

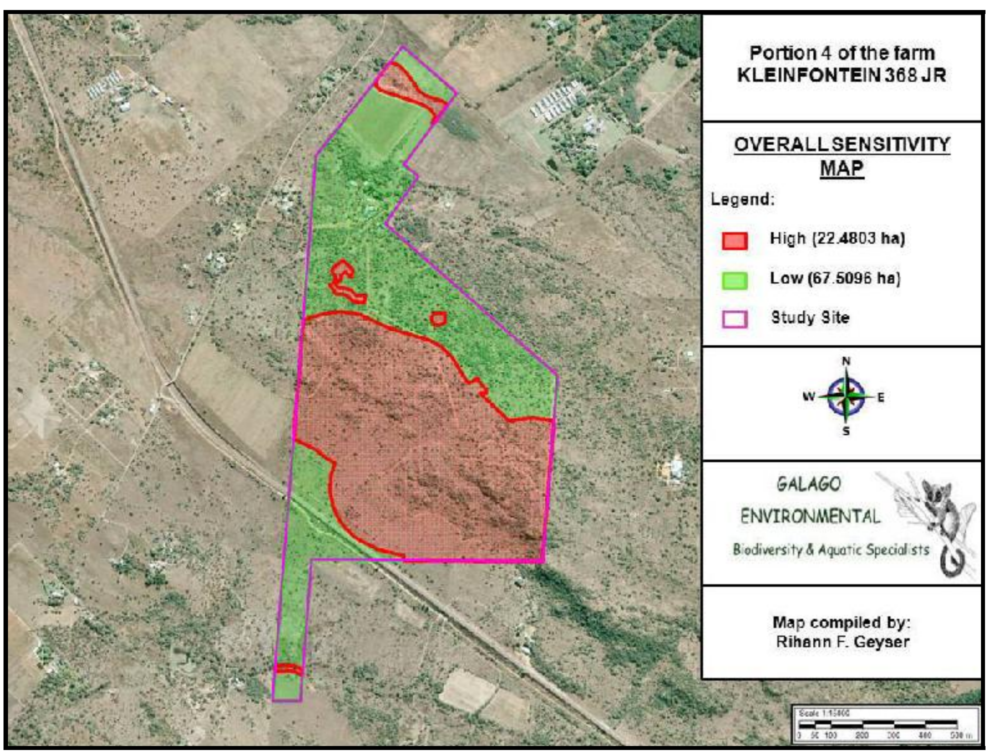

Figure 2: Combined environmental sensitivity map

Sensitivity mapping rules:

BIODIVERSITY ELEMENT	SENSITIVITY MAPPING RULE
Flora communities	Sensitive flora communities
Avifaunal & Mammal habitat	Sensitive fauna habitat
Ridge	Class 1 ridge and 200m buffer

9. Conclusion:

From all the biodiversity studies undertaken it is clear that the class 1 ridge on and surrounding the study site is deemed sensitive. It is recommended that the ridge, some of the rocky outcrop vegetation, the drainage/wetland areas as well as a buffer area of 200m surrounding the ridge be considered sensitive. These areas must be included in an open space area and an Ecological Management plan developed to ensure the future conservation of these sensitive areas.

It was also determined that most of the study site (as seen in Figure 3) falls within a corridor area set out by GDARD in C-plan 3.3 (2011). This must be taken into consideration with the future activities that are planned for the different plots. These activities must be low density developments allowing large patches of indigenous vegetation to ensure the connectivity between the ridges in the area.

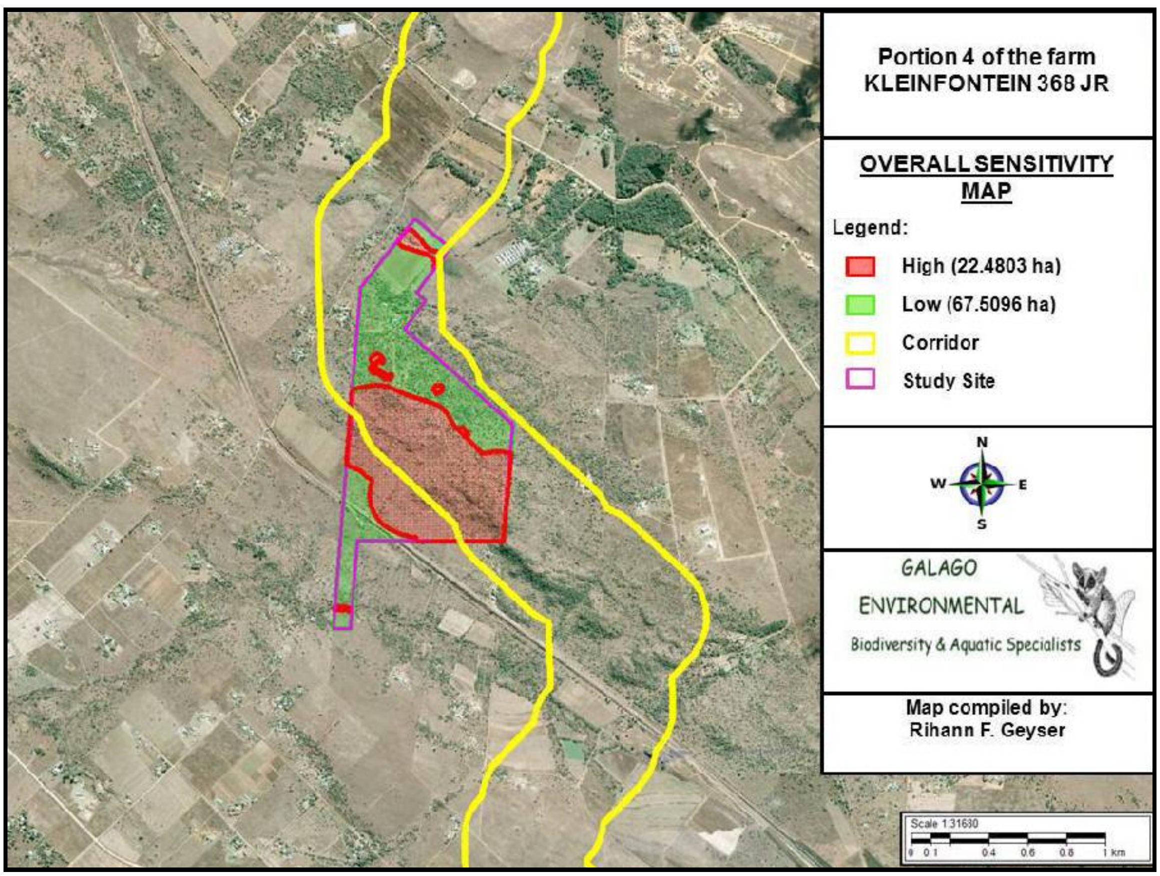

Figure 3: Map showing the sensitivity of the site in terms of biodiversity and the corridor as determined by GDARD (C-plan 3.3, 2011)

10. GDARD biodiversity requirements

With regard to the above project, specialist biodiversity studies are required to investigate the following aspects:

- Plants, with specific reference to:
  - ✓ *Brachycorythis conica*
  - ✓ *Ceropegia decidua*
  - ✓ *Eulophia coddii*
  - ✓ *Argyrolobium campicolla*
  - ✓ *Habenaria bicolor*
  - ✓ *Habenaria kraenzliniana*
- Mammals, with specific reference to *Lutra maculicollis* (Spotted-necked otter).
- Birds, with specific reference to *Tyto capensis* (African Grass Owl).
- Vegetation
- Wetlands
- River
- Ridges

Annexure G(v)

HERITAGE IMPACT ASSESSEMENT

PHASE 1 HERITAGE IMPACT ASSESSMENT FOR THE PROPOSED KLEINFONTEIN MIXED LAND USE DEVELOPMENT ON PORTIONS 38, 90, 96 AND THE REMAINING EXTENT OF THE FARM KLEINFONYEIN 368 JR AND ON PORTIONS 63, 67, 68 AND THE REMAINING EXTENT OF PORTION 14 OF THE FARM DONKERHOEK 365 JR TO BE KNOWN AS “KLEINFONTEIN NEDERSETTING”

Prepared by:

Leonie Marais-Botes

BA (Cultural History and Archaeology) (UP), BA (Hons) Cultural History (UP), Post Grad Dip Museology (UP), Cert Conservation of Traditional Buildings (Univ of Canberra), Post Grad Dip: Heritage (Wits)
Heritage experience: 18 years.

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0084

Tel: 082 5766253

For

Bokamoso Landscape Architects and Environmental Consultants

February 2012

DISCLAIMER:

Although all possible care is taken to identify/find all sites of cultural importance during the initial survey of the study area, the nature of archaeological and historical sites are as such that it is always possible that hidden or sub-surface sites could be overlooked during the study. Leonie Marais-Botes will not be held liable will not be held liable for such oversights or for the costs incurred as a result thereof.

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ABOUT THIS REPORT

The heritage report must reflect that consideration has been given to the history and heritage significance of the study area and that the proposed work is sensitive towards the heritage resources and does not alter or destroy the heritage significance of the study area.

The heritage report must refer to the heritage resources currently in the study area.

The opinion of an independent heritage consultant is required to evaluate if the proposed work generally follows a good approach that will ensure the conservation of the heritage resources.

The National Heritage Resources Act (Act 25 of 1999) and the National Environmental Management Act (Act 107 of 1998) are the guideline documents for a report of this nature.

Leonie Marais-Botes was appointed by Bokamoso Landscape Architects and Environmental Consultants toprepare a Phase 1 Heritage Impact Assessment (HIA) for a proposed mixed use development on Portions 38, 90, 96 and the Remaining Extent of the Farm Kleinfontein 368 JR and on Portions 63, 67, 68 and the Remaining Extent of Portion 14 of the Farm Donkerhoek 365 JR to be known as "KleinfonteinNedersetting".

EXECUTIVE SUMMARY

The study area is located south of Cullinan, just south of the N4 and west of the R515 in the Kungwini Municipality. The development is approx. 10km from Rayton. Kleinfontein was established in 1992 and activities within the site are managed by "KleinfonteinBoerebelangeKoöperatiefBeperk".

This project may impact on any types and ranges of heritage resources that are outlined in Section 3 of the National Heritage Resources Act (Act 25 of 1999) Consequent a Heritage Impact Assessment (HIA) was commissioned by Bokamoso Landscape Architects and Environmental Consultants and conducted by Leonie Marais-Botes (Heritage Practitioner).

A number of heritage sites and objects of significance were identified in the study area.

INTRODUCTION

The “KleinfonteinBoerebelangeKoöperatiefBeperk” is planning a Land Development Area (LDA) for a proposed mixed land use development on Portions 38, 90, 96 and the Remaining Extent of the farm Kleinfontein 368 JR and on Portions 63, 67, 68 and the Remaining Extent of Portion 14 of the FarmDonkerhoek 365 JR to be known as the “KleinfonteinNedersetting”. The study area is approx. 721 ha in extent and is situated in the area of jurisdiction of the City of Tshwane Metropolitan Municipality.

Activities in the greater study area include:

- Formal and Informal Housing
- Commercial Activities (formal and informal)
- Tourism
- Farming

LOCATION OF THE STUDY AREA

The study area is located south of Cullinan, just south of the N4 and west of the R515 in the Kungwini Municipality. The proposed development is approx. 10km from Rayton in the Gauteng Province.

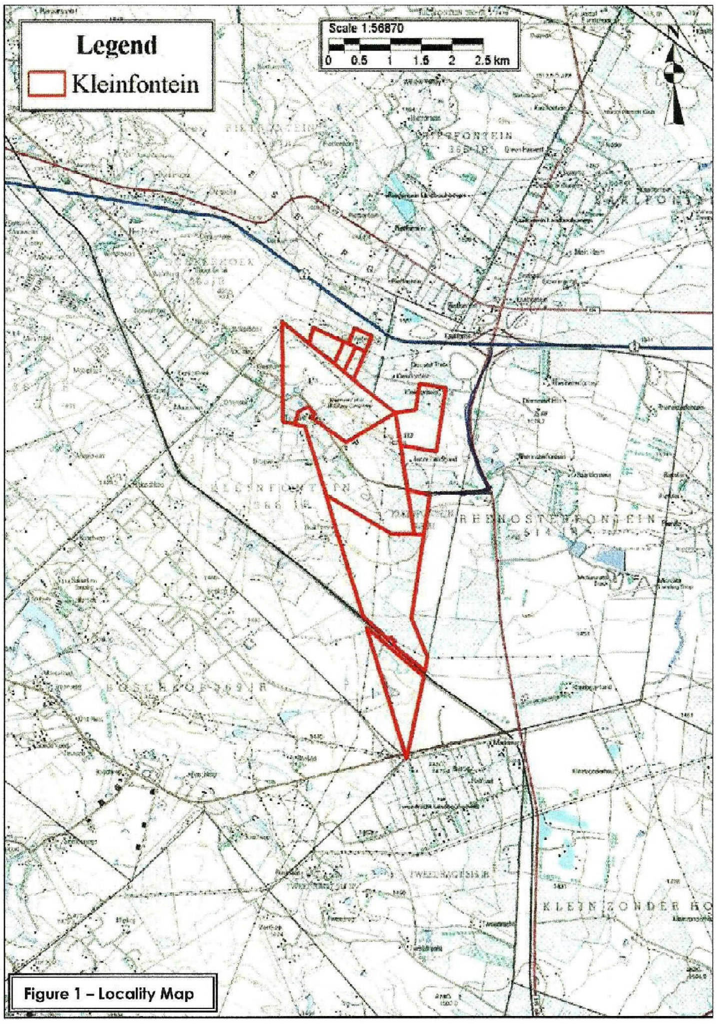

Figure 1 – Locality Map

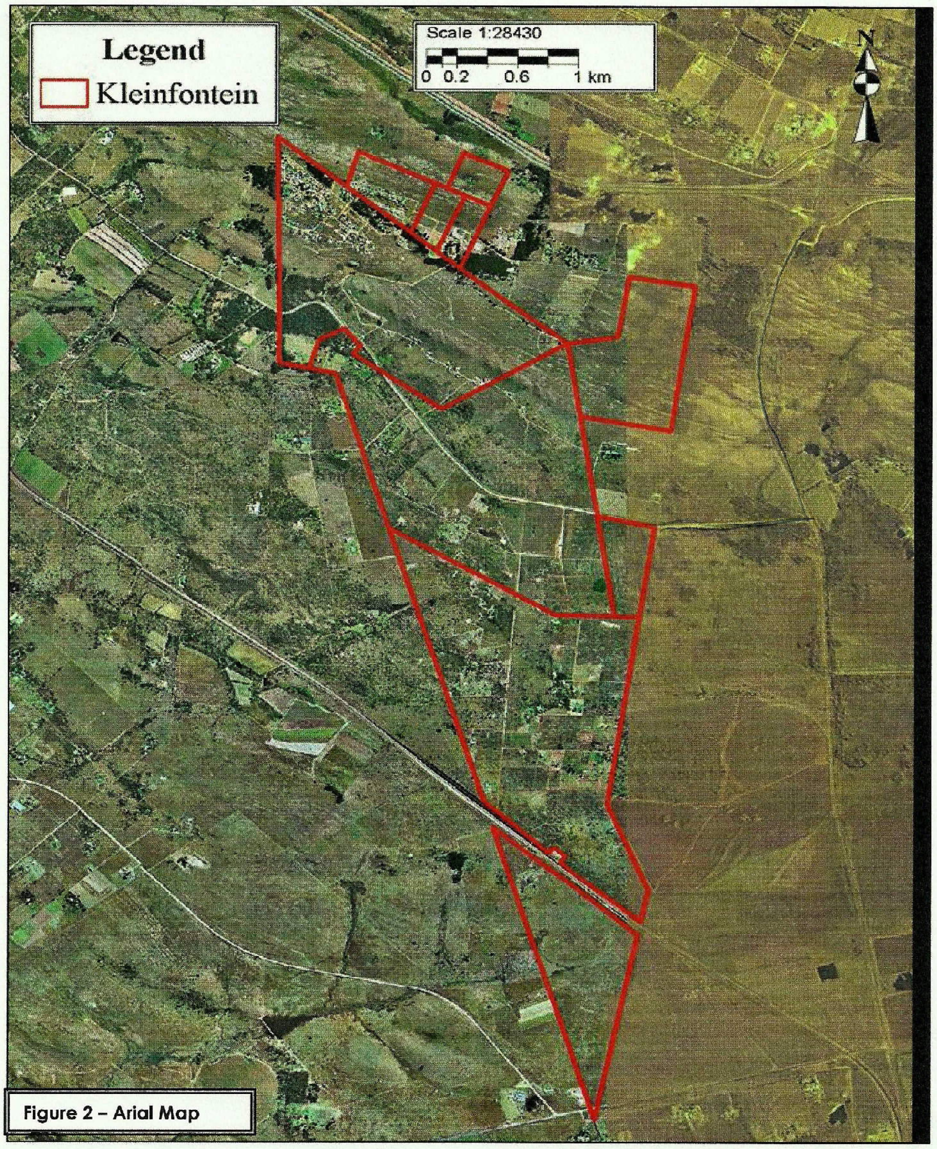

Figure 2 – Arial Map

DESCRIPTION OF THE STUDY AREA

The study area is divided into two sections, the northern living area and the southern small holdings area. A gravel road divides these two areas. The northern part is home to various game species such as Zebra, Wildebeest and other antelope. Steep rocky outcrops of ecological importance characterize the area. Approx. central co-ordinates are S 25º 48’ 54.52” and E 028º 29’ 43.97”.

METHOD

The objective of this study was not to undertake a detailed heritage survey, but to gain an overall understanding of the heritage sensitivities of the area and indicate how they may be impacted on through development activities. The survey took place on 15 February 2012.

In order to establish heritage significance the following method was followed:

- Investigation of primary resources (archival information)
- Investigation of secondary resources (literature and maps)
- Physical evidence (site investigation)
- Determining Heritage Significance

LEGASLATIVE REQUIREMENTS

The National Heritage Resources Act (Act 25 of 1999)

According to the above mentioned act the following is protected as cultural resources:

a. Archaeological artefacts, structures and sites older than 100 years
b. Ethnographic art objects (e.g. prehistoric rock) art and ethnography
c. Objects of decorative and visual arts
d. Military objects, structures and sites older than 75 years
e. Historical objects, structures and sites older than 60 years
f. Proclaimed heritage sites
g. Cemeteries and graves older than 60 years
h. Meteorites and fossils
i. Objects, structures and sites of technological value.

The national estate includes the following:

a. Places, buildings, structures and equipment of cultural significance
b. Places to which oral traditions are attached or which are associated with living heritage
c. Historical settlements and townscapes

d. Landscapes and features of cultural significance
e. Geological sites of scientific or cultural importance
f. Archaeological and palaeontological importance
g. Graves and burial grounds
h. Sites of significance relating to the history of slavery
i. Movable objects (e.g. archaeological, palaeontological, meteorites, geological specimens, military, ethnographic, books etc.

PROPOSED KLEINFONTEIN MIXED LAND DEVELOPMENT TO BE KNOWN AS "KLEINFONTEIN NEDERSETTING"

1. BRIEF BACKGROUND HISTORY OF THE AREA

The first owner of the farm Kleinfontein

The first owner of the farm Kleinfontein was David Adolph Michael Botha (1806-1879). The extent of the orinal farm was 1658 morgen.

In 1866 the western part, where Kleinfontein are currently situated, was transferred to his youngest son Johannes Jacobus (Kootjie) Botha (21 April 1839-10 June 1932). He farmed the land until he passed away.

After the Battle of Donkerhoek/Diamond Hill (11-12 June 1900) Kootjie Botha fenced the English cemetery and maintained the said cemetery.[1]

The Battle of Donkerhoek/Diamond Hill 11-12 June 1900

The Battle of Donkerhoek/Diamond Hill that occurred during the Anglo-Boer War (1899-1902) was the largest military battle in the history of Pretoria and occurred partially on the farm Donkerhoek therefor sometimes referred to as the Battle of Donkerhoek. It was part of the British strategy to lure the Boer defence away from Pretoria after the successful annexation of the capital on 5 June 1900, but also part of the Boer strategy to limited British access to the country east of Pretoria. General Louis Botha's men took up defence positions on 9-10 June 1900 on the hills east of Pretoria the main aim was to block the road and railway line to the east. Lord Roberts attacked on 11-12 June 1900 and occupied Diamond Hill. General Botha was afraid that this action will enable the British forces to occupy his other defences. In the night of 12/13 June he decided to stop the battle and retreat to the east. The British succeeded to drove the Boer forces from Pretoria and the Boers succeeded indelaying the British advance. Both parties claimed victory.[2]

[1] E.J.M. Baumbach, Op padnaonstoekoms. Kleinfontein se geskiedenis en ontwikkeling.
[2] J.H. Breytenbach, Die Geskiedenis van die TweedeVryheidsoorlog (6).

Other important happenings:

Rebellion

On Monday 26 October 1914, General Chris Muller, Field Cornets P.Viljoen and M.Bredenkamp and approx. 42 other men met at JJ (Kootjie) Botha's residence to object to the then government's decision to invade German-West Africa (South West Africa/Namibia).

December 1938

An original ox-wagon dating from 1853 symbolizing the Blood River wagon left Kleinfontein for the Voortrekker Monument site for the 100th anniversary celebration of the Great Trek.

June 1985

Diamond Hill Military Cemetery is declared a National Monument (current status Provincial Heritage Site)

December 1988

The 150th anniversary of the Great Trek is celebrated on Kleinfontein.[3]

2. FINDINGS

2.1 PRE-COLONIAL HERITAGE SITES

The Stone Age

The period referred to as the Stone Age is the period in history when lithic (stone) material was mainly used to produce tools.[4] In South Africa the Stone Age can be divided in three periods:

Early Stone Age (ESA) 2 million – 150 000 years ago
Middle Stone Age (MSA) 150 000 – 30 000 years ago
Late Stone Age (LSA) 40 000 –to approx. 1850 AD[5]

Various stone tools are located on the northern ridge of the farm.

[3]E.J.M. Baumbach, Op padnaonstoekoms. Kleinfontein se geskiedenis en ontwikkeling.
[4]P.J. Coertze& R.D. Coertze, VerklarendevakwoordeboekvirAntropologie en Argeologie.
[5]S.A. Korsman& A. Meyer, Die Steentydperk en rotskuns in *J.S. Bergh (red.) Geskiedenisatlas van Suid-Afrika. Die viernoordelikeprovinsies.*

The so-called Northern Ridge of the Farm Kleinfontein

Stone tools mainly dating from the Middle and Late Stone Age were collected on the Northern Ridge (S 25º 48' 08.4" E 028º 29' 21.2")

The Iron Age

The Iron Age is the name associated with the period in human history when metal was mainly used to produce artefacts.[6]

According to van der Ryst & Meyer (1999) the Iron Age in South Africa provincial can be divided in two phases;

Early Iron Age (EIA) 250 – 900AD
Late Iron Age (LIA) 1000 – 1850AD[7]

Huffman (2007) however includes a Middle Iron Age. His dates are as follow;

---

[6]P.J. Coertze& R.D. Coertze, Verklarendevakwoordeboekvir Antropologie en Argeologie
[7]M.M. van der Ryst& A. Meyer, Die Ystertydperk in J.S. Bergh (red.)*Geskiedenisatlas van Suid-Afrika. Die viernoordelikeprovinsies*.

Early Iron Age (EIA) 250 – 900AD
Middle Iron Age (MIA) 900 – 1300AD
Late Iron Age 1300 – 1840AD[8]

No sites/artefacts associated with the above were identified in the study area.

2.2 HISTORICAL PERIOD HERITAGE SITES

Anglo-Boer War entrenchment (S 25º 48' 14.9" E 028º 29' 25.5")

In a radius from the GPS waypoint S 25º 48' 12.7" E 028º 29' 24.5" approx. 6 entrenchments are visible. These entrenchments are located in an ecological sensitive area

[8]T.N. Huffman, A Handbook to the Iron Age: The Archaeology of Pre-Colonial Farming Societies in Southern Africa

Botha’s sheep “kraal” (enclosure)

Diamond Hill Military Cemetery (S 25º 48’ 22.3” and E 028º 29’ 24.1”)

Marker erected by the “Pretoria Streekskomiteevir die herdenking van die TweedeVryheidsoorlog” 10 June 2000 (S 25º 48’ 20.3” E 028º 29’ 26.3”)

Rock pile 150th anniversary of the Great Trek 1988 (S 25º 48'09.3" E 028º 29' 18.5")

.2.3 ORIGINAL LANDSCAPE

Some areas featuring the original landscapes survived.

2.4 INTANGIBLE HERITAGE

The intangible heritage related to the study area is most likely found in the stories of past and present residents of the greater study area.

3. ADDITIONAL SITES OF CULTURAL SIGNIFICANCE IDENTIFIED IN THE STUDY AREA

Modern Cemetery (S 25º 48’ 20.9” E 028º 29’ 21.3”)

All graves and cemeteries are of high significance and are protected by various laws. Legislation with regard to graves included the National Heritage Resources Act (Act 25 of 1999) whenever graves are 60 years and older. Other legislation with regard to graves includes those when graves are exhumed and relocated, namely the Ordinance on Exhumations (no 12 of 1980) and the Human Tissues Act (Act 65 of 1983 as amended).

The possibility of sub-surface graves always exists. In the case of a sub-surface grave/graves being discovered the South African Police Service (SAPS) must be contacted. If the graves are identified as historical a heritage practitioner should be contacted.

4. OPPORTUNITIES, RESTRICTIONS, IMPACTS

- In a radius from the GPS waypoint S 25º 48' 12.7" E 028º 29' 24.5" various historical sites including approx. 6 Anglo-Boer War (1899-1902) entrenchments, the Botha sheep "kraal" (enclosure) and the northern ridge where various stone tools have been collected, this area is of great importance and no development should be allowed here.
- If archaeological finds are unearthed during excavations in the non-sensitive parts of the study area, work should stop and an archaeologist contacted to evaluate the situation.
- The archaeological potential of the study area should be investigated.
- All identified heritage sites in the study area are protected by the National Heritage Resources Act, Act 25 of 1999 and may only be altered or removed with the necessary approval of the relevant heritage authority.
- All graves and cemeteries are of high significance whether historical or recent.

5. THE WAY FORWARD

- A section 38 application in line with the National Heritage Act (Act 25 of 1999) should be submitted to the Provincial Heritage Authority of Gauteng for comments.

6. REFERENCES

Baumbach, E.J.M. Op pad na ons toekoms. Kleinfontein se geskiedenis en ontwikkeling 1853 – 2008. Unpublished work.

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Huffman, T.N. A Handbook to the Iron Age: The Archaeology of Pre- Colonial Farming Societies in Southern Africa. University of KwaZulu-Natal Press 2007

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Flora Assessment

of

Portion 4 of the farm Kleinfontein 368-JR

February 2013

Report author: Mrs. P. Lemmer (Cert. Sci. Nat: B.Sc.)
Report verified/reviewed by: Dr. L.A. Coetzer (D.Sc., Prof. Nat. Sci.)

VERIFICATION STATEMENT

Petro Lemmer is a Certified Natural Scientist with the S.A. Council for Natural Scientific Professions. This communication serves to verify that the flora report compiled by Petro Lemmer has been prepared under my supervision, and I have verified the contents thereof.

Declaration of Independence: I, Dr. L.A. Coetzer (421009 5029 089) declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them
- abide by the Code of Ethics of the S.A. Council for Natural Scientific Professions
- act as an independent specialist consultant in the field of botany
- am subcontracted as specialist consultant by Galago Environmental CC for the proposed development project on Portion 4 of the farm Kleinfontein described in this report
- have no financial interest in the proposed development other than remuneration for work performed
- have or will not have any vested or conflicting interests in the proposed development
- undertake to disclose to Galago Environmental CC and its client as well as the competent authority any material information that have or may have the potential to influence the decision of the competent authority required in terms of the Environmental Impact Assessment Regulations, 2006.

L.A. Coetzer

Dr. L.A. Coetzer

DECLARATION OF INDEPENDENCE

I, Petro Lemmer (440129 0025 085) declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them
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Petro Lemmer

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TABLES:

1. INTRODUCTION

Galago Environmental was appointed to conduct a vegetation survey on Portion 4 of the farm Kleinfontein 368-JR, scheduled for low density residential development. The objective was to determine which species might still occur on the site. Special attention had to be given to the habitat requirements of all the Red List species that may occur in the area. This survey focuses on the current status of threatened plant species occurring, or which are likely to occur on the study site, and a description of the available and sensitive habitats on the site and within 200 meters of the boundary of the site.

2. OBJECTIVES OF THE STUDY

- To assess the current status of the habitat component and current general conservation status of the area;
- To list the perceptible flora of the site and to recommend steps to be taken should endangered, vulnerable or rare species be found;
- To highlight potential impacts of the development on the flora of the proposed site; and
- To provide management recommendations to mitigate negative and enhance positive impacts should the proposed development be approved.

3. SCOPE OF STUDY

This report:

- Lists the more noticeable trees, shrubs, herbs, geophytes and grasses observed during the study and offers recommendations about the protection of the sensitive areas on the study site;
- Indicates medicinal plants recorded and lists alien species;
- Comments on connectivity with natural vegetation on adjacent sites;
- Comments on ecological sensitive areas;
- Evaluates the conservation importance and significance of the site with special emphasis on the current status of resident threatened species; and
- Offers recommendations to reduce or minimise impacts, should the proposed development be approved

4. STUDY AREA

4.1 Regional vegetation

The study site lies in the quarter degree square 2528CD (Rietvlei dam). According to Mucina & Rutherford (2006) the study site falls within two vegetation units, Marikana Thornveld, that comprised the western, and largest, part of the site and Rand Highveld Grassland that occurred in the eastern part of the site. Marikana Thornveld is characterised by open *Acacia karroo* woodland occurring in valleys and by slightly undulating plains and lowland hills. Shrubs are denser along drainage lines, on termitaria and rocky outcrops or in other fire-protected habitat. Most of the area is underlain by mafic intrusive rocks such as gabbro, norite, pyroxenite and anorthosite. The shales and quartzites of the Pretoria group also contribute. The soil is mainly vertic, dark clays with leached layers of compressed particles and some freely-drained, deep soils. This unit falls within a summer-rainfall region with very dry winters and frequent winter frosts.

The Marikana Tornveld vegetation unit is considered endangered. Its conservation target is 19%. Less than 1% is conserved in statutory reserves such as Magaliesberg Nature Area and De Onderstepoort Nature Reserve. The unit is considerably impacted, with 48% transformed, mainly by urbanization and cultivation. Towards the west this unit is transformed by agriculture while in the east industrial development is the greater threat.

Rand Highveld Grassland (Mucina & Rutherford 2006) on the other hand is a highly variable landscape with extensive sloping plains and a series of slightly elevated ridges. The vegetation is species-rich, wiry, sour grassland, characterized by *Themeda, Eragrostis, Heteropogon* and *Elionurus*, alternating with low sour scrubland on rocky outcrops and steeper slopes. Typical herbs mostly belong to the Asteraceae and rocky ridges carry sparse woodlands with *Acacia caffra* and *Celtis africana* accompanied by a rich suite of shrubs with the genus *Searsia* most prominent. The area comprises quartzite ridges supporting shallow soils on rocky ridges and soils of various qualities elsewhere.

It is a warm-temperate region with strongly seasonal summer rainfall with very dry winters and frequent winter frosts.

The Rand Highveld Grassland vegetation unit is considered endangered. Its conservation target is 24%. Poorly conserved (only 1%) in statutory reserves and a few private nature reserves. Almost 50% of the unit is already been transformed by cultivation, plantations, urbanization and dam-building.

4.2 The study site

The 89,9888 ha study site lies near the northwestern boundary of the farm Kleinfontein 368-JR and almost entirely between gravel road D1342 and the Sentra Rand railway line with the railway line cutting through the southern tip of the site.

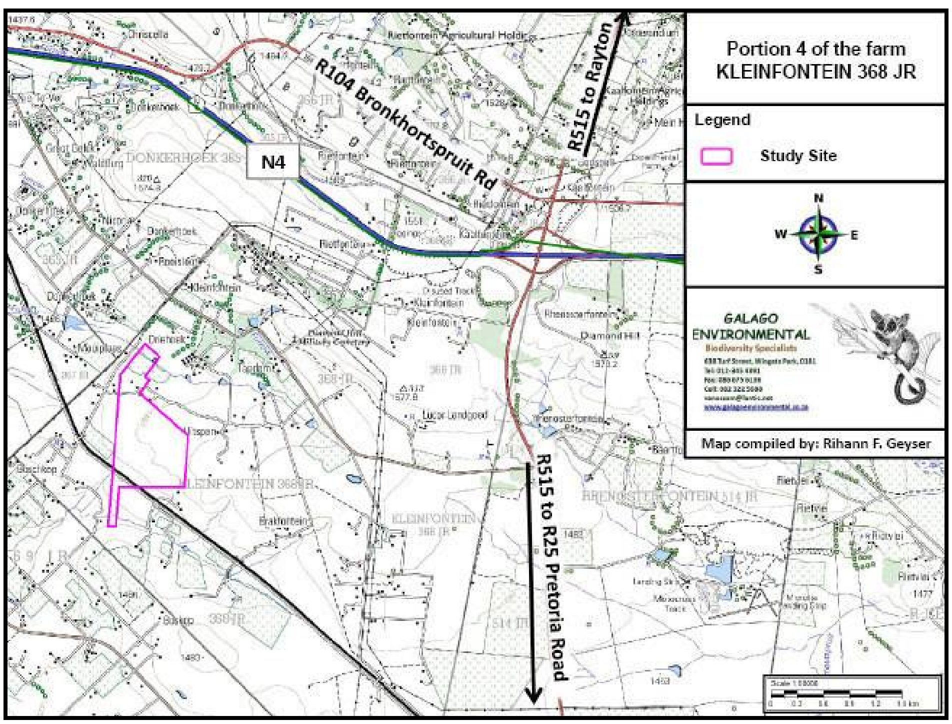

Figure 1: Locality map of the study area

5. METHOD

A desktop study of the habitats of the Red List and Orange List species known to occur in the area was done before the site visit. Information about the Red List and Orange List plant species that occur in the area was obtained from GDARD. The Guidelines issued by GDARD to plant specialists as well as various publications (see Section 11) were consulted about the habitat preferences of the Red- and Orange List species concerned.

The list of plants recorded in the 2628AD quarter degree square was obtained from SANBI and consulted to verify the record of occurrence of the plant species seen on the site. The vegetation map published in Mucina and Rutherford (2006) was consulted about the composition of Marikana Thornveld and Rand Highveld Grassland.

The study site was first visited on 6 December 2012 to determine whether suitable habitat for the Red List species known to occur in the quarter degree square existed and to survey the flora present on the site. The site was again visited on 27 February 2013 to search for Red List species that did not flower during the first site visit.

The various study units were identified (see Figure 2) and one or more plots, depending on the size and composition of the study unit, were selected at random from each study unit for detailed study. Each plot, which measured about 10m x 10m, was surveyed in a random crisscross fashion and the plants recorded. Areas where the habitat was suitable for the Red List species known to occur in the quarter degree square were examined in detail.

Suitable habitat for Red List species on the neighbouring properties, where accessible, was examined to a distance of 200 m from the boundaries of the site for the presence of Red List plant species.

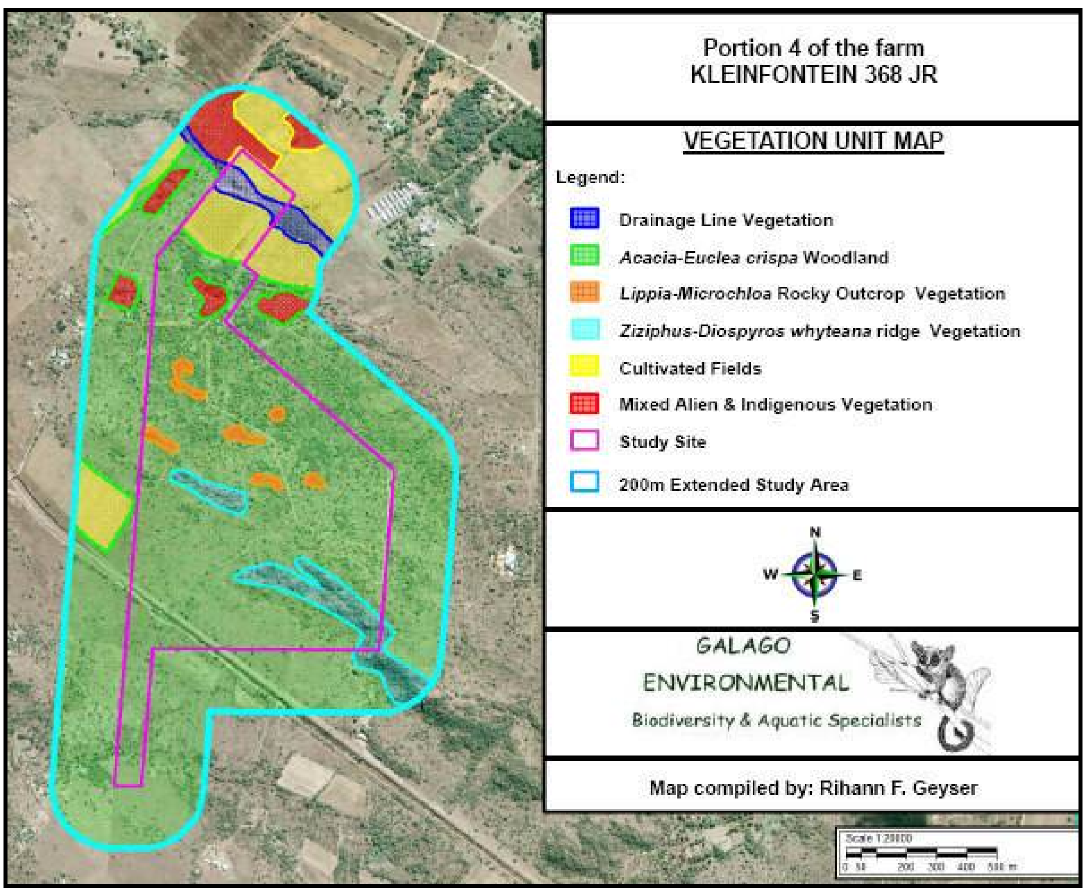

Figure 2: Vegetation study units identified on the study site

6. RESULTS

6.1 Vegetation study units

Five vegetation study units were identified:

- *Acacia – Euclea crispa* woodland;
- *Lippia – Microchloa* rocky outcrop vegetation;
- Drainage line vegetation;
- *Ziziphus – Diospyros whyteana* ridge vegetation; and
- Cultivated fields.

Tables 3 to 6 list the trees, shrubs, geophytes, herbs and grasses actually found on each of the surveyed areas of the site.

6.2 Medicinal plants

The names of known medicinal plants are marked with numbers to footnotes in Tables 3 to 6 and the footnotes themselves appear at the end of the last table. Of the 164 plant species recorded on the site, 41 species with medicinal properties were found. Their distribution in the various study units is as follows:

Table 1: Number of medicinal species in the various study units

STUDY UNIT	TOTAL NO OF SPECIES IN STUDY UNIT	NO OF MEDICINAL SPECIES IN STUDY UNIT
Acacia – Euclea crispa woodland	94	27
Lippia – Microchloa rocky outcrop vegetation	64	16
Drainage line vegetation	29	13
Ziziphus – Diospyros whyteana ridge vegetation	47	23
Cultivated fields	Not surveyed	

6.3 Alien plants

Alien plants are not listed separately, but are included in the lists as they form part of each particular study unit. Their names are marked with an asterisk in Tables 3 to 6. Twenty-five alien plant species, of which five species were Category 1 Declared weeds, one was a Category 2 Declared invader and two were Category 3 Declared invaders, were recorded on the site. The number of alien species in each study unit is reflected in table 2.

Table 2: Number of Alien species in each study unit

STUDY UNIT	NO. OF ALIEN SPECIES	CAT 1	CAT 2	CAT 3	NOT DECLARED
Acacia – Euclea crispa woodland	17	4	0	0	13
Lippia – Microchloa rocky outcrop vegetation	3	0	0	0	3
Drainage line vegetation	11	1	1	2	7
Ziziphus – Diospyros whyteana ridge vegetation	0	0	0	0	0
Cultivated fields	Not surveyed				

The alien plant names printed in **bold** in the plant tables are those of Category 1 Declared Weeds and the removal of these plants is ***compulsory*** in terms of the regulations formulated under "The Conservation of Agricultural Resources Act" (Act No. 43 of 1983), as amended.

In terms of these regulations, Category 2 Declared invaders may not occur on any land other than a demarcated area and should likewise be removed.

Although the regulations under the above Act require that Category 3 Declared invader plants may not occur on any land or inland water surface other than in a biological control reserve, these provisions shall not apply in respect of category 3 plants already in existence at the time of the commencement of said regulations. If this is the case, a land user must take all reasonable steps to curtail the spreading of propagating material of Category 3 plants.

6.4 Orange List species on the study site

The habitat was suitable for five of the six Orange List plant species known to occur in the 2528CD quarter degree square. One of these species, *Hypoxis hemerocallidea* was found in two of the study units. (See Annexure A for a list of the Orange- and Red List species known to occur in the quarter degree square.)

6.5 Red List species on the study site

Fourteen Red List plant species are known to occur in the 2528CD quarter degree square, five of these within 5 km of the site. The habitat was suitable for only two of these species, but none were found during the two site visits. It was required that the specialist focused on *Argyrolobium campicola, Brachycorythis conica* subsp *transvaalensis, Ceropegia decidua* subsp. *pretoriensis, Habenaria bicolor, Habenaria kraenzliniana* and *Trachyandra erythrorrhiza.* A second site visit to cover the flowering times of all species concerned was carried out on 27 February 2013.

6.6 *Acacia – Euclea crispa* woodland

6.6.1 Compositional aspects and Connectivity

This study unit comprised overgrazed natural woodland severely infested with *Schkuria pinnata* and *Zinnia peruviana*. Connectivity with natural woodland existed to the southeast, but was limited in other directions by the railway line and by cultivated fields. Plant species that favour moist soil conditions were observed in the areas above the rocky outcrops. The species diversity of this study unit was high with 57% of all species recorded on the site found in this unit. Of the 164 plant species recorded on the site 94 were recorded in the *Acacia – Euclea crispa* woodland study unit. Of these, 77 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	46
Tree species	14
Shrubs and dwarf shrubs	14
Grasses	7
Geophytes	7
Sedges	2
Succulents	4
Total No of species	94

6.6.2 Red– and Orange List species on the study unit

The habitat of this study unit was not suitable for any of the Red List species, but was suitable for the Orange List species, *Hypoxis hemerocallidea*, which was sparsely scattered in the study unit.

6.6.3 Medicinal and alien species

Twenty-seven of the 41 medicinal species and 17 of the 25 alien species recorded on the site were found in the *Acacia – Euclea crispa* woodland study unit. Of the alien species, four were Category 1 Declared weeds.

6.6.4 Sensitivity

Owing to the alien infestation in this study unit, it was not considered sensitive.

Figure 3: *Acacia – Euclea crispa* woodland.

Figure 4: *Schkuria pinnata* and *Zinnia peruviana* infestation.

Table 3: Plants recorded in the *Acacia – Euclea crispa* woodland

SCIENTIFIC NAME	COMMON NAMES
Acacia caffra	Common hook thorn / Gewone haakdoring
Acacia karroo[1,2]	Sweet thorn / Soetdoring
Acacia robusta subsp robusta	Broad-pod robust thorn / Enkeldoring
Acacia tortilis subsp heteracantha	Umbrella thorn / Haak-en-steek
Afrocanthium gilfillanii	Velvet rock alder / Fluweelklipels
Agelanthus natalitius subsp zeyheri	Bird lime / Voëlent
Aloe greatheadii var *davyana*[1,2]	Kleinaalwyn
Aloe marlothii subsp marlothii[1,2,4]	Mountain aloe / Bergaalwyn
Aristida congesta subsp *congesta*	Tassle threeawn grass / Katstertsteekgras
Asparagus flavicaulis subsp flavicaulis	
Asparagus suaveolens	Wild asparagus / Katdoring
Athrixia elata	Wild tea / Bostee
Berkheya radula	Boesmanrietjie
Bonatea antennifera	Terrestrial orchid / Grondorgidie
Campuloclinium macrocephalum*	**Pom pom weed / Pompombossie**
Celtis africana	White stinkwood / Witstinkhout
Cereus jamacaru*	**Queen of the night / Nagblom**
Cheilanthes viridis var viridis	Cliff brake / Kransruigtevaring
*Chenopodium ambrosiodes**	
Cleome monophylla	
*Commelina benghalensis**	Wandering jew / Wandelende jood
Commelina livingstonii	
Conyza podocephala	
Cucumis zeyheri	Wild cucumber / Wilde agurkie
Cynodon dactylon	Couch grass / Kweek
Cynoglossum hispidum	Hound's tongue / Ossetongblaar
Cyperus obtusiflorus var flavissimus	Geelbiesie
Datura ferox*	**Large thorn apple / Groot stinkblaar**
Dianthus mooiensis subsp mooiensis var mooiensis[2,3]	Wild pink / Wilde angelier
Diospyros lycioides subsp guerkei	Bushveld bluebush / Bosveldbloubos
Dipcadi viride	Sslymuintjie
Dombeya rotundifolia[1,2]	Wild pear / Drolpeer
Dovyalis zeyheri	Wild apricot / Wilde appelkoos
Ehretia rigida cf subsp *nervifolia*[2,4]	Puzzle bush / Deurmekaarbos
Euclea crispa subsp crispa[4]	Blue guarri / Bloughwarrie
*Euphorbia heterophylla**	Wild poinsettia / Wilde poinsettia
Felicia muricata subsp *muricata*[3]	White felicia / Blouheuning karooblom
Gerbera viridifolia	Griekwateebossie
Gladiolus dalenii subsp dalenii[3]	Wild gladiolus / Wildeswaardlelie
Gomphocarpus fruticosus subsp fruticosus[1,2]	Milkweed / Melkbos
*Gomphrena celosioides**	Bachelor's button / Mierbossie
Grewia occidentalis var occidentalis[2]	
Gymnosporia buxifolia[2]	Spikethorn / Pendoring
Helichrysum rugulosum[2,3]	
Hermannia depressa[2,3]	Creeping red Hermannia / Rooiopslag
Heteromorpha arborescens var abyssinica[1,2]	Common parsley tree / Gewone pietersielieboom
Hibiscus pusillus	Dwarf hibiscus
*Hibiscus trionum**	Bladder hibiscus / Terblansbossie
Hyparrhenia hirta	Common thatching grass / Dekgras
Hypoxis hemerocallidea[1,2,3]	Star flower / Gifbol
Ipomoea oenotherae	
*Ipomoea purpurea**	Morning glory / Purperwinde
Kyllinga alba	White button sedge / Witbiesie
Lantana rugosa[2,3]	Bird's brandy / Voëlbrandewyn
Ledebouria ovatifolia	
*Lepidium bonariense**	Pepper weed / Peperbossie
Lessertia stricta	

SCIENTIFIC NAME	COMMON NAMES
Lippia javanica[1,2,3]	Fever tea / Koorsbossie
Monsonia angustifolia	Crane's bill / Angelbossie
Opuntia ficus-indica*	**Sweet prickly pear / Boereturksvy**
Ornithogalum tenuifolium subsp tenuifolium	Bosui
Oxalis obliquifolia	Sorrel / Suring
Paspalum scrobiculatum	Veld paspalum / Veldpaspalum
Pentarrhinum insipidum	Donkieperske
Polygala hottentotta[2, 3]	Small purple broom
Rhoicissus tridentata subsp cuneifolia[1]	Northern bushman's grape / Noordelike boesmansdruif
Rhynchosia caribaea	
Rhynchosia totta var totta	Yellow carpet bean / Tottabossie
Salvia runcinata	Wildesalie
*Salvia tiliifolia**	
Scabiosa columbaria[1,2,3]	Wild scabiosa / Bitterbos
*Schkuhria pinnata**	Dwarf marigold / Klein kakiebos
Searsia lancea	Karee
Searsia leptodictya forma leptodictyaB	Mountain karee / Bergkaree
Searsia pyroides var gracilis[4]	Common wild currant / Taaibos
Searsia pyroides var pyroides[4]	Common wild currant / Taaibos
Searsia zeyheri[2]	Blue currant / Blou taaibos
Setaria sphacelata var sphacelata	Small creeping foxtail / Kleinkruipmannagras
Solanum lichtensteinii	Giant bitter apple / Bitterappel
Solanum supinum var *supinum*	
*Tagetes minuta**	Tall khaki weed / Lang kakiebos
Talinum caffrum[2]	Porcupine root
Teucrium trifidum	Koorsbossie
Themeda triandra	Red grass / Rooigras
Tragus berteronianus	Common carrot-seed grass / Gewone wortelsaadgras
Tribulus terrestris	Dubbeltjie
Tripteris aghillana var aghillana	Bietou
Vahlia capensis subsp vulgaris var linearis	Cape valerian / Wildebalderjan
Vangueria infausta subsp infausta[2]	Wild medlar / Wildemispel
*Verbena aristigera**	Fine-leaved verbena / Fynblaar verbena
*Verbena bonariensis**	Purple top / Blouwaterbossie
Vigna vexillata var vexillata[3]	Narrow-leaved wild pea / Wilde-ertjie
*Zinnia peruviana**	Redstar zinnia / Wildejakobregop
Ziziphus mucronata subsp mucronata[1,2]	Buffalothorn / Blinkblaarwag-'n-bietjie

6.7 *Lippia – Microchloa* rocky outcrop vegetation

6.7.1 Compositional aspects and Connectivity

The *Lippia – Microchloa* rocky outcrop vegetation study unit occurred as small islands of bare rock with pockets of vegetation in the *Acacia – Euclea crispa* woodland. Limited connectivity with natural woodland existed in all directions on the site. The study unit should be carefully mapped for exclusion purposes. Of the 164 plant species recorded on the site 64 were recorded in the *Lippia – Microchloa* rocky outcrop vegetation study unit. Of these, 61 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	33
Tree species	3
Shrubs and dwarf shrubs	8
Grasses	10
Geophytes	6
Succulents	4
Total No of species	64

6.7.2 Red– and Orange List species on the study unit

The habitat of the *Lippia – Microchloa* rocky outcrop vegetation study unit was suitable for the Red List species, *Adromischus umbraticola* subsp *umbraticola.* None was, however, found during the survey. The Orange List species *Hypoxis hemerocallidea* was found sparsely scattered in this study unit.

6.7.3 Medicinal and alien species

Sixteen of the 41 medicinal species recorded on the site were found in this study unit. Three alien species were recorded in this study unit. None of these were declared invaders.

6.7.4 Sensitivity

Owing to its near pristine condition, this study unit was considered sensitive.

Figure 5: *Lippia – Microchloa* rocky outcrop vegetation.

Table 4: Plants recorded in the Lippia – Microchloa rocky outcrop vegetation

SCIENTIFIC NAME	COMMON NAMES
Acacia caffra	Common hook thorn / Gewone haakdoring
Aloe greatheadii var *davyana*[1,2]	Kleinaalwyn
Cheilanthes hirta var hirta[1,2]	Hairy lip fern / Harige lipvaring
Cheilanthes involuta var obscura[1,2]	Involuted lip fern / Lipvaring
Cheilanthes viridis var glauca	Blue cliff brake / Blou kransruigtevaring
Chlorophytum fasciculatum	
Clematis brachiata[2]	Traveler's joy / Klimop
Cleome monophylla	
Commelina africana var africana	
Commelina africana var krebsiana	
Conyza podocephala	
Crassula capitella subsp nodulosa	
Crassula lanceolata subsp transvaalensis	
Cussonia paniculata subsp sinuata[2]	Highveld cabbage / Hoëveld kiepersol
Cynodon dactylon	Couch grass / Kweek
Diospyros lycioides subsp guerkei	Bushveld bluebush / Bosveldbloubos
Dombeya rotundifolia[1,2]	Wild pear / Drolpeer
Elionurus muticus	Wire grass / Draadgras
Eragrostis capensis	Heartseed love grass / Hartjiesgras
Gerbera viridifolia	Griekwateebossie
Heteropogon contortus	Spear grass / Assegaaigras
Hilliardiella oligocephala[1,2]	Cape vernonia / Blounaaldetee bossie
Hypoestis forskaolii	White ribbon bush
Hypoxis argentea var argentea	Small yellow star flower
Hypoxis hemerocallidea[1,2,3]	Star flower / Gifbol
Hypoxis rigidula var *rigidula*	Silver-leaved star flower / Wilde tulp
Ipomoea magnusiana	
Ipomoea obscura var obscura	Wild petunia / Wilde patat
Ipomoea oenotherae	
Jamesbrittenia aurantiaca	Cape saffron / Saffraanbossie
Kalanchoe paniculata	Krimpsiektebossie
Kohautia virgata	
Kyphocarpa angustifolia	
Lapeirousia sandersonii	Blou-angelier
Lippia javanica[1,2,3]	Fever tea / Koorsbossie
Melinis nerviglumis	Bristle leaf red top / Steekblaarblinkgras
Melinis repens subsp repens	Red top grass
Menodora africana	Balbossie
Merremia palmata	
Microchloa caffra	Pincushion grass / Elsgras
Mohria vestita[1,2]	Scented fern
Monsonia angustifolia	Crane's bill / Angelbossie
Oxalis obliquifolia	Sorrel / Suring
Paspalum scrobiculatum	Veld paspalum / Veldpaspalum
Pavetta gardeniifolia var gardeniifolia	Common bride's bush / Gewone bruidsbos
Pellaea calomelanos var calomelanos [1,2]	Black cliff brake / Swart kransruigtevaring
Raphionacme hirsuta[2]	Khadi root / Khadiwortel
Rhoicissus tridentata subsp cuneifolia[1]	Northern bushman's grape / Noordelike boesmansdruif
Rhynchosia minima var prostrata	
Rhynchosia nitens	Vaalboontjie
*Schkuhria pinnata**	Dwarf marigold / Klein kakiebos
Selaginella dregei	Drege's spike moss / Drege se stekelmos
Senecio erubescens var crepidifolius	
Senecio venosus	Besembossie
Sida dregei	Spider-leg
Sporobolus stapfianus	Fibrous dropseed / Veselfynsaadgras
*Tagetes minuta**	Tall khaki weed / Lang kakiebos
Talinum caffrum[2]	Porcupine root

SCIENTIFIC NAME	COMMON NAMES
Trichoneura grandiglumis var grandiglumis	Small rolling grass / Klein rolgras
Vangueria infausta subsp infausta[2]	Wild medlar / Wildemispel
Xenostegia tridentata subsp augustifolia	
Xerophyta retinervis[1,2]	Monkey's tail / Bobbejaanstert
Xerophyta schlechteri	
*Zinnia peruviana**	Redstar zinnia / Wildejakobregop

6.8 Drainage line vegetation

6.8.1 Compositional aspects

A drainage line runs through the cultivated field on the narrow northern part of the study site. The species diversity of this study unit was low. Of the 164 plant species recorded on the site 29 were recorded in the Drainage line vegetation study unit. Of these, 18 were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	11
Tree species	4
Shrubs and dwarf shrubs	1
Grasses	8
Geophytes	1
Sedges	4
Total No of species	29

6.8.2 Red– and Orange List species on the study unit

The habitat of this study unit was suitable for the Red List species, *Trachyandra erythrorrhiza,* but none was found. The habitat was suitable for two of the Orange List species known to occur in the quarter degree square. None were, however, found.

6.8.3 Medicinal and alien species

Thirteen of the 41 medicinal species and 11 of the 25 alien species recorded on the site were found in the Drainage line vegetation study unit. Of the alien species one was a Category 1 Declared weed, one was a Category 2 Declared invader and two were Category 3 Declared invaders.

6.8.4 Sensitivity

As wetlands form biological filters and drainage lines form corridors for the movement of species, which include pollinators of plant species, this study unit was considered sensitive and should be excluded from development.

Figure 6: Drainage line vegetation near the northwestern boundary line.

Figure 7: Drainage line vegetation near the southeastern boundary line.

Table 5: Plants recorded in the Drainage line vegetation

SCIENTIFIC NAME	INV CAT	COMMON NAMES
Arundinella nepalensis		River grass / Riviergras
Berkheya radula		Boesmanrietjie
Cirsium vulgare*	1	**Scotch thistle / Skotse dissel**
Commelina africana var africana		
Cynodon dactylon		Couch grass / Kweek
Cyperus esculentus var esculentus		Yellow nutsedge / Geeluintjie
Eragrostis capensis		Heartseed love grass / Hartjiesgras
Gomphocarpus fruticosus subsp fruticosus[1,2]		Milkweed / Melkbos
Helichrysum rugulosum[2,3]		
Hyparrhenia tamba		Blue thatching grass / Blou tamboekiegras
Imperata cylindrica		Cottonwool grass / Donsgras
Juncus excertus		
Juncus lomatophyllus		
Kyllinga erecta var erecta		Green button sedge / Groenknoop biesie

SCIENTIFIC NAME	INV CAT	COMMON NAMES
*Melia azedarach**	3	Syringa / Sering
*Morus alba**	3	Common mulberry / Gewone moerbei
*Oenothera rosea**		Pink evening primrose / Pienk aandblom
*Paspalum dilatatum**		Common paspalum / Gewone paspalum
*Pennisetum clandestinum**		Kikuyu / Kikoejoe
Phragmites australis		Fluitjiesriet
*Populus alba**	2	White poplar / Witpopulier
Senecio erubescens var crepidifolius		
Sida rhombifolia subsp rhombifolia		Arrow leaf Sida / Taaiman
*Solanum nigrum**		/ Nastergal
*Tagetes minuta**		Tall khaki weed / Lang kakiebos
Thelypteris confluens		Common bog fern / Gewone moerasvaring
Typha capensis[1,2]		Bulrush / Papkuil
*Verbena bonariensis**		Purple top / Blouwaterbossie
*Zinnia peruviana**		Redstar zinnia / Wildejakobregop

6.9 *Ziziphus – Diospyros whyteana* ridge vegetation

6.9.1 Compositional aspects and Connectivity

This small study unit comprised natural woodland on the ridges northeast of the railway line. Connectivity with similar vegetation existed to the southeast. Of the 164 plant species recorded on the site 47 were recorded in the *Ziziphus – Diospyros whyteana* ridge vegetation study unit. All of these were indigenous species. The following number of species in each life form was noted:

LIFE FORM	NUMBER OF SPECIES
Annual & perennial herbaceous species	12
Tree species	14
Shrubs and dwarf shrubs	16
Grasses	1
Geophytes	2
Succulents	2
Total No of species	47

6.9.2 Red– and Orange List species on the study unit

The habitat of this study unit was not suitable for any of the Red List species or Orange List species known to occur in the quarter degree square.

6.9.3 Medicinal and alien species

Twenty-three of the 41 medicinal species recorded on the site were found in the *Ziziphus – Diospyros whyteana* ridge vegetation study unit. No alien species were recorded in this study unit.

6.9.4 Sensitivity

Owing to its pristine condition, this study unit was considered sensitive.

Figure 8: *Ziziphus – Diospyros whyteana* ridge vegetation.

Table 6: Plants recorded in the Ziziphus – Diospyros whyteana ridge vegetation

SCIENTIFIC NAME	COMMON NAMES
Acacia caffra	Common hook thorn / Gewone haakdoring
Acacia robusta subsp robusta	Broad-pod robust thorn / Enkeldoring
Afrocanthium gilfillanii	Velvet rock alder / Fluweelklipels
Aloe greatheadii var *davyana*[1,2]	Kleinaalwyn
Asparagus suaveolens	Wild asparagus / Katdoring
Bonatea antennifera	Terrestrial orchid / Grondorgidie
Celtis africana	White stinkwood / Witstinkhout
Cheilanthes viridis var viridis	Cliff brake / Kransruigtevaring
Clematis brachiata[2]	Traveler's joy / Klimop
Cleome monophylla	
Commelina livingstonii	
Cussonia paniculata subsp sinuata[2]	Highveld cabbage / Hoëveld kiepersol
Cynodon dactylon	Couch grass / Kweek
Cyphostemma lanigerum[1,2]	
Diospyros lycioides subsp guerkei	Bushveld bluebush / Bosveldbloubos
Diospyros whyteana	Bladder nut / Swartbas
Dombeya rotundifolia[1,2]	Wild pear / Drolpeer
Dovyalis zeyheri	Wild apricot / Wilde appelkoos
Ehretia rigida cf subsp *nervifolia*[2,4]	Puzzle bush / Deurmekaarbos
Euclea crispa subsp crispa[4]	Blue guarri / Bloughwarrie
Gomphocarpus fruticosus subsp fruticosus[1,2]	Milkweed / Melkbos
Grewia occidentalis var occidentalis[2]	
Gymnosporia buxifolia[2]	Spikethorn / Pendoring
Heteromorpha arborescens var abyssinica[1,2]	Common parsley tree / Gewone pietersielieboom
Hypoestis forskaolii	White ribbon bush
Ipomoea bathycolpos	Veldsambreeltjies
Kalanchoe paniculata	Krimpsiektebossie
Kyphocarpa angustifolia	
Lantana rugosa[2,3]	Bird's brandy / Voëlbrandewyn
Lippia javanica[1,2,3]	Fever tea / Koorsbossie
Mohria vestita[1,2]	Scented fern
Oxalis obliquifolia	Sorrel / Suring
Pappea capensis[4]	Jacket plum / Doppruim
Pavetta gardeniifolia var gardeniifolia	Common bride's bush / Gewone bruidsbos
Rhoicissus tridentata subsp cuneifolia[1]	Northern bushman's grape / Noordelike

SCIENTIFIC NAME	COMMON NAMES
	boesmansdruif
Rhynchosia nitens	Vaalboontjie
Scabiosa columbaria[1,2,3]	Wild scabiosa / Bitterbos
Scolopia zeyheri	Thorn pear / Doringpeer
Searsia leptodictya forma leptodictya	Mountain karee / Bergkaree
Searsia pyroides var pyroides[4]	Common wild currant / Taaibos
Searsia zeyheri[2]	Blue currant / Blou taaibos
Talinum caffrum[2]	Porcupine root
Tephrosia longipes subsp longipes var longipes	
Teucrium trifidum	Koorsbossie
Vangueria infausta subsp infausta[2]	Wild medlar / Wildemispel
Zanthoxylum capense[1,2]	Small knobwood / Klein perdepram
Ziziphus mucronata subsp mucronata[1,2]	Buffalothorn / Blinkblaarwag-'n-bietjie

1) Van Wyk, B-E., Van Oudtshoorn, B. & Gericke, N. 2002.
2) Watt, J.M. & Breyer-Brandwijk, M.G. 1962.
3) Pooley, E. 1998.
4) Van Wyk, B. & Van Wyk P. 1997.

6.10 Cultivated fields

6.10.1 Compositional aspects

This study unit comprised recently cultivated fields. A vegetation survey was not deemed necessary.

6.10.2 Red– and Orange List species on the study unit

The habitat of this study unit was not suitable for any of the Red List or Orange List species known to occur in the quarter degree square.

6.10.3 Sensitivity

The vegetation of this study unit was not considered sensitive.

7. LIMITATIONS, ASSUMPTIONS AND GAPS IN KNOWLEDGE

Sufficient information was received and sufficient rain had fallen to accomplish the survey that was done during optimum growing conditions.

8. FINDINGS AND POTENTIAL IMPLICATIONS

The *Acacia – Euclea crispa* woodland study unit comprised natural woodland severely infested with *Schkuria pinnata* and *Zinnia peruviana* as a result of overgrazing. Few invader species were found in the *Lippia – Microchloa* rocky outcrop vegetation and none in the *Ziziphus – Diospyros whyteana* ridge vegetation. These two study units were considered sensitive. The drainage line vegetation was considered sensitive because it forms a corridor for the movement of species, which include pollinators of plant species.

9. RECOMMENDED MITIGATION MEASURES

The following mitigation measures are proposed by the specialist:

- Where possible, trees naturally growing on the site should be retained as part of the landscaping. Measures to ensure that these trees survive the physical disturbance from the development should be implemented. A tree surgeon should be consulted in this regard.
- Dumping of builders' rubble and other waste in the areas earmarked for exclusion must be prevented, through fencing or other management measures. These areas must be properly managed throughout the lifespan of the project in terms of fire, eradication of exotics etc. to ensure continuous biodiversity.
- All Declared Weeds and invaders and other alien species must be removed from the site.

The following mitigation measures were developed by GDARD (Directorate of Nature Conservation, GDACE, 2008 and 2009) and are applicable to the study site. Where appropriate, Galago Environmental's specific elaborations are given in brackets.

- An appropriate management authority (e.g. the body corporate) that must be contractually bound to implement the Environmental Management Plan (EMP) and Record of Decision (ROD) during the operational phase of the development should be identified and informed of their responsibilities in terms of the EMP and ROD.
- All areas designated as sensitive in a sensitivity mapping exercise should be incorporated into an open space system. Development should be located on the areas of lowest sensitivity.
- Development structures should be clustered as close as possible to existing development.
- The open space system should be managed in accordance with an Ecological Management Plan that complies with the *Minimum Requirements for Ecological Management Plans* and forms part of the EMP.
- The Ecological Management Plan should:
  - include an ongoing monitoring and eradication programme for all non-indigenous species, with specific emphasis on invasive and weedy species
  - include a comprehensive surface runoff and storm water management plan, indicating how all surface runoff generated as a result of the development (during both the construction and operational phases) will be managed (e.g. artificial wetlands / storm water and flood retention ponds) prior to entering any natural drainage system or wetland and how surface runoff will be retained outside of any demarcated buffer/flood zones and subsequently released to simulate natural hydrological conditions
  - include a monitoring programme for all Red and Orange List species
  - facilitate/augment natural ecological processes
  - provide for the habitat and life history needs of important pollinators
  - minimize artificial edge effects (e.g. water runoff from developed areas & application of chemicals)
  - include a comprehensive plan for limited recreational development (trails, bird hides etc.) within the open space system
  - result in a report back to the Directorate of Nature Conservation on an annual basis
- The open space system should be fenced off prior to construction commencing (including site clearing and pegging). All construction-related impacts (including service roads, temporary housing, temporary ablution, disturbance of natural habitat, storing of equipment/building materials/vehicles or any other activity) should be excluded from the open space system. Access of vehicles to the open space system should be prevented and access of people should be controlled, both during the construction and operational

phases. Movement of indigenous fauna should however be allowed (i.e. no solid walls, e.g. through the erection of palisade fencing).

- Only indigenous plant species, preferably species that are indigenous to the natural vegetation of the area, should be used for landscaping in communal areas. As far as possible, plants naturally growing on the development site, but would otherwise be destroyed during clearing for development purposes, should be incorporated into landscaped areas. Forage and host plants required by pollinators should also be planted in landscaped areas.
- In order to minimize artificially generated surface stormwater runoff, total sealing of paved areas such as parking lots, driveways, pavements and walkways should be avoided. Permeable material should rather be utilized for these purposes.
- The crossing of natural drainage systems should be minimized and only constructed at the shortest possible route, perpendicular to the natural drainage system. Where possible, bridge crossings should span the entire stretch of the buffer zone.

10. CONCLUSION

The *Lippia – Microchloa* rocky outcrop vegetation, the *Ziziphus – Diospyros whyteana* ridge vegetation and the Drainage line vegetation were considered sensitive and should be excluded from development. Where possible, these areas must be connected to other natural vegetation areas on the neighbouring properties to facilitate connectivity. To lessen the impact of the development on the vegetation of the site, great care should be taken to group residences on smaller lots in certain areas, rather than spreading them out over large areas. Roads, footpaths, services etc should be constructed with great care.

It was required that the specialist focused on *Argyrolobium campicola, Brachycorythis conica* subsp *transvaalensis, Ceropegia decidua* subsp*. pretoriensis, Habenaria bicolor, Habenaria kraenzliniana* and *Trachyandra erythrorrhiza.* A second site visit to cover the flowering times of all species concerned was carried out on 27 February 2013, but these species were not found.

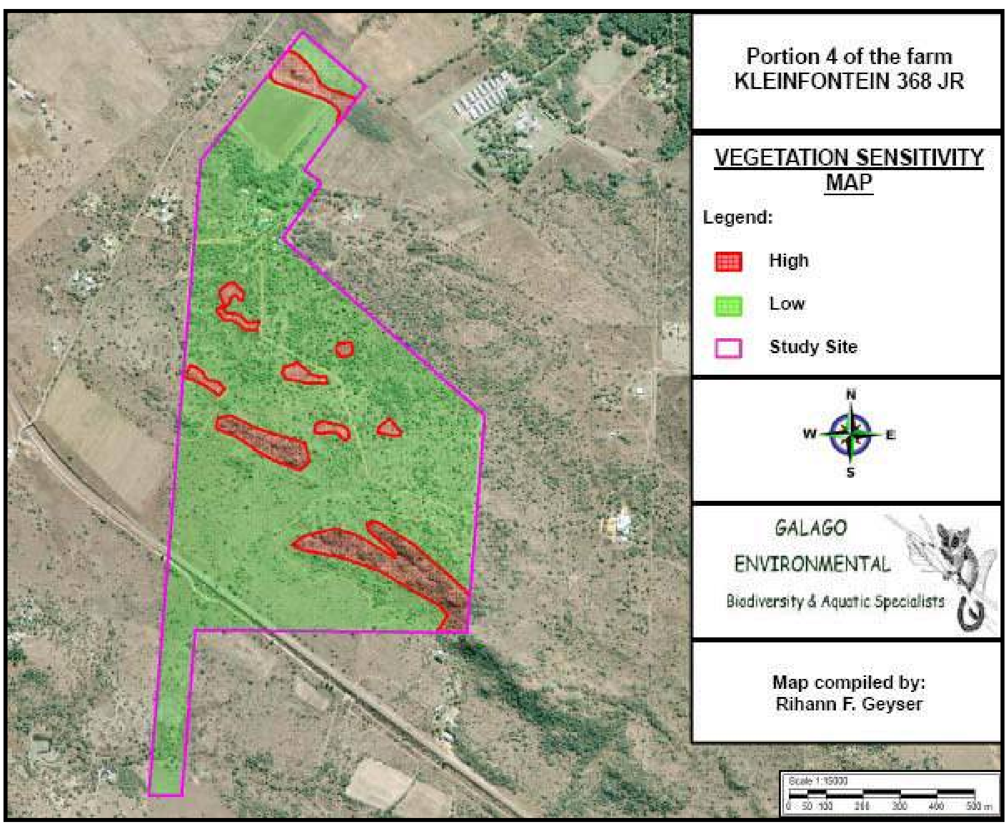

Figure 9: Vegetation sensitivity map

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ANNEXURE A: Red– and Orange List* plants of the 2528CD q.d.s.

Species	Flower season	Suitable habitat	Priority group	Conserv status	PRESENT ON SITE
Adromischus umbraticola subsp *umbraticola*	Sep-Jan	Rock crevices on rocky ridges, usually south-facing, or in shallow gravel on top of rocks, but often in shade of other vegetation.	A2	Near threatened[1]	**Habitat suitable**
Argyrolobium campicola	Nov-Feb	Highveld grassland	A3	Near threatened[1]	Habitat not suitable
Boophane disticha	Oct-Jan	Dry grassland and rocky areas.	N/A	Declining[2]	**Habitat suitable**
Bowiea volubilis subsp volubilis	Sep-Apr	Shady places, steep rocky slopes and in open woodland, under large boulders in bush or low forest.	B	Vulnerable[2]	Habitat not suitable
Brachycorythis conica subsp transvaalensis	Jan-Mrt	Short grassland, hillsides,on sandy gravel overlying dolomite, sometimes also on quartzites, occasionally open woodland, 1000 – 1705m	A3	Vulnerable[1]	Habitat not suitable
Callilepis leptophylla	Aug-Jan & May	Grassland or open woodland, often on rocky outcrops or rocky hillslopes.	N/A	Declining[2]	**Habitat suitable**
Ceropegia decidua subsp. pretoriensis	Nov-Apr	Direct sunshine or shaded situations, rocky outcrops of the quartzitic Magaliesberg mountain series, in pockets of soil among rocks, in shade of shrubs and low trees, can be seen twining around grass spikes.	A1	Vulnerable[1]	Habitat not suitable
Cheilanthes deltoidea subsp silicicola	Nov-Jun	Southwest-facing soil pockets and rock crevices in chert rocks.	A2	Vulnerable[1]	Habitat not suitable
Crinum macowanii	Oct-Jan	Grassland along rivers in gravely soil or on sandy flats	N/A	Declining[2]	**Habitat suitable**
Delosperma leendertziae	Oct-Apr	Rocky ridges; on rather steep south facing slopes of quartzite in mountain grassveld.	A2	Near Threatened[1]	Habitat not suitable
Eucomis autumnalis	Nov-Apr	Damp open grassland and sheltered places.	N/A	Declining[2]	**Habitat suitable**
Eulophia coddii	Early Dec	Steep hillsides on soil derived from sandstone, grassland or mixed bush.	A2	Vulnerable[1]	Habitat not suitable
Gunnera perpensa	Oct-Mar	In cold or cool continually moist localities, mainly along upland streambanks.	N/A	Declining[2]	Habitat not suitable
Habenaria barbertonii	Feb-Mar	In grassland on rocky hillsides.	A2	Near threatened[1]	Habitat not suitable
Habenaria bicolor	Jan-Apr	Well-drained grassland, at about 1600m.	B	Near Threatened[2]	Habitat not suitable
Habenaria kraenzliniana	Feb-Apr	Terrestrial in stony, grassy hillsides, recorded from 1000 to 1400m.	A3	Near Threatened[1]	Habitat not suitable
Habenaria mossii	Mar-Apr	Open grassland on dolomite or in black sandy soil.	A1	Endangered[1]	Habitat not suitable
Hypoxis hemerocallidea	Sep-Mar	Occurs in a wide range of habitiats. Grassland and mixed woodland.	N/A	Declining[2]	**FOUND**
Stenostelma umbelluliferum	Sep-Mar	Deep black turf in open woodland mainly in the vicinity of drainage lines.	A3	Near threatened[1]	Habitat not suitable
Trachyandra erythrorrhiza	Sep-Nov	Marshy areas, grassland, usually in black turf marshes.	A3	Near Threatened[1]	**Habitat suitable**

1) global status
2) national status
* Orange listed plants have no priority grouping and are designated 'N/A'
▲ Has been recorded from the farm on which the study site is situated / within 5km of the study site. Should suitable habitat be present, it is highly likely that this species occur on the study site.

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Mammal
Habitat Assessment

of

PORTION 4 OF FARM KLEINFONTEIN 368 JR

February 2013

Report author: I.L. Rautenbach Pr.Sci.Nat. # 400300/05, T.H.E.D., Ph.D,

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Declaration of Independence:

I, Ignatius Lourens Rautenbach (421201 5012 08 8) declare that I

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them
- abide by the Code of Ethics of the S.A. Council for Natural Scientific Professions
- act as an independent specialist consultant in the field of zoology
- am subcontracted as specialist consultant by Galago Environmental CC for the Project "Mammal Habitat Scan of Portion 4 of Farm Kleinfontein 368 JR" described in this report
- have no financial interest in the proposed development other than remuneration for work performed
- have or will not have any vested or conflicting interests in the proposed development
- undertake to disclose to the Galago Environmental CC and its client as well as the competent authority any material information that have or may have the potential to influence the decision of the competent authority required in terms of the Environmental Impact Assessment Regulations 2006
- My intellectual property in this report will only be transferred to the client (the party/ company that commissioned the work) on full payment of the contract fee. Upon transfer of the intellectual property, I recognise that written consent of the client will be required for release of any part of this report to third parties.

I.L. Rautenbach

1. INTRODUCTION

Galago Environmental CC. was appointed to undertake a mammal habitat survey and species richness assessment for Portion 4 of the Farm Kleinfontein 368 JR, which is scheduled for subdivision in twenty 4.5 ha small holdings for residential and auxiliary domestic development.

This report focuses on the reigning status of threatened and sensitive mammals likely to occur on the proposed development site. Special attention was paid to the qualitative and quantitative habitat conditions for Red Data species deemed present on the site, and mitigation measures to ameliorate the effect of the development that is suggested. The secondary objective of the investigation was to gauge which mammals might still reside on the site and compile a complete list of mammal diversity of the study area.

This assignment is in accordance with the 2010 EIA Regulations (No. R. 543-546, Department of Environmental Affairs and Tourism, 18 June 2010) emanating from Chapter 5 of the National Environmental Management Act, 1998 (Act No. 107 of 1998).

2. SCOPE AND OBJECTIVES OF THE STUDY

- To qualitatively and quantitatively assess the significance of the mammal habitat components and current general conservation status of the property;
- Identify and comment on ecological sensitive areas;
- Comment on connectivity with natural vegetation and habitats on adjacent sites;
- To provide a list of mammals which occur or might occur, and to identify species of conservation importance;
- To highlight potential impacts of the proposed development on the mammals of the study site, and
- To provide management recommendations to mitigate negative and enhance positive impacts should the proposed development be approved.

3. STUDY AREA

The study site is located in the Donkerhoek District east of Pretoria, south of the Magaliesberg and is to its south bordered by the main railway line to Maputo. It is spatially defined by 25º 48' 40"S; 28º 28' 13"E. The site is presently used for grazing and has no structural developments. The site is in the midst of a rural area with a minimum of destructive land-use practices other than occasional overgrazing.

The site falls in the Marikana Thornveld and the Highveld Grassland vegetation units as defined by Mucina and Rutherford (2006). However, the typical plant assemblages of the vegetation units have been compromised by overgrazing.

The site is densely wooded. Topographically it consists of woodland plains with weakly developed andesite outcrops. The latter is pronounced to the east within the 500 meters of the neighbouring property. The soil is a reddish loam with high clay content. A small and weak wetland system to the extreme northern portion of the site is likely to support wetland-reliant species such as vlei rats and forest shrews.

A number of collapsed rock walls were found which could be of historical interest. There may be bat roosts in the cliff faces of the randjie to the east of the study site. The conservation potential of the site is rated as below average in terms of mammals given the overgrazed condition of the basal cover, but this situation could change should the basal cover be restored to natural conditions.

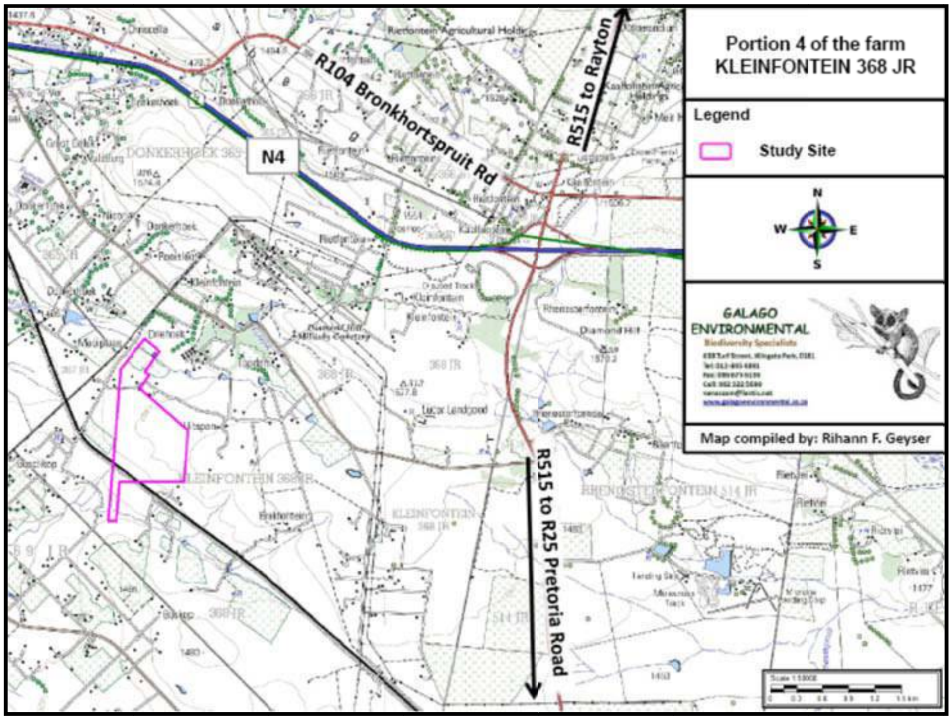

Figure 1: Locality map of the study area

4. METHODS

A six hour site visit was conducted on 29 December 2012. During this visit the observed and derived presence of mammals associated with the recognized habitat types of the study site, were recorded. This was done with due regard to the well recorded global distributions of Southern African mammals, coupled to the qualitative and quantitative nature of recognized habitats.

The 500 meters of adjoining properties was scanned for important fauna habitats.

4.1 Field Surveys

During the site visit mammals were identified by visual sightings through random transect walks. No trapping or mist netting was conducted, as the terms of reference did not require such intensive work. In addition, mammals were also identified by means of spoor, droppings, burrows or roosting sites.

Three criteria were used to gauge the probability of occurrence of mammals on the study site. These include known distribution range, habitat preference and the qualitative and quantitative presence of suitable habitat.

4.2 Desktop Surveys

As the majority of mammals are secretive, nocturnal, hibernators and/or seasonal, distributional ranges and the presence of suitable habitats were used to deduce the presence or absence of these species based on authoritative tomes, scientific literature, field guides, atlases and databases. This can be done irrespective of season. During the field work phase of the project, this derived list of occurrences is audited.

The probability of occurrences of **mammal** species was based on their respective geographical distributional ranges and the suitability of on-site habitat. In other words, *high* probability would be applicable to a species with a distributional range overlying the study site as well as the presence of prime habitat occurring on the study site. Another consideration for inclusion in this category is the inclination of a species to be common, i.e. normally occurring at high population densities.

Medium probability pertains to a mammal species with its distributional range peripherally overlapping the study site, or required habitat on the site being sub-optimal. The size of the site as it relates to its likelihood to sustain a viable breeding population, as well as its geographical isolation is also taken into consideration. Species categorised as *medium* normally do not occur at high population numbers, but cannot be deemed as rare.

A *low* probability of occurrence will mean that the species' distributional range is peripheral to the study site <u>and</u> habitat is sub-optimal. Furthermore, some mammals categorised as *low* are generally deemed rare.

4.3 Specific Requirements

During the visit the site was surveyed and assessed for the potential occurrence of Red Data and/or wetland-associated species such as:

Juliana's golden mole (*Neamblosomus juliana*), Highveld golden mole (*Amblysomus septentrionalis*), Rough-haired golden mole (*Chrysospalax villosus*), African marsh rat (*Dasymys incomtus*), Angoni vlei rat (*Otomys angoniensis*), Vlei rat (*Otomys irroratus*), White-tailed rat (*Mystromys albicaudatus*), a nember of shrews such as the Forest shrew (*Myosorex varius*), Southern African hedgehog *(Atelerix frontalis), a number of bats such as the* Short-eared trident bat (*Cloeotis percivali*), African clawless otter (*Aonyx capensis*), Spotted-necked otter (*Lutra maculicollis*), Marsh mongoose (*Atilax paludinosus*), Brown hyena (*Parahyaena brunnea*), etc.

5. RESULTS

All four major habitat types are to a greater or lesser extent present on the study site. The site falls in a much larger area which reflects the urban condition of the site. Connectivity is considered as excellent.

The wetland in the form of a small stream to the extreme northern portion of the property is modest, but is part of a drainage system which falls within the 500 meters extended study site. It is likely to support moisture-reliant small mammals such as the forest shrew and vlei rat species (Table 1).

It is not often that one can forward the premise that an arboreal habitat predominates over a terrestrial habitat on a site (Figure 1). Trees and shrubs even grow on the ridge and rocky outcrops wherever roots can find footholds. *Acacia karroo*, *A. robustra*, *A. caffra*, *Euclea crispa* and *Ziziphus mucronata* predominates. However, the woodland canopy is low and branches are thin; as such failing to provide optimum habitat for arboreal species such as black-tailed and Acacia rats as well as woodland dormice.

The randjie within the 500 meters to the east of the site is conspicuous with prominent cliff faces and andesite rocky summits which provides excellent habitat for rupiculous species such as rock elephant shrews, Namaqua rock rats and rock rabbits. It is even possible that deep crevices in the cliff faces on the neighbouring property occur which seasonally provide sanctuary for cave-dwelling bats. The rocky outcrops on the site itself (Figure 2) are poorly developed and do not have copious nooks and crannies as refuges for rock-dwelling mammals, but justifies being recognized as marginally sensitive. The vegetation along the crest of the randjie is in pristine condition, but the grass amongst the rocky outcrops on the plains of the site tends to suffer from overgrazing.

The terrestrial habitat amongst the trees is overgrazed, apart from suffering from the shade-effect of the low tree canopy. The conservation ranking of this habitat in terms of mammals is considered as low, which detracts from the overall rating of the site *per se*.

The highest aspects of the rocky outcrops that eastwards connect with the prominent randjie, is deemed marginally sensitive.

Figure 2: A westerly view over the plains section, illustrating the dense woody cover typical of the site and adjoining properties. Basal cover is impaired by overgrazing and the shade-effect of the dense canopy.

Figure 3: The rocky outcrops on the site, which are in fact outliers of the more prominent randjie to the east. Note the overgrazed condition of the grass cover and the woody plants amongst the andesite rocks. The higher aspects of the outcrops are identified as marginally sensitive.

Expected and Observed Mammal Species Richness

Large mammals have long since been locally exterminated to maximise farming endeavours. However, the wooded nature of the area, coupled to localised conservation-minded groupings in the district, allow for the continued existence of more reticent species such as kudu, duiker, steenbok and black-backed jackals.

Of the 46 mammal species expected to occur on the study site (Table 1), only four were confirmed during the site visit (Table 2). It should be noted that potential occurrences is interpreted as to be possible over a period of time as result of environmentally induced expansion and contractions of population densities and ranges which stimulate migration.

Table 1 lists the mammals which were observed or deduced to occupy the site, or to be occasional visitors. All feral mammal species expected to occur on the study site (e.g. house mice, house rats, dogs and cats) were omitted from the assessment since these cannot be considered when estimating the conservation value of the site.

Most of the species of the resident diversity (Table 2) are common and widespread such as elephant shrews, mole rats, multimammate mouse species, yellow house bat species, yellow and slender mongooses etc. Others cannot be considered as common but are nevertheless always present in fairly stable woodland environments (viz. red rock rabbits, porcupines, dormouse species, four-striped field mice, tree rat species, vlei rat species, genets, duiker and steenbok). However, discerning species closely reliant on pristine habitat have succumbed as result of environmental degradation, such as white-tailed rats.

Forty-six species of mammals on 90 hectares close to a large metropolitan area can be considered as a fair species richness considering the fact that more prominent species have been extirpated and that the site and adjoining properties have been farmed at the cost of healthy conservation practices.

Threatened and Red Listed Mammal Species

It is amazing how many local mammals have never been studied in nature. As result, the conservation status of species such as the rock dormouse, the forest shrew, the greater dwarf shrew, the lesser red musk shrew and the reddish-grey musk shrew are unknown entities and are forced to be ranked as "Data Deficient" as a precautionary measure. Based on 40 years of field observations and museum collecting, this author does not deem any of these as threatened species.

Hedgehogs "Near Threatened" are capable to withstand predation with their passive defence mechanisms. They became endangered directly as result of predation by humans and their pets, which is a consideration in this instance. Considering the undisturbed and extensive nature of the site, its continued presence is most likely *sans* predation by humans and domesticated carnivore pets.

The brown hyena is an extremely secretive scavenger, and its presence is often overlooked or population densities under-estimated. Records of occurrence are to this date still accrued in the rural areas outside Pretoria.

Vlei rats are not ranked as Red Data species but are here deemed 'sensitive' given their reliance on a moist and rank habitat close to water.

No other Red Data or sensitive species are deemed present on the site, either since the site is too disturbed, falls outside the distributional ranges of some species, or does not offer suitable habitat(s).

Table 1: The mammals which were observed or deduced to occupy the site
(Systematics and taxonomy as proposed by Bronner et.al [2003] and Skinner and Chimimba [2005])

	SCIENTIFIC NAME	ENGLISH NAME
*	*Elephantulus myurus*	Eastern rock elephant shrew
√	*Lepus saxatilis*	Scrub hare
?	*Pronolagus randensis*	Jameson's red rock rabbit
√	*Cryptomys hottentotus*	African mole rat
*	*Hystrix africaeaustralis*	Cape porcupine
DD*	*Graphiurus platyops*	Rock dormouse
*	*Graphiurus murinus*	Woodland dormouse
*	*Rhabdomys pumilio*	Four-striped grass mouse
*	*Mus minutoides*	Pygmy mouse
*	*Mastomys natalensis*	Natal multimammate mouse
*	*Mastomys coucha*	Southern multimammate mouse
?	*Thallomys paedulcus*	Acacia rat
?	*Thallomys nigricauda*	Black-tailed tree rat
*	*Aethomys ineptus*	Tete veld rat
*	*Aethomys namaquensis*	Namaqua rock mouse
*	*Otomys angoniensis*	Angoni vlei rat
*	*Otomys irroratus*	Vlei rat
*	*Gerbilliscus brantsii*	Highveld gerbil
*	*Saccostomus campestris*	Pouched mouse
*	*Dendromus melanotis*	Grey pygmy climbing mouse
*	*Dendromus mesomelas*	Brants' climbing mouse
*	*Dendromus mystacalis*	Chestnut climbing mouse
?	*Galago moholi*	South African galago
?	*Cercopithecus pygerythrus*	Vervet monkey
DD*	*Myosorex varius*	Forest shrew

	SCIENTIFIC NAME	ENGLISH NAME
DD?	*Suncus lixus*	Greater dwarf shrew
DD*	*Crocidura cyanea*	Reddish-grey musk shrew
DD*	*Crocidura hirta*	Lesser red musk shrew
NT√	*Atelerix frontalis*	Southern African hedgehog
?	*Taphozous mauritianus*	Mauritian tomb bat
?	*Sauromys petrophilus*	Flat-headed free-tailed bat
*	*Tadarida aegyptiaca*	Egyptian free-tailed bat
√	*Neoromicia capensis*	Cape serotine bat
√	*Scotophilus dinganii*	African yellow house bat
√	*Scotophilus viridis*	Greenish yellow house bat
NT√	*Parahyaena brunnea*	Brown hyena
*	*Felis silvestris*	African wild cat
*	*Genetta genetta*	Small-spotted genet
*	*Genetta tigrina*	SA large-spotted genet
*	*Cynictis penicillata*	Yellow mongoose
√	*Galerella sanguinea*	Slender mongoose
√	*Canis mesomelas*	Black-backed jackal
*	*Ictonyx striatus*	Striped polecat
√	*Tragelaphus strepsiceros*	Kudu
√	*Sylvicapra grimmia*	Common duiker
√	*Raphicerus campestris*	Steenbok

√ Definitely there or have a *high* probability to occur;
***** *Medium* probability to occur based on ecological and distributional parameters;
? *Low* probability to occur based on ecological and distributional parameters.

Red Data species rankings as defined in Friedmann and Daly's S.A. Red Data Book / IUCN (World Conservation Union) (2004) are indicated in the first column: CR= Critically Endangered, En = Endangered, Vu = Vulnerable, LR/cd = Lower risk conservation dependent, LR/nt = Lower Risk near threatened, DD = Data Deficient. All other species are deemed of Least Concern.

Table 2: Mammal species positively confirmed from the study site, observed indicators and habitat.

SCIENTIFIC NAME	ENGLISH NAME	OBSERVATION INDICATOR	HABITAT
L. saxatilis	Scrub hare	Faecal pellets	Short grassveld
G. sanguinea	Slender mongoose	Sight record	Universal
T. strepsiceros	Kudu	Faecal pellets	Savannah
S. grimmia	Common duiker	Faecal pellets	Grassveld

Scrub hares, slender mongooses and common duikers are widespread and common. They are reticent in habits or unique in habitat selection and are therefore seldom observed. They frequently co-exist with human settlements in peri-urban settings. The record of a kudu is probably of a vagrant and is not surprising considering the relatively undisturbed nature of the area and the several conservancies in the district.

6. FINDINGS AND POTENTIAL IMPLICATIONS

Species richness: The species richness is deemed to be relatively good for a largish site close to town and subjected to land-use practices not necessary in sympathy with nature conservation.
Endangered species: No threatened mammal species is singled out that require special consideration when considering the application to develop the site. The Red Data species identified as occupants are not decidedly endangered, and are widespread in the Subcontinent. It is suggested that all seven species operate at the apex of their respective food chains, as consequence of which their population

densities are lower than that of their prey species, and also since determining their densities require species-specific census techniques.

Sensitive species and/or areas (Conservation ranking): Most mammal species are terrestrial. Since this habitat type is over-utilized the conservation ranking of the site is rated as below-average and the permanent occurrence of discerning species is less likely.

Habitat(s) quality and extent: The quality of rupiculous habitat on the site itself is below par since nooks and crannies as refuge for rock-dwelling species are scarce, but are in prime condition along the summit of the isolated randjie on the property to the east of the study site. However, the highest aspects of the rocky rise where it connects to the prominent randjie at the boundary, justifies exclusion from future development. Arboreal habitat is sub-optimal given the low and dense canopy of trees, wetland habitat is minuscule and almost non-existent on the site, and the quality of the terrestrial habitat is abominable.

Impact on species richness and conservation: It is predicted that the proposed development will have a negative impact on species richness and conservation, but considering the sub-optimal condition of on-site habitats and related species richness and population health, this will not be of significance on a universal scale.

Connectivity: Rated as normal or near-normal, and migration can occur virtually unhindered.

Management recommendation: It would be ideal if new owners collectively subscribe to a nature conservation management plan, but the likelihood of that happening is remote. Any form of development or undue utilization along the highest point of the on-site rocky outcrops and especially of the ridge on the neighbouring property must be avoided, although the latter ideal does not fall within the jurisdiction of this report and proposed development constraints.

General: First impressions of the site as a vibrant biodiversity enclave are favourable, but closer inspection soon moderates such enthusiasm.

7. LIMITATIONS, ASSUMPTIONS AND GAPS IN INFORMATION

The Galago Environmental CC personnel are amply experienced to derive reasonably accurate species lists of a location such as this site. Specialists have access to ample data bases and information resources, and have earlier conducted numerous intensive field surveys which allow the extrapolation of habitat diversity and quality into species richness. In this instance an intensive mammal survey is deemed an expensive and fruitless experience with little chance of radically altering neither our primary data nor our recommendations.

Even though every care is taken to ensure the accuracy of this report, environmental assessment studies are limited in scope, time and budget. Discussions and proposed mitigations are to some extent made on reasonable and informed assumptions built on *bone fide* information sources, as well as deductive reasoning. Deriving a 100% factual report based on field collecting and observations can only be done over several years and seasons to account for fluctuating environmental conditions and migrations. Since environmental impact studies deal with dynamic natural systems additional information may come to light at a later stage. Galago Environmental can thus not accept responsibility for conclusions and mitigation measures made in good faith based on own databases or on the information provided at the time of the directive. This report should therefore be viewed and acted upon with these limitations in mind.

8. RECOMMENDED MITIGATION MEASURES

The following mitigation measures are proposed by the author:

- Should hedgehogs be encountered during the construction phase of the development, these should be relocated to natural grassland areas in the vicinity.
- The contractor must ensure that no fauna species are disturbed, trapped, hunted or killed during the construction phase. Conservation-orientated clauses should be built into contracts for construction personnel, complete with penalty clauses for non-compliance.
- The open space system (highest aspects of the rocky outcrop outliers of the easterly randjie) should be fenced off prior to selling adjoining properties or construction commencing (including site clearing and pegging). All construction-related impacts (including service roads, temporary housing, temporary ablution, disturbance of natural habitat, storing of equipment/building materials/vehicles or any other activity) should be excluded from the open space system. Access of vehicles to the open space system should be prevented and access of people should be controlled, both during the construction and operational phases. Movement of indigenous fauna should however be allowed (i.e. no solid walls, e.g. through the erection of palisade fencing).
- Ecological management plans developed for the study site should include management recommendations for neighbouring land, especially where correct management on adjacent land within 500 meters from the proposed development is crucial for the long-term persistence of sensitive species present on the development site (cf. the summit of the randjie on the adjoining property to the east)

The following mitigation measures were developed by GDARD (Directorate of Nature Conservation, 2012) and are applicable to the study site.

An appropriate management authority (e.g. the body corporate) that must be contractually bound to implement the Environmental Management Plan (EMP) and Record of Decision (ROD) during the operational phase of the development should be identified and informed of their responsibilities in terms of the EMP and ROD.

- All areas designated as sensitive in a sensitivity mapping exercise should be incorporated into an open space system. Development should be located on the areas of lowest sensitivity.
- The open space system should be managed in accordance with an Ecological Management Plan that complies with the *Minimum Requirements for Ecological Management Plans* and forms part of the EMP.
- The Ecological Management Plan should:
    - include a fire management programme to ensure persistence of grassland
    - include an on-going monitoring and eradication programme for all non-indigenous species, with specific emphasis on invasive and weedy species
    - include a comprehensive surface runoff and storm water management plan, indicating how all surface runoff generated as a result of the development (during both the construction and operational phases) will be managed (e.g. artificial wetlands / storm water and flood retention ponds) prior to entering any natural drainage system or wetland and how surface runoff will be retained outside of any demarcated buffer/flood zones and subsequently released to simulate natural hydrological conditions
    - ensure the persistence of all Red and Orange List species

- include a monitoring programme for all Red and Orange List species
- facilitate/augment natural ecological processes
- provide for the habitat and life history needs of important pollinators
- minimize artificial edge effects (e.g. water runoff from developed areas & application of chemicals)
- include a comprehensive plan for limited recreational development (trails, bird hides etc.) within the open space system
- include management recommendations for neighbouring land, especially where correct management on adjacent land within 500 meters from the proposed development is crucial for the long-term persistence of sensitive species present on the development site (cf. the summit of the randjie on the adjoining property to the east)
- result in a report back to the Directorate of Nature Conservation on an annual basis
- investigate and advise on appropriate legislative tools (e.g. the NEMA: Protected Areas Act 57 of 2003) for formally protecting the area (as well as adjacent land where it is crucial for the long-term persistence of sensitive species present on the development site)

9. CONCLUSIONS

The conservation condition of the site in terms of mammals is ranked as below average. It is recommended that eradicating obnoxious alien plants (viz. Queen of the Night) should be a priority on the site. The highest aspects of the andesite outcrops are considered marginally sensitive and justify conservation justification. No threatened mammal species is singled out that require special consideration in considering the application to develop the site. Habitat types represented on the site are inclined to be sub-optimal.

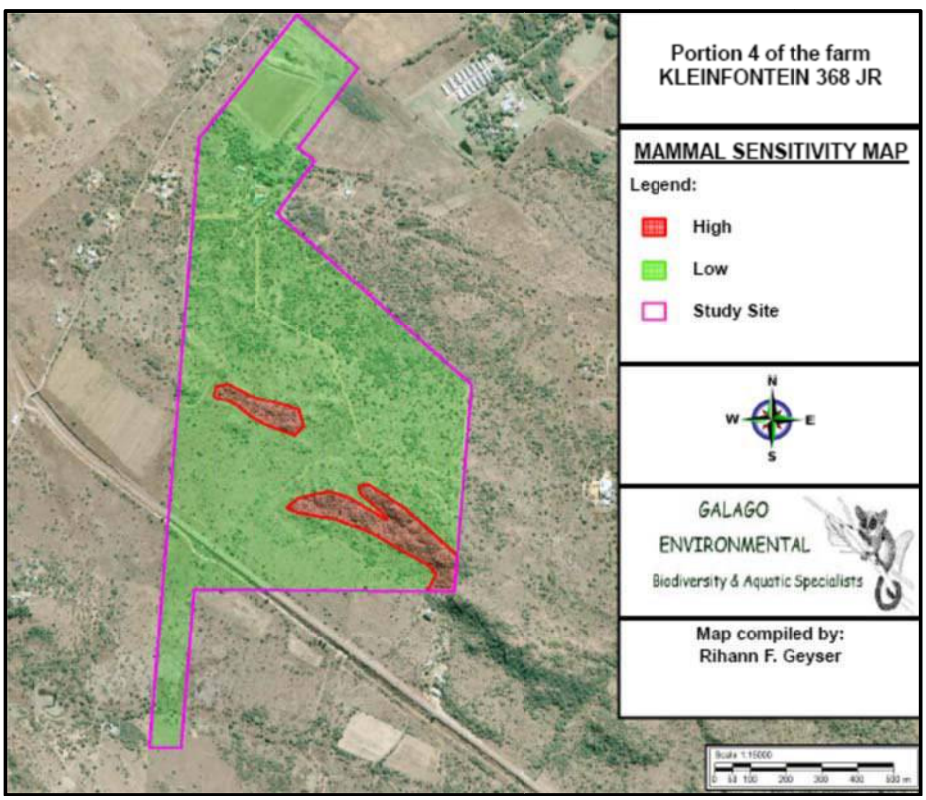

Figure 4: Mammal sensitivity map

The site itself is in an ecologically abused state and the proposed development will result in more environmental degradation and eventual loss of species richness. This is to be expected along the periphery of a large and growing metropolis. The fragmentation of the 90 hectares site and the associated ecological transformation does not raise undue concern considering the wide occurrence of all the listed species. From the perspective of extant mammals recorded from the site, the site is considered low sensitive.

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Avifaunal Habitat Assessment

of

PORTION 4 OF THE FARM KLEINFONTEIN 368 JR

February 2013

Report author: Mr. R.F. Geyser
Report verified/reviewed by: Dr. A.C. Kemp (Ph.D., Pr.Sci. Nat. (Zoology & Ecology))

VERIFICATION STATEMENT Mr R. Geyser is not registered as a Professional Natural Scientist with the S.A. Council for Natural Scientific Professions. This communication serves to verify that the bird report compiled by Mr R.F. Geyser has been prepared under my supervision, and I have verified the contents thereof.

Declaration of Independence: I, Alan Charles Kemp (4405075033081), declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them
- abide by the Code of Ethics of the S.A. Council for Natural Scientific Professions
- act as an independent specialist consultant in the field of zoology
- am subcontracted as specialist consultant by Galago Environmental CC for the proposed Portion 4 of the farm Kleinfontein 368 JR described in this report
- have no financial interest in the proposed development other than remuneration for work performed
- neither have nor will have any vested or conflicting interests in the proposed development
- undertake to disclose to Galago Environmental CC and its client, and the competent authority, any material information that has or may have the potential to influence decisions by the competent authority as required in terms of the Environmental Impact Assessment Regulations 2006

Dr. A.C. Kemp

DECLARATION OF INDEPENDENCE:

I, Rihann F. Geyser (690304 5248 084), declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them
- act as an independent specialist consultant in the field of zoology
- am subcontracted as specialist consultant by Galago Environmental CC for the proposed Portion 4 of the farm Kleinfontein 368 JR development described in this report
- have no financial interest in the proposed development other than remuneration for work performed
- neither have nor will have any vested or conflicting interests in the proposed development
- undertake to disclose to Galago Environmental CC and its client, and the competent authority, any material information that has or may have the potential to influence decisions by the competent authority as required in terms of the Environmental Impact Assessment Regulations 2006

Rihann F. Geyser

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1. INTRODUCTION

Galago Environmental CC. was appointed to undertake an avifaunal habitat survey for Portion 4 of the farm Kleinfontein 368 JR (hereinafter referred to as the study site), which is scheduled for residential development. This is in accordance with the 2010 EIA Regulations (No. R. 543-546, Department of Environmental Affairs and Tourism, 18 June 2010) emanating from Chapter 5 of the National Environmental Management Act, 1998 (Act No. 107 of 1998).

The primary objective was to determine the presence of Red Data avifaunal species and to identify suitable habitat for these species. Direct observations and published data apart, qualitative and quantitative habitat assessments were used to derive the presence / absence of Red Data avifaunal species. A list of avifaunal species likely to be affected by the new development is compiled.

2. SCOPE AND OBJECTIVES OF THE STUDY

- To qualitatively and quantitatively assess the significance of the avifaunal habitat components, and current general conservation status of the property;
- To comment on ecologically sensitive areas;
- To comment on connectivity with natural vegetation and habitats on adjacent sites;
- To provide a list of avifauna that occur or that are likely to occur, and to identify species of conservation importance;
- To highlight potential impacts of the proposed development on the avifauna of the study site, and
- To provide management recommendations to mitigate negative and enhance positive impacts should the proposed development be approved.

3. STUDY AREA

3.1 Locality

The study site, ±89.9888 ha in extent (excluding the 500 m extended study area), is situated within the 2528CD quarter degree grid cell (q.d.g.c.) and 2540_2825 pentad (SABAP2 protocol), south-west of the N4/R515 Rayton interchange, north-east of Pretoria and within Gauteng Province (25º48’40.99” S and 28º28’13.40” E). The study site is situated at an altitude of about 1 440 metres above sea level (m a.s.l.) sloping gradually downwards to the south.

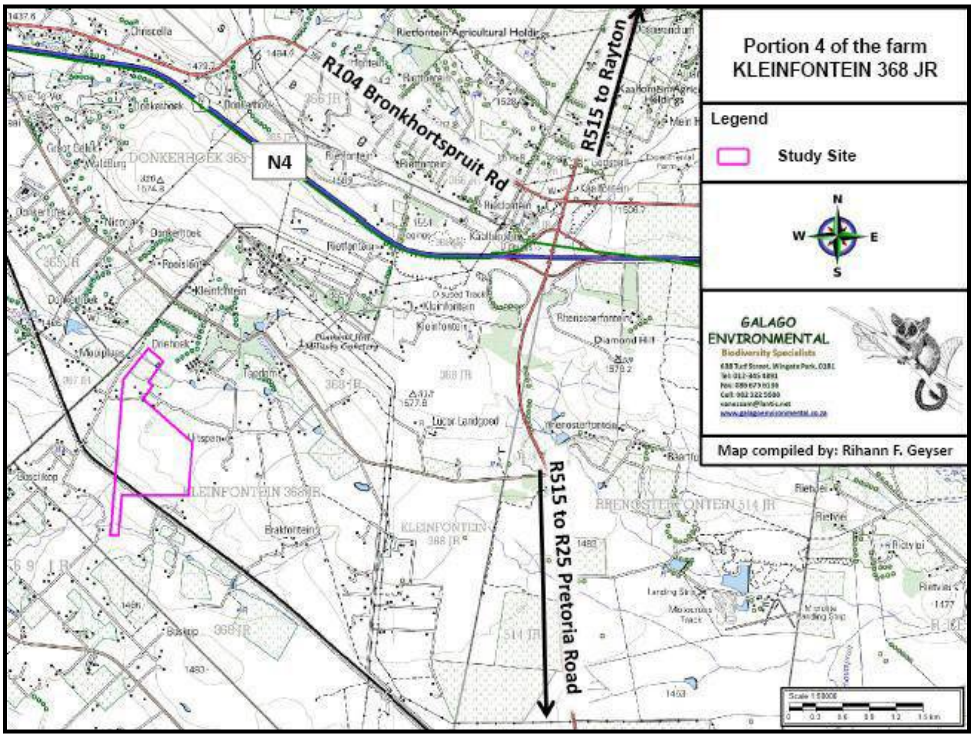

Figure 1: Locality map of the study area

3.2 Land Use

The largest portion of the study site consists of *Acacia* dominated woodland. The primary land use is grazing by livestock.

3.3 Biophysical Information

The study site is situated within two vegetation types which are as follows (Figure 2):

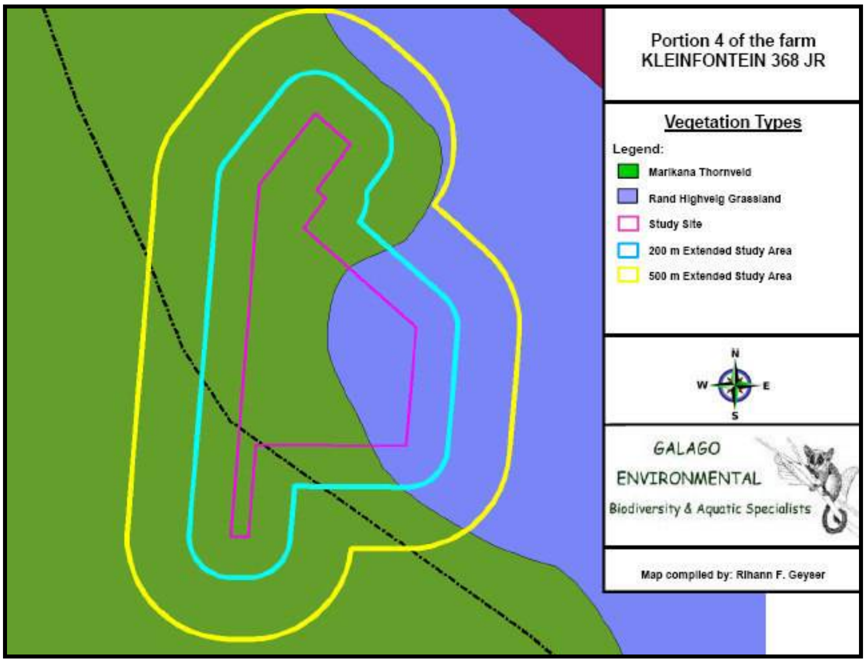

Figure 2: Vegetation types in which the study site is situated according to Mucina and Rutherford (2006).

3.3.1 Rand Highveld Grassland (Gm 11)

Vegetation type and landscape
The study site is situated within the Mesic Highveld Grassland Bioregion of the Grassland Biome and more specifically within the **Rand Highveld Grassland** (Gm 11) vegetation type according to Mucina and Rutherford (2006).

The landscape is highly variable with extensive sloping plains and a series of ridges slightly elevated over undulating surrounding plains. The vegetation is species-rich, wiry, sour grassland alternating with low, sour shrubland on rocky outcrops and steeper slopes. Most common grasses on the plains belong to the genera *Themeda, Eragrostis, Heteropogon* and *Elionurus*. A high diversity of herbs, many of which belong to the Asteraceae, is also a typical feature. (Mucina and Rutherford, 2006). Rocky hills and ridges carry sparse (savannoid) woodlands with *Protea caffra* subsp. *caffra*, *P. welwitschii*, *Acacia caffra* and *Celtis africana*, accompanied by a rich suite of shrubs among which the genus now *Searcia* (especially *S. magalismonata*) is prominent.

Climate
The study site is situated in a strongly seasonal summer-rainfall, warm-temperate region with very dry winters. The rainfall ranges between 570 and 800 mm of rainfall (average 654 mm) p/a and is slightly lower in the western regions. The incidence of frost is higher in the west (30-40 days) than in the east (10-35 days).

Conservation status of habitat
This habitat type is considered endangered and is poorly conserved (only 1%). Almost half has been transformed mostly by urbanisation, cultivation, plantations or dam-building. Cultivation may also have had an impact on an additional portion of the surface area of the unit where old lands currently classified as grasslands in land-cover classifications and poor land management has led to degradation of significant portions of the remainder of this unit. Scattered aliens (most prominently *Acacia mearnsii*) occur in about 7% of this unit. Only about 7% has been subjected to moderate to high erosion levels.

3.3.2 Marikana Thornveld (SVcb 6)

Vegetation type and landscape
The study site is situated within the Central Bushveld Bioregion of the Savanna Biome. More specifically within the **Marikana Thornveld** (SVcb 6) vegetation type according to Mucina and Rutherford (2006).

The Marikana Thornveld consists of open *Acacia karroo* dominated woodland growing in valleys on slightly undulating plains, and some lowland hills. Shrubs are denser along drainage lines, and on termitaria and rocky outcrops or other areas that are protected by fire (Mucina and Rutherford, 2006).

Climate
The study site is situated in a summer rainfall region with very dry winters. The rainfall varies between 600 and 750 mm. Frost occurs frequently in winter but less commonly on the ridges and hills. Temperatures vary between 32.8°C in summer (January) and -1.8°C in winter (July) (Mucina and Rutherford, 2006).

Conservation status of habitat
Marikana Thornveld is considered endangered (Mucina and Rutherford, 2006).

4. METHODS

An eight-hour site visit was conducted on 6 December 2013 to record the presence of avifaunal species associated with the habitat systems on and within 500 m surrounding the study site and to identify possible sensitive areas. During this visit the observed and derived presence of avifaunal species associated with the recognized habitat types of the study site, were recorded. This was done with due regard to the well recorded global distributions of Southern African avifauna, coupled to the qualitative and quantitative nature of recognized habitats.

4.1 Field Surveys

Avifaunal species were identified visually, using 10X42 Bushnell Legend binoculars and a 20X-60X Pentax spotting scope, and by call, and where necessary were verified from Sasol Birds of Southern Africa (Sinclair *et al*., 2011) and Southern African Bird Sounds (Gibbon, 1991).

The 500 m of adjoining properties was scanned for important avifaunal species and habitats.

During the site visit, avifaunal species were identified by visual sightings or aural records along random transect walks. No trapping or mist netting was conducted, since the terms of reference did not require such intensive work. In addition, avifaunal species were also identified by means of feathers, nests, signs, droppings, burrows or roosting sites. Locals were interviewed to confirm occurrences or absences of species.

4.2 Desktop Surveys

The presence of suitable habitats was used to deduce the likelihood of presence or absence of avifaunal species, based on authoritative tomes, scientific literature, field guides, atlases and databases. This can be done irrespective of season.

The likely occurrence of key avifaunal species was verified according to distribution records obtained during the Southern African Bird Atlas Project 1 (SABAP1) period from 1981 to 1993 (Harrison *et al.* 1997). Earlier records of only Red Data avifaunal species were obtained from the period between 1974 and 1987 according to Tarboton *et al.* (1987). The most recent avifaunal distribution data were obtained from the current SABAP2 project which commenced on 1 July 2007.

The occurrence and historic distribution of likely avifaunal species, especially all Red Data avifaunal species recorded for the q.d.g.c. 2528CD, were verified from SABAP1 (southern Africa Bird Atlas Project 1) data (Harrison *et al.* 1997), Tarboton *et al.* (1987) and the current SABAP2 project (SABAP2 data for the 2528CD q.d.g.c. and for the 2545_2825 pentad). The reporting rate for each avifaunal species likely to occur on the study site, based on Harrison *et al*. (1997), was scored between 0 – 100% and was calculated as follows: Total number of cards on which a species was reported during the Southern African Bird Atlas SABAP1 and, Red Data species only, the current SABAP2 project period X 100 ÷ total number of cards for the particular q.d.g.c. (Harrison *et al*., 1997) and pentad(s) (SABAP2). It is important to note that a q.d.g.c. (SABAP1 Protocol) covers a large area: for example, q.d.g.c. 2528CD covers an area of ±27 X 25 km (±693 km^2) (15 minutes of latitude by 15 minutes of longitude, 15' x 15') and a pentad (SABAP2 Protocol) and area of ±8 X 7.6 km (5 minutes of latitude by 5 minutes of longitude, 5' x 5') (Figure 3) and it is possible that suitable habitat will exist for a certain Red Data avifaunal species within this wider area surrounding the study site. However, the specific habitat(s) found on site may not suit the particular Red Data species, even though it has been recorded for the q.d.g.c. or pentad. For example, the Cape Vulture occurs along the Magaliesberg but will not favour the habitat found within the Pretoria CBD, both of which are in the same q.d.g.c. Red Data bird species were selected and categorised according to Barnes (2000).

2528CD

2545_2815	2545_2820	**2545_2825**
2550_2815	2550_2820	2550_2825
2555_2815	2555_2820	2555_2825

Figure 3: The 2528CD q.d.g.c. (15 minutes of latitude by 15 minutes of longitude, 15' x 15') is divided in nine smaller grids (5 minutes of latitude by 5 minutes of longitude, 5' x 5') of which each represent a pentad. The pentad in red represents the pentad in which the study site is situated.

An avifaunal biodiversity index (ABI), which gives an indication of the habitat system on the study site that will hold the richest avifaunal species diversity, was calculated as the sum of the probability of occurrence of bird species within a specific habitat system on site. For each species and habitat, the probability of occurrence was ranked as: 5 = present on site, 4 = not observed on site but has a high probability of occurring there, 3 = medium probability, 2 = low probability, 1 = very low probability and 0 = not likely to occur.

4.3 Specific Requirements

During the site visit, the study site was surveyed visually and its habitats assessed for the potential occurrence of priority Red Data avifauna, according to GDARD's requirements for Biodiversity Assessments, Version 2 (June 2012) and C-Plan Version 3.3 (2011), as well as for any other Red Data avifaunal species: The priority Red Data avifaunal species for Gauteng are (in Roberts VII order and nomenclature, Hockey *et al.* 2005):

- Half-collared Kingfisher (*Alcedo semitorquata*)
- African Grass-Owl (*Tyto capensis*)
- White-bellied Korhaan (*Eupodotis senegalensis*)
- Blue Crane (Anthropoides paradiseus)
- African Finfoot (Podica senegalensis)
- Cape Vulture (Gyps coprotheres)
- African Marsh-Harrier (*Circus ranivorus*)
- Martial Eagle (Polemaetus bellicosus)
- Secretarybird (Sagittarius serpentarius)
- Lesser Kestrel (*Falco naumanni*)
- Greater Flamingo (Phoenicopterus ruber)

- Lesser Flamingo (Phoenicopterus minor)
- White-backed Night-Heron (*Gorsachius leuconotus*)
- Black Stork (*Ciconia nigra*)

Particular reference was made to the occurrence of **African Grass-owl** (*Tyto capensis*) on or surrounding the study site.

5. RESULTS

Avifaunal Habitat Assessment:

Four major avifaunal habitat systems were identified on and within 500 m surrounding the study site. A short description of each habitat type follows, ranked from most to least important. Figure 4 illustrates the major habitat systems identified as likely to be used by bird species expected to occur on the study site.

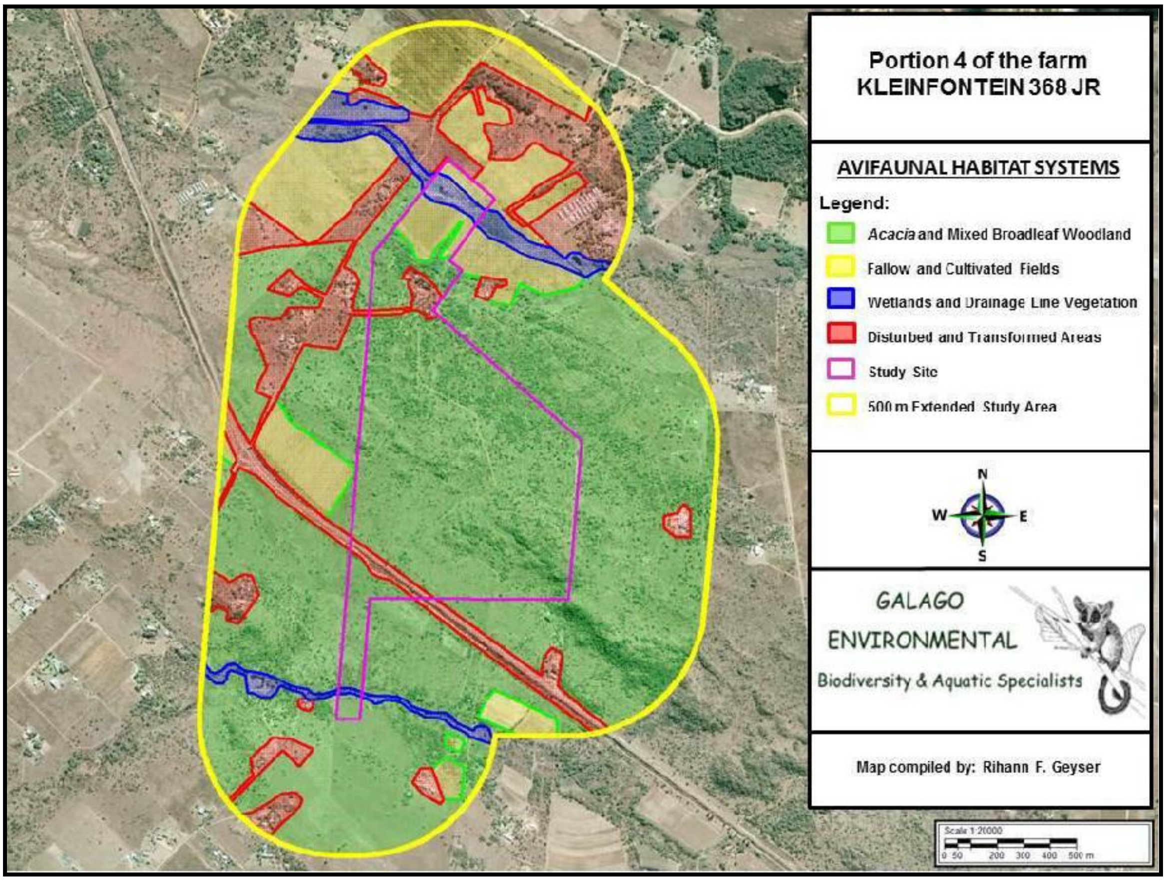

Figure 4: **Avifaunal species habitat systems identified on and within 500 m surrounding the study site.**

Wetlands and Drainage Lines:
3% (±12.8 ha) of the total surface area of the study site (including the 500 m extended study area) consists of drainage lines with wetland areas that have formed within these drainage lines.

The wetland on the study site consists of palustrine wetlands which are wetlands that have high ground water content, but which can often dry up during the dry winter season (Ginkel *et al.* 2011). Water accumulates during the wet summer rainy season and the plants that are adapted to these conditions grow in this habitat where obligate plants are often found.

Two drainage lines run through the study site with an east to west water flow. The first drainage line is situated within the northern most end of the study site and is overgrown by aquatic and semi- aquatic vegetation (Figure 5). This drainage line originates about 1.7 km to the east of the study site on the same farm Kleinfontein 368 JR, crosses the northern most boundary of the study site and later runs into the Pienaars River about 7.6 km north-west of the study site. This perennial drainage line does not have a specific name and is referred to as a furrow on the topographical maps. The other drainage line is situated at the southernmost end of the study site. This drainage line originates about 2.3 km southeast of the study site, crosses the southernmost area of the study site and then later forms the Pienaars River about 8 km northwest of the study site. A series of man-made impoundments have been constructed within these drainage lines, none of which are prominent on the study site.

Figure 5: Drainage line overgrown by reeds and other aquatic and semi-aquatic vegetation

This habitat system consists of static or slow-flowing water and is extensively covered with wetland vegetation such as rushes and reeds bordered with sedges and wetland grass. This habitat is ideal for such birds as warblers, weavers, bishops, crakes and moorhen that hunt and feed in the undergrowth at water level. Bishops and weavers, that use the rushes for roosting and breeding, and birds such as snipe and some duck species, that use the short march grass on the edge of the wetland for feeding and breeding, also prefer this habitat. This is mainly a permanent wetland area that probably never dies up completely except in times of drought. During the winter the water flow is limited to a shallow and narrow stream that meanders through the wetland area but during summer with high rainfall events, the meandering stream floods its banks creating a broad wetland stretch and create ideal habitat for wetland avifaunal species. In winter the aquatic and semi-aquatic vegetation becomes dry and brown due to limited water, cold and frost, or being burnt down completely and during summer the vegetation becomes lush and green especially after good rains. Some swallows and martins make use of this wetland habitat for roosting or forages over the wetland area.

Acacia dominated woodland:

68.8% (±293.031 ha) of the total surface area of the study site (including the 500 m extended study area) consists of *Acacia-Euclea crispa* dominated woodland. This woodland varies from dense woodland that grow in areas with deeper soils (Figure 6), to *Lippia-Microchloa* rocky outcrop vegetation (Figure 7), a ridge dominated by *Ziziphus-Diospyros whyteana* vegetation (Figure 8) and open woodland with scattered trees resembling *Acacia* savanna woodland (Figure 9).

Figure 6: Dense woodland

Figure 7: Vegetation on rocky outcrops

Figure 8: Ridge vegetation

Figure 9: Open woodland

This habitat will favour species typically associated with a dense woodland habitat and more specifically mixed broadleaf and *Acacia* woodland. This habitat generally include a great variety of arboreal passerines such as drongos, warblers, flycatchers, shrikes, sunbirds, waxbills and weavers and arboreal non-passerines such as doves, cuckoos, woodpeckers. Many of these species make use of the thorny nature of these trees to build their nests. *Acacia* trees generally attract many insects and in turn attract a good diversity of typical “Bushveld” bird species.

The open grassland systems on the study site forms part of the Marikana Thornveld vegetation type (Mucina and Rutherford, 2006) and can be described as open savanna grassland with scattered trees and shrubs.

The presence and abundance of bird species in this habitat will vary from season to season - lush and green in summer after summer rains and dry, brown, frosted or burnt during winter. The habitat favours ground-living bird species, such as lapwings, francolins, pipits, longclaws, larks and chats. These birds hunt for insects and/or breed on the ground, in burrows in the ground, or between the grasses. Weavers and widowbirds make use of such habitat for feeding on ripe seeds during late summer and early winter when the grass is not burnt, and widowbirds and cisticolas will also breed in the tall grass during summer. Species such as weavers and bishops that breed in the wetland habitat during summer will also make use of the open grassland habitat for feeding during winter after the grasses have seeded. Aerial feeding birds such as martins, swifts and swallows will also hunt for insects over the grasslands.

The rocky outcrops and ridge area will favour avifaunal species associated with rocky habitats, such as chats, wheatears, rock-thrushes and cisticolas, which favour the rocky nature of the area for breeding and to perch on to hunt for insects and detect predators. The trees and shrubs growing between these rocks will also provide food in the form of seeds and fruits to various avifaunal species, and shelter and nesting sites for many birds, especially passerines.

Fallow and cultivated fields:
14.92% (±63.5140 ha) of the total surface area of the study site (including the 500 m extended study area) consists of fallow and cultivated fields (Figure 10).

Figure 10: Cultivated fields

Seed-eating bird species (granivorous species), such as queleas, doves and bishops, largely benefit from maize, wheat and other cereals as their seeds supply food in large quantities. Many of these species flock in large numbers on to these fields and become pests to farmers, and weeds that grow on cropped and/or fallow fields also supply abundant seeds. The birds least likely to be affected by this transformation of grassland to cultivated fields are smaller species that are able to persist in small fragmented remnants of the undisturbed grassland habitat. The larger species with larger home ranges are most likely to show disrupted patterns of distribution (Barnes, 1998). The only species that will benefit from the current state of this disturbed habitat are bishops, widowbirds, waxbills, cisticolas and prinias, that forage and breed within the grass but feed among the plants that have been established on these cultivated fields. Aerial feeding birds such as martins, swifts and swallows will hunt for insects over these cultivated fields

The presence and abundance of avifaunal species in the fallow field habitat will vary from season to season - lush and green in summer after summer rains and dry, brown, frosted or burnt during winter. The habitat favours ground-living bird species, such as lapwings, francolins, pipits, longclaws, larks and chats. These birds hunt for insects and/or breed on the ground, in burrows in the ground, or between the grasses. Weavers and widowbirds make use of such habitat for feeding on ripe seeds during late summer and early winter when the grass is not burnt, and widowbirds and cisticolas will also breed in the tall grass during summer. Species such as weavers and bishops that breed in the wetland habitat during summer will also make use of the open grassland habitat for feeding during winter after the grasses have seeded. Aerial feeding birds such as martins, swifts and swallows will also hunt for insects over the grasslands.

Disturbed and Transformed area:
±13.22% (±56.3072 ha) of the total surface area of the study site (including the 500 m extended study area) is disturbed or has been transformed by past and present human activities. These areas mainly consists of houses surrounded by garden vegetation, areas overgrown by alien exotic vegetation (Figure 11), roads and railways and other areas of development such as chicken farms.

Figure 11: Alien exotic trees

Dense stands of exotic vegetation and plantations usually do not offer a large variation in plant communities and these trees are mostly unpalatable in their live stage for insect and game species. As a result, few insect-eating bird species will occur within these plantations. A number of nectar feeding species, such as white-eyes and sunbirds, will feed on the nectar produced by the flowers of these trees, and some birds also make nests in these trees.

A few species of bird of prey, which require tall trees for nest building, have increased their ranges due to the presence of these trees. These include Black and Ovambo Sparrowhawks.

No or little grass growth takes place on the ground where these trees grow and seed-eating bird species are few. The roots of these trees are known to extract large volumes of water daily and the surrounding ground is normally hard and dry.

The growth of black wattle on and surrounding the study site varies from single standing trees to dense woodland. In general, black wattle trees create a sterile environment and are not utilised by many bird species. Some of the most common species have however adapted to black wattle plantations, such as Cape White-eye, White-bellied Sunbird, Southern Boubou, Neddicky, Black-crowned Tchagra and Cape Robin. These birds either make use of the flowers for nectar-feeding or the trees for nest building or shelter.

Rural and suburban gardens have created an evergreen habitat for many bird species, where birds can hide, breed and forage for food. Natural predators such as snakes and smaller wild-cat species, which largely are persecuted by man, have been driven out of these areas, making it a relatively safe environment for birds apart from domestic cats and dogs. Many bird species have adapted to human-altered areas and these species are mainly the more common bird species found within southern Africa.

The ranges of some species have also increased and species not previously known to occur within Gauteng suburbs are now common, e.g. Grey-go-away Bird and Thick-billed Weaver. Some species, which are mainly alien species, are dependent on humans for survival such as the House Sparrow and Common Myna.

Large gardens, parks, sport fields and golf courses with open lawns also create ideal habitat for ground-feeding birds. These lawns are usually well watered and the ground soft, making it easy for birds that probe in the ground with their beaks in search of worms and other ground-living insects. There is usually water present, in the form of irrigation systems, ponds, manmade dams such as at golf courses, water features and/or swimming pools. The interest in birds among the public has grown and bird feeders are today a normal feature in most gardens. Certain exotic trees reach considerable heights in gardens, which allow birds to nest in them and thereby be protected from predators.

Fruit-bearing trees are also an important food supply for many bird species. Most of these bird species are not habitat specific and, due to their high level of adaptability, are also not threatened.

Observed and Expected Species Richness

Of the 341 avifaunal species recorded for the 2528CD q.d.g.c., 199 (58.3 %) are likely to occur on the study site and 67 (33.6 %) of these avifaunal species were actually observed on and within 500 m surrounding the study site.

The avifaunal biodiversity index (ABI) indicates that the largest avifaunal species diversity is likely to occur within the *Acacia* dominated woodland vegetation habitat system on and within 500m surrounding the study site, with an avifauna biodiversity index (ABI) of 646, followed by the disturbed and transformed area (ABI 489), fallow and cultivated fields (ABI 282) and wetlands and drainage lines (ABI 230).

The avifaunal species listed in Table 1 are in the species order according to *Roberts - Birds of Southern Africa* VIIth edition (Hockey *et al*, 2005). These comprise the 199 species that are likely to occur within the specific habitat systems on and within 500 m extended study area, with those actually observed in **bold**. This does not include overflying birds or rare vagrants. The reporting rate for each species is the percentage for the q.d.g.c. according to the SABAP 1 atlas (Harrison *et al.* 1997) and is represented by colour codes as follows: Yellow = Very Low, Light Orange = Low, Dark Orange = Medium and Red = High. Our habitat preference scores for each species are shown under the recognised habitat types on site: **WD = Wetlands and drainage lines, WW = *Acacia* dominated woodland, FC = Fallow and Cultivated Fields,** and **DD = Disturbed and Transformed,** with their possibility of occurrence in these specific habitats rated as 5 = present, 4 = High, 3 = Medium, 2 = Low, 1 = Very low, and 0 = Not likely to occur.

Table 1: Avifaunal species observed and that are likely to occur on the study site.

SCIENTIFIC NAMES	ENGLISH NAMES	R rate (%)*	HABITAT PREFERENCE			
		2528CD	WD	AW	FC	DD
Peliperdix coqui	Coqui Francolin	6	0	3	2	0
Dendroperdix sephaena	Crested Francolin	1	0	2	1	0
Pternistis swainsonii	**Swainson's Spurfowl**	19	3	5	5	3
Numida meleagris	**Helmeted Guineafowl**	52	2	5	5	4
Dendrocygna viduata	White-faced Duck	9	2	0	0	0
Alopochen aegyptiaca	Egyptian Goose	33	3	0	4	0
Anas sparsa	African Black Duck	8	2	0	0	0
Anas undulata	Yellow-billed Duck	16	3	0	1	0
Anas erythrorhyncha	Red-billed Teal	3	2	0	0	0
Indicator indicator	Greater Honeyguide	4	0	2	0	4
Indicator minor	Lesser Honeyguide	8	0	3	0	4
Prodotiscus regulus	**Brown-backed Honeybird**	1	0	5	0	3
Jynx ruficollis	Red-throated Wryneck	32	0	2	0	4
Campethera abingoni	Golden-tailed Woodpecker	9	0	4	0	2
Dendropicos fuscescens	Cardinal Woodpecker	18	0	4	0	4
Dendropicos namaquus	Bearded Woodpecker	1	0	3	0	2
Pogoniulus chrysoconus	Yellow-fronted Tinkerbird	7	0	3	0	2
Tricholaema leucomelas	**Acacia Pied Barbet**	20	0	5	0	4
Lybius torquatus	**Black-collared Barbet**	74	0	5	0	5
Trachyphonus vaillantii	**Crested Barbet**	91	0	5	0	5
Tockus nasutus	**African Grey Hornbill**	4	0	5	0	4
Upupa africana	African Hoopoe	80	0	4	0	4
Phoeniculus purpureus	**Green Wood-Hoopoe**	62	0	5	0	4
Rhinopomastus cyanomelas	Common Scimitarbill	11	0	2	0	0
Halcyon senegalensis	**Woodland Kingfisher**	7	0	5	0	4
Halcyon albiventris	**Brown-hooded Kingfisher**	22	0	5	0	4
Merops bullockoides	White-fronted Bee-eater	12	0	3	2	3
Merops pusillus	Little Bee-eater	2	0	2	0	0
Merops apiaster	European Bee-eater	18	0	4	3	2
Colius colius	White-backed Mousebird	3	0	2	0	2
Colius striatus	**Speckled Mousebird**	79	0	5	0	5
Urocolius indicus	Red-faced Mousebird	38	0	4	0	4
Clamator jacobinus	Jacobin Cuckoo	1	0	3	0	2
Clamator levaillantii	Levaillant's Cuckoo	<1	0	3	0	2
Cuculus solitarius	**Red-chested Cuckoo**	25	0	5	0	4
Cuculus clamosus	**Black Cuckoo**	9	0	5	0	3
Cuculus gularis	African Cuckoo	<1	0	3	0	0
Chrysococcyx klaas	**Klaas's Cuckoo**	6	0	5	0	2
Chrysococcyx caprius	**Diderick Cuckoo**	33	4	5	4	4
Centropus burchellii	Burchell's Coucal	64	4	4	0	4
Cypsiurus parvus	**African Palm-Swift**	22	3	5	4	5
Apus barbatus	African Black Swift	3	2	3	3	2
Apus affinis	**Little Swift**	33	2	5	5	4
Apus caffer	**White-rumped Swift**	24	2	5	5	4
Corythaixoides concolor	**Grey Go-away-bird**	55	0	5	0	5
Tyto alba	Barn Owl	7	1	3	2	4

SCIENTIFIC NAMES	ENGLISH NAMES	R rate (%)*	HABITAT PREFERENCE			
		2528CD	WD	AW	FC	DD
Bubo africanus	Spotted Eagle-Owl	**12**	1	3	2	4
Glaucidium perlatum	Pearl-spotted Owlet	**1**	0	3	0	1
Caprimulgus pectoralis	Fiery-necked Nightjar	**1**	0	2	1	0
Caprimulgus tristigma	Freckled Nightjar	**1**	0	1	0	0
Caprimulgus rufigena	Rufous-cheeked Nightjar	**<1**	0	2	1	0
Caprimulgus europaeus	European Nightjar	**1**	0	2	0	0
Columba livia	Rock Dove	**31**	1	2	3	4
Columba guinea	**Speckled Pigeon**	**57**	2	5	4	5
Columba arquatrix	African Olive-Pigeon	**1**	0	2	0	2
Streptopelia senegalensis	**Laughing Dove**	**96**	4	5	5	5
Streptopelia capicola	**Cape Turtle-Dove**	**81**	4	5	4	5
Streptopelia semitorquata	**Red-eyed Dove**	**22**	4	5	5	5
Turtur chalcospilos	Emerald-spotted Wood-Dove	**1**	0	2	0	0
Treron calvus	African Green-Pigeon	**1**	0	3	0	3
Amaurornis flavirostris	Black Crake	**3**	3	0	0	0
Gallinula chloropus	Common Moorhen	**10**	4	0	0	0
Fulica cristata	Red-knobbed Coot	**21**	2	0	0	0
Gallinago nigripennis	African Snipe	**1**	2	0	0	0
Tringa nebularia	Common Greenshank	**1**	2	0	0	0
Tringa glareola	Wood Sandpiper	**4**	3	0	0	0
Actitis hypoleucos	Common Sandpiper	**4**	2	0	0	0
Burhinus capensis	Spotted Thick-knee	**40**	0	4	4	4
Charadrius tricollaris	Three-banded Plover	**15**	2	0	1	0
Vanellus armatus	**Blacksmith Lapwing**	**39**	4	1	5	4
Vanellus senegallus	African Wattled Lapwing	**15**	2	1	4	3
Vanellus coronatus	Crowned Lapwing	**80**	0	3	4	4
Elanus caeruleus	Black-shouldered Kite	**48**	0	4	4	4
Circaetus pectoralis	Black-chested Snake-Eagle	**<1**	0	3	1	0
Accipiter minullus	Little Sparrowhawk	**1**	0	4	0	4
Accipiter ovampensis	Ovambo Sparrowhawk	**2**	0	2	0	4
Accipiter melanoleucus	Black Sparrowhawk	**1**	0	2	0	4
Buteo vulpinus	**Steppe Buzzard**	**4**	0	5	0	4
Aquila verreauxii	Verreauxs' Eagle	**<1**	0	2	0	0
Aquila pennatus	Booted Eagle	**<1**	0	1	0	0
Aquila wahlbergi	Wahlberg's Eagle	**1**	0	2	0	0
Falco rupicolus	Rock Kestrel	**1**	0	2	1	0
Falco biarmicus	Lanner Falcon (**NT**)	**1**	0	1	1	0
Falco peregrinus	Peregrine Falcon (**NT**)	**<1**	0	1	1	0
Ardea melanocephala	**Black-headed Heron**	**33**	0	4	5	2
Bubulcus ibis	**Cattle Egret**	**75**	3	5	5	4
Scopus umbretta	Hamerkop	**24**	3	0	0	2
Bostrychia hagedash	**Hadeda Ibis**	**91**	4	4	4	5
Oriolus larvatus	Black-headed Oriole	**20**	0	4	0	4
Dicrurus adsimilis	Fork-tailed Drongo	**35**	0	4	0	4
Terpsiphone viridis	**African Paradise-Flycatcher**	**18**	0	5	0	4
Nilaus afer	Brubru	**9**	0	4	0	2
Dryoscopus cubla	Black-backed Puffback	**18**	0	4	0	4
Tchagra senegalus	Black-crowned Tchagra	**25**	0	4	0	1
Tchagra australis	**Brown-crowned Tchagra**	**10**	0	5	0	2

SCIENTIFIC NAMES	ENGLISH NAMES	R rate (%)*	HABITAT PREFERENCE			
		2528CD	WD	AW	FC	DD
Laniarius ferrugineus	**Southern Boubou**	**36**	0	5	0	4
Laniarius atrococcineus	**Crimson-breasted Shrike**	**8**	0	5	0	3
Telophorus zeylonus	**Bokmakierie**	**68**	0	5	1	3
Telophorus sulfureopectus	**Orange-breasted Bush-Shrike**	**<1**	0	5	0	3
Malaconotus blanchoti	Grey-headed Bush-Shrike	**1**	0	3	0	2
Batis molitor	**Chinspot Batis**	**23**	0	5	0	1
Corvus albus	**Pied Crow**	**56**	0	5	4	4
Lanius collurio	Red-backed Shrike	**2**	0	4	2	1
Lanius minor	Lesser Grey Shrike	**1**	0	4	2	0
Lanius collaris	**Common Fiscal**	**93**	0	5	4	5
Corvinella melanoleuca	Magpie Shrike	**1**	0	2	3	1
Campephaga flava	**Black Cuckooshrike**	**6**	0	5	0	0
Parus niger	Southern Black Tit	**3**	0	4	0	0
Riparia paludicola	Brown-throated Martin	**7**	2	2	1	0
Hirundo rustica	**Barn Swallow**	**23**	5	5	5	4
Hirundo albigularis	White-throated Swallow	**24**	4	4	4	4
Hirundo dimidiata	Pearl-breasted Swallow	**2**	0	3	2	2
Hirundo cucullata	**Greater Striped Swallow**	**41**	4	5	5	4
Hirundo abyssinica	**Lesser Striped Swallow**	**33**	4	5	4	4
Hirundo semirufa	Red-breasted Swallow	**9**	0	3	0	1
Hirundo fuligula	Rock Martin	**13**	0	3	1	3
Delichon urbicum	Common House-Martin	**4**	0	3	2	2
Pycnonotus tricolor	**Dark-capped Bulbul**	**94**	3	5	1	5
Stenostira scita	Fairy Flycatcher	**5**	0	4	0	2
Sphenoeacus afer	Cape Grassbird	**15**	3	1	1	0
Sylvietta rufescens	Long-billed Crombec	**13**	0	4	0	0
Eremomela usticollis	**Burnt-necked Eremomela**	**pers obs**	0	5	0	0
Bradypterus baboecala	Little Rush-Warbler	**4**	3	0	0	0
Acrocephalus schoenobaenus	Sedge Warbler	**1**	2	0	0	0
Acrocephalus baeticatus	African Reed-Warbler	**2**	4	0	0	0
Acrocephalus palustris	**Marsh Warbler**	**<1**	0	5	2	4
Acrocephalus arundinaceus	Great Reed-Warbler	**1**	3	4	1	4
Acrocephalus gracilirostris	Lesser Swamp-Warbler	**9**	3	0	0	0
Phylloscopus trochilus	**Willow Warbler**	**9**	2	5	0	5
Turdoides jardineii	Arrow-marked Babbler	**18**	0	4	0	4
Parisoma subcaeruleum	**Chestnut-vented Tit-Babbler**	**24**	0	5	0	1
Sylvia borin	Garden Warbler	**2**	0	4	0	4
Zosterops virens	**Cape White-eye**	**78**	0	5	0	5
Cisticola aberrans	Lazy Cisticola	**4**	0	2	0	0
Cisticola chiniana	Rattling Cisticola	**7**	0	4	1	0
Cisticola tinniens	Levaillant's Cisticola	**12**	4	0	2	0
Cisticola fulvicapilla	**Neddicky**	**28**	0	5	3	4
Cisticola juncidis	**Zitting Cisticola**	**12**	3	4	5	3
Prinia subflava	Tawny-flanked Prinia	**32**	4	4	4	4
Prinia flavicans	**Black-chested Prinia**	**37**	1	5	4	3
Apalis thoracica	Bar-throated Apalis	**17**	0	4	0	2
Camaroptera brevicaudata	Grey-backed Camaroptera	**<1**	0	3	0	2
Mirafra africana	Rufous-naped Lark	**16**	0	3	2	1
Calendulauda sabota	Sabota Lark	**1**	0	2	0	1

SCIENTIFIC NAMES	ENGLISH NAMES	R rate (%)*	HABITAT PREFERENCE			
		2528CD	WD	AW	FC	DD
Psophocichla litsitsirupa	Groundscraper Thrush	8	0	2	2	4
Turdus libonyanus	Kurrichane Thrush	14	0	4	0	4
Turdus smithi	**Karoo Thrush**	84	0	5	0	5
Bradornis mariquensis	Marico Flycatcher	2	0	3	0	0
Melaenornis pammelaina	Southern Black Flycatcher	2	0	4	0	4
Sigelus silens	**Fiscal Flycatcher**	46	0	5	0	4
Muscicapa striata	**Spotted Flycatcher**	7	0	5	4	4
Cossypha caffra	**Cape Robin-Chat**	78	3	5	3	5
Cossypha humeralis	**White-throated Robin-Chat**	9	0	5	0	1
Cercotrichas leucophrys	**White-browed Scrub-Robin**	8	0	5	0	1
Cercotrichas paena	Kalahari Scrub-Robin	1	0	2	0	0
Saxicola torquatus	African Stonechat	20	4	0	4	0
Cercomela familiaris	Familiar Chat	5	0	2	2	2
Onychognathus morio	Red-winged Starling	10	0	3	0	3
Lamprotornis nitens	Cape Glossy Starling	33	0	4	2	4
Cinnyricinclus leucogaster	Violet-backed Starling	5	0	4	0	3
Spreo bicolor	Pied Starling	8	0	1	1	0
Acridotheres tristis	**Common Myna (INT)**	7	2	4	4	5
Chalcomitra amethystina	**Amethyst Sunbird**	51	0	5	1	4
Cinnyris talatala	**White-bellied Sunbird**	59	0	5	1	4
Cinnyris mariquensis	Marico Sunbird	2	0	3	0	1
Ploceus capensis	Cape Weaver	33	3	2	2	4
Ploceus velatus	**Southern Masked-Weaver**	84	5	5	4	5
Ploceus cucullatus	Village Weaver	6	2	2	1	2
Quelea quelea	Red-billed Quelea	4	4	4	4	2
Euplectes orix	Southern Red Bishop	44	4	3	4	4
Euplectes albonotatus	**White-winged Widowbird**	27	5	3	5	3
Euplectes ardens	Red-collared Widowbird	28	4	3	4	3
Euplectes progne	Long-tailed Widowbird	18	2	1	3	0
Amblyospiza albifrons	Thick-billed Weaver	<1	4	2	2	4
Sporaeginthus subflavus	Orange-breasted Waxbill	7	3	1	2	0
Ortygospiza atricollis	**African Quailfinch**	4	4	5	3	0
Amadina erythrocephala	Red-headed Finch	1	1	4	2	4
Estrilda astrild	**Common Waxbill**	20	5	4	2	4
Granatina granatina	Violet-eared Waxbill	<1	1	2	0	2
Uraeginthus angolensis	Blue Waxbill	4	1	4	0	4
Pytilia melba	**Green-winged Pytilia**	1	1	5	0	2
Lagonosticta senegala	Red-billed Firefinch	3	1	3	0	3
Lagonosticta rhodopareia	Jameson's Firefinch	3	4	4	3	3
Spermestes cucullatus	Bronze Mannikin	30	3	4	4	4
Vidua macroura	Pin-tailed Whydah	24	4	4	4	4
Vidua paradisaea	Long-tailed Paradise-Whydah	6	0	3	3	3
Vidua chalybeata	Village Indigobird	1	1	3	1	2
Vidua funerea	Dusky Indigobird	1	1	1	1	2
Passer domesticus	House Sparrow	71	0	0	0	4
Passer melanurus	Cape Sparrow	93	2	4	4	4
Passer diffusus	**Southern Grey-headed Sparrow**	28	2	5	4	5
Motacilla capensis	Cape Wagtail	70	4	0	3	4
Macronyx capensis	Cape Longclaw	20	2	2	4	0

SCIENTIFIC NAMES	ENGLISH NAMES	R rate (%)*	HABITAT PREFERENCE			
		2528CD	WD	AW	FC	DD
Anthus cinnamomeus	African Pipit	8	0	4	4	3
Crithagra mozambicus	Yellow-fronted Canary	15	3	4	3	4
Crithagra atrogularis	Black-throated Canary	30	3	4	4	4
Crithagra gularis	Streaky-headed Seedeater	23	0	4	1	4
Emberiza tahapisi	**Cinnamon-breasted Bunting**	7	0	5	0	0
Emberiza flaviventris	**Golden-breasted Bunting**	1	1	5	0	0
	Avifaunal biodiversity Index:		230	646	282	489

*The reporting rate is calculated as follows: Total number of cards on which a species was reported X 100 ÷ total number of cards for a particular quarter degree grid cell. **INT** = Introduced or alien birds species to Southern Africa.

Red Data Species Categories for the birds (Barnes, 2000)
RE = Regionally extinct, **CR** = Critically Endangered **EN** = Endangered, **VU** = Vulnerable, **NT** = Near-threatened.

The Avifaunal biodiversity index gives an indication of which habitat will hold the richest avifaunal diversity on and within 500 m surrounding the study site. The colour codes for each species are represented as follows: The colour codes for each species are represented as follows: Yellow = Very Low, Light Orange = Low, Dark Orange = Medium and Red = High. The likelihood of occurrence of each species in the specific habitat systems on the study site are as follow: 5 = present, 4 = High, 3 = Medium, 2 = Low, 1 = very low, and 0 = Not likely to occur.

Threatened and Red Listed Bird Species

The following Red Data avifaunal species were recorded for the 2528CD q.d.g.c. according to Tarboton *et al* (1987)*,* the SABAP1 data (Harrison *et al.* 1997), the SABAP2 data for the 2528CD q.d.g.c. and more specifically the 2545_2825 pentad (Table 2).

Table 2: Red Data avifaunal species recorded for the 2528CD q.d.g.c.

SCIENTIFIC NAMES	ENGLISH NAMES	Tarboton	Reporting Rate (%)*		
			SABAP1	SABAP2	Pentad
Alcedo semitorquata	Half-collared Kingfisher (**NT**)	**(T)**	**<1**	**1.2**	0
Tyto capensis	African Grass-Owl (**VU**)	**(Tb)**	**1**	**0.9**	0
Neotis denhami	Denham's Bustard (**VU**)	**(T)**	0	0	0
Eupodotis caerulescens	Blue Korhaan (**NT**)	**(T)**	**<1**	0	0
Eupodotis senegalensis	White-bellied Korhaan (**VU**)	**(T)**	**<1**	**0.7**	0
Anthropoides paradiseus	Blue Crane (**VU**)	**(Tb)**	**3**	**Incd**	0
Podica senegalensis	African Finfoot (**VU**)	**(T)**	0	0	0
Crex crex	Corn Crake (**VU**)	0	**<1**	0	0
Rostratula benghalensis	Greater Painted-snipe (**NT**)	0	**<1**	**0.3**	0
Glareola nordmanni	Black-winged Pratincole (**NT**)	**(T)**	**<1**	0	0
Sterna caspia	Caspian Tern (**NT**)	0	**<1**	0	0
Gyps coprotheres	Cape Vulture (**VU**)	**(T)**	0	**Incd**	0
Aegypius tracheliotus	Lappet-faced Vulture (**VU**)	**(T)**	0	0	0
Terathopius ecaudatus	Bateleur (**VU**)	**(T)**	0	0	0
Circus ranivorus	African Marsh-Harrier (**VU**)	**(T)**	0	**0.2**	0
Circus macrourus	Pallid Harrier (**NT**)	0	0	**0.2**	0
Aquila rapax	Tawny Eagle (**VU**)	0	**<1**	0	0
Aquila ayresii	Ayres's Hawk-Eagle (**NT**)	0	**<1**	**0.1**	**5.9**
Polemaetus bellicosus	Martial Eagle (**VU**)	**(Tb)**	0	**0.1**	0
Sagittarius serpentarius	Secretarybird (**NT**)	**(T)**	**2**	**4.8**	0
Falco naumanni	Lesser Kestrel (**VU**)	**(T)**	**1**	**0.7**	0
Falco biarmicus	Lanner Falcon (**NT**)	**(Tb)**	**1**	**1.9**	0
Falco peregrinus	Peregrine Falcon (**NT**)	0	**<1**	**0.8**	0
Phoenicopterus ruber	Greater Flamingo (**NT**)	**(T)**	**<1**	**0.8**	0

SCIENTIFIC NAMES	ENGLISH NAMES		Reporting Rate (%)*		
		Tarboton	SABAP1	SABAP2	Pentad
Phoenicopterus minor	Lesser Flamingo (**NT**)	0	0	**0.1**	0
Mycteria ibis	Yellow-billed Stork (**NT**)	**(T)**	0	**0.2**	0
Anastomus lamelligerus	African Openbill (**NT**)	0	0	**0.2**	0
Ciconia nigra	Black Stork (**NT**)	0	**<1**	0	0
Mirafra cheniana	Melodious Lark (**NT**)	**(Tb)**	0	**1.1**	**5.9**
	TOTAL:	**19**	**17**	**19**	**2**

*The reporting rate is calculated as follows: Total number of cards on which a species was reported X 100 ÷ total number of cards for a particular quarter degree grid cell. T = Avifaunal species recorded as present (light blue) and Tb = bird species recording as breeding (dark blue) for the q.d.g.c. according to Tarboton *et al* (1987). Bird species with both reporting rates and T or Tb were recorded for the q.d.g.c. according to both Harrison *et al.* (1997) and Tarboton *et al.* (1987). The colour codes for each species are represented as follows: The colour codes for each species are represented as follows: Yellow = Very Low, Light Orange = Low, Dark Orange = Medium and Red = High. Incd = Incidental sighting

Red Data Species Categories for the birds (Barnes, 2000)
RE = Regionally extinct, **CR** = Critically Endangered **EN** = Endangered, **VU** = Vulnerable, **NT** = Near-threatened.

A total of 29 Red Data avifaunal species have been recorded within the 2528CD q.d.g.c. Four of these species appear to have disappeared from the area or were not subsequently recorded for this q.d.g.c. during the time of the southern African Bird Atlas project (SABAP1). It is unlikely that they will ever recur in this region again except maybe on rare occasions in or in protected areas. Five of these species used to breed within the said q.d.g.c (Tarboton et al, 1987) and only one, the African Grass-Owl, have been recorded as a breeding species for the q.d.g.c. during the period of SABAP1. This decline in breeding species is probably due to the large extent of development that took place during a short space of time. Blue Cranes and Secretarybirds indicate a low reporting rate while all the rest of the Red Data avifaunal species indicate a very low reporting rate. Nineteen Red Data avifaunal species were recorded for the same q.d.g.c. according to the SABAP2 data. This is probably due to the occurrence of these species within the Rietvlei Nature Reserve which is situated within the same q.d.g.c. and where suitable habitat can be found for these species. Ayres' Eagle was probably recorded mainly in eastern Pretoria where Feral Pigeons are common. Only two Red Data avifaunal species were recorded for the 2545_2825 pentad and none were recorded during the survey on the study site (Table 5).

Summary of the Red Data bird species

Table 3 provides a list of the Red Data avifaunal species recorded for the 2528CD q.d.g.c. according to Harrison *et al.* (1997) and the current SABAP2 project and an indication of their likelihood of occurrence on the study site based on habitat and food availability.

Table 3: Red Data avifaunal species assessment for the 2528CD q.d.g.c.

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
*Alcedo semitorquata** (Half-collared Kingfisher) (**NT**)	None on site: Requires fast-flowing streams, rivers and estuaries, usually with dense marginal vegetation (Maclean, 1993), especially perennial streams and smaller rivers with overhanging riparian vegetation on their banks. Nests in sand/earth banks (Tarboton *et al.* 1987) and requires riverbanks in which to excavate nest tunnels (Harrison *et al.* 1997a). Most typically occurs along fast-flowing streams with clear water and well-wooded riparian growth, often near rapids. It most frequently favours broken escarpment terrain and requires at least 1 km	Highly unlikely Due to a lack of suitable river and riparian vegetation for foraging and breeding purposes.

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
	up and down stream of undisturbed river and riparian vegetation while breeding. It occurs from sea-level to 2000 m.a.s.l. in southern Africa. Usually perches low down on the banks of rivers and streams, often on exposed roots, as well as exposed rock and low overhanging tree branches.	
*Tyto capensis** (African Grass-Owl) (**VU**)	None on site: Occurs predominately in rank grass, typically but not always at fairly high altitudes. Breeds mainly in permanent and seasonal vleis, which it vacates while hunting or during post-breeding although it will sometimes breed in any area of long grass, sedges or even weeds (Van Rooyen, pers comm.) and not necessarily associated with wetlands (Tarboton *et al.* 1987) although this is more the exception than the rule. Foraging mainly confined to tall grassland next to their wetland vegetation and rarely hunts in short grassland, wetlands or croplands nearby (Barnes, 2000). Mainly restricted to wet areas (marshes and vleis) where tall dense grass and/or sedges occur. Prefers permanent or seasonal vleis and vacates the latter when these dried up or are burnt. Roosts and breeds in vleis but often hunt elsewhere e.g. old lands and disturbed grassland although this is suboptimal habitat conditions (Tarboton *et al.* 1987). May rarely occur in sparse *Acacia* woodland where patches of dense grass cover are present (Harrison *et al.* 1997a).	Highly unlikely No suitable breeding, roosting and foraging habitat were identified on and surrounding the study site
Eupodotis caerulescens (Blue Korhaan) (**VU**)	None on site: Occurs in flat undulating terrain in grassland and Nama Karoo, where rainfall 300-1 000 mm /a. Often on damp ground; sometimes attracted to burnt areas. Favours short vegetation; 61 % of 141 groups where vegetation ≤ belly height. At Wakkerstroom, Mpumalanga, abundance positively correlated with altitude, flat topography and burnt grassland. In Nama Karoo, 96% of 88 groups in natural vegetation, 2% in fallow fields, 1% in cultivated grass and pastures and 1% in lucerne pastures. At De Aar, Northern Cape, near western edge of range, only found close to large Lucerne fields. Remains < 1 km from water (Hockey *et al.*, 2005).	Highly unlikely Due to a lack of suitable habitat. Localised in SE Gauteng were common. Occasional visitor to most other areas in Gauteng. (Marais & Peacock, 2008)
*Eupodotis senegalensis** (White-bellied Korhaan) (**VU**)	None on site: Occurs in fairly tall, dense grassland, especially sour and mixed grassland, in open or lightly wooded, undulating to hilly country. In winter, occasionally on modified pastures and burnt ground (Harrison *et al.* 1997a).	Highly unlikely Due to a lack of suitable open grassland habitat.
*Anthropoides paradiseus** (Blue Crane) (**VU**)	None on site: Midlands and highland grassland, edge of karoo, cultivated land and edges of vleis (Maclean, 1993). Nests in both moist situations in vleis which have short grass cover and in dry sites far from water, usually exposed places such as on hillsides; forages in grassland and cultivated and fallow lands; roosts communally in the shallow water of pans and dams (Tarboton *et al.* 1987). Short dry grassland, being more abundant and evenly disturbed in the eastern "sour" grassland, where natural grazing of livestock is the predominant land use. Prefers to nest in areas of open grassland	Highly unlikely Due to a lack of suitable habitat. Localised but common in the south-eastern Gauteng (Marais & Peacock, 2008)

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
	(Barnes, 2000) In the fynbos biome it inhabit cereal croplands and cultivated pastures and avoids natural vegetation. By contrast, it is found in natural vegetation in the Karoo and grassland biomes, but it also feeds in crop fields (Harrison *et al*. 1997a).	
Crex crex (Corn Crake) (**VU**)	None on site: Rank grassland and savanna, dry grassland bordering marshes and streams, including long grass areas of seasonally flooded grassland and, occasionally, wet clay patches and soft mud fringing ponds. In Acacia savanna, occurs mostly where trees are small and scattered, and grass dense often tussocky, 0.7 – 1.5 m tall (Hockey *et al*. 2005).	Highly unlikely Due to a lack of suitable habitat. Rare summer visitor. Widespread but elusive (Marais & Peacock, 2008).
Rostratula benghalensis (Greater Painted-snipe) (**NT**)	None on site: Dams, pans and marshy river flood plains. Favours waterside habitat with substantial cover and receding water levels with exposed mud among vegetation, departing when water recedes beyond the fringes of vegetation. Rare in seasonally flooded grassland and palm savanna (Hockey *et al*. 2005).	Highly unlikely Due to a lack of suitable habitat Uncommon visitor and resident (Marais & Peacock, 2008)
Glareola nordmanni (Black-winged Pratincole) (**NT**)	None on site: A non-breeding overland migrant to southern Africa. In southern Africa winter quarters, prefers open grassland, edges of pans and cultivated fields, but most common in seasonally wet grasslands and pan systems. Attracted to damp ground after rains, also tp agricultural activities, including mowing and ploughing, and to newly flooded grassland (Hockey *et al*. 2005).	Highly unlikely Due to a lack of suitable habitat. Erratic summer migrant sometimes in large flocks (Marais & Peacock, 2008)
Sterna caspia (Caspian Tern) (**NT**)	None on site: Occurs along coast, mostly in sheltered bays and estuaries. Inland, at large water bodies, both natural and man-made, with preference for saline pans and large impoundments. Coastal breeding habitat primarily offshore islands, but with increasing use of sandy beaches and islands in saltworks, where protection is offered. Inland, breeds on small, low islets in pans and dams (Hockey *et al*. 2005).	Highly unlikely Due to a lack of suitable foraging and breeding habitat. Non-breeding winter visitor to large water bodies in Gauteng (Marais & Peacock, 2008)
*Gyps coprotheres** (Cape Vulture) (**VU**)	They mostly occur in mountainous country, or open county with inselbergs and escarpments; less commonly as visitors to savannah or desert (Maclean, 1993). Forage over open grassland, woodland and agricultural areas; usually roosts on cliffs, but will also roost on trees and pylons (Barnes, 2000). It is reliant on tall cliffs for breeding but it wanders widely away from these when foraging. It occurs and breeds from sea level to 3 100 m.a.s.l. Current distribution is closely associated with subsistence communal grazing areas characterised by high stock losses and low use of poisons and, to a lesser extent, with protected areas (Harrison *et al*. 1997a), but their presence is ultimately dependent on the availability of food.	Highly unlikely Due to a lack of suitable foraging and breeding habitat. Breeds in Magaliesberg; uncommon wanderer elsewhere; mostly SW & NW Gauteng (Marais & Peacock, 2008)
*Circus ranivorus** (African Marsh-Harrier) (**VU**)	None on site: Almost exclusively inland and coastal wetlands (Hockey *et al*. 2005). Wetland and surrounding grasslands. Most highveld wetlands > 100 ha support a breeding pair (Tarboton & Allan	Highly unlikely There are no suitable foraging, breeding or

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
	1984). Nests in extensive reed beds often nigh above water. Forages over reeds, lake margins, floodplains and occasionally even woodland. Almost entirely absent from areas below 300 mm of rainfall (Harrison et al., 1997a). Marsh, vlei, grassland (usually near water); may hunt over grassland, cultivated lands and open savanna (Maclean, 1993). Dependant on wetlands, particularly permanent wetlands for breeding, roosting and feeding. May utilise small wetlands 1-2 ha in extent for foraging, but larger wetlands are required for breeding (Barnes, 2000).	roosting habitat for this species on the study site. Declining resident of large vleis, occurs mainly in south-eastern Gauteng (Marais & Peacock, 2008)
Circus macrourus Pallid Harrier (**NT**)	None on site: Grasslands associated with open pans or flood plains; also croplands.	Highly unlikely There are no suitable foraging, breeding or roosting habitat for this species on the study site.
Aquila rapax (Tawney Eagle) (**VU**)	None on site: Occurs in lightly wooded savanna; absent from dense forests and highlands. Able to colonise Nama Karoo and treeless grasslands by breeding on pylons and alien trees (Hockey *et al.* 2005).	Highly unlikely There are no suitable foraging, breeding or roosting habitat for this species on the study site. Uncommon. NW & NE Gauteng (Marais & Peacock, 2008)
Aquila ayresii (Ayres's Hawk-Eagle) (**NT**)	None on site: Non-breeding summer visitor to South Africa, favouring dense woodland and forest edge, often in hilly country. Regular in larger northern cities and towns (Johannesburg, Pretoria, Mokopane/Pietersburg), where it often roosts in *Eucalyptus* stands or other tall trees within its prime distribution range (Hockey *et al.* 2005).	Highly unlikely There is no suitable habitat for this species on the study site. Rare in Gauteng (Marais & Peacock, 2008)
*Polemaetus bellicosus** (Martial Eagle) (**VU**)	None on site: Tolerates a wide range of vegetation types, being found in open grassland, scrub, Karoo, agricultural lands and woodland, It relies on large trees (or electricity pylons) to provide nest sites (Barnes, 2000) as well as windmills and even cliffs in treeless areas . It occurs mainly in flat country and is rarer in mountains, and it also avoids extreme desert, and densely wooded and forested areas (Harrison *et al.* 1997a & Barnes, 2000).	Highly unlikely Due to a lack of suitable habitat and disturbance cause by the large scale development surrounding the study site. Uncommon local resident (Marais & Peacock, 2008)
*Sagittarius serpentarius** (Secretarybird) (**NT**)	None on site: Open grassland with scattered trees, shrubland, open *Acacia* and *Combretum* savanna (Hockey *et al.* 2005). Restricted to large conservation areas in the region. Avoids densely wooded areas, rocky hills and mountainous areas (Hockey *et al.* 2005 & Barnes, 2000). Requires	Highly unlikely Due to a lack of suitable habitat. Uncommon in open areas within Gauteng (Marais & Peacock,

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
	small to medium-sized trees with a flat crown for nesting, and often roosts in similar locations. Nesting density only about 150 km^2/pair (n = 4, Kemp, 1995).	2008)
*Falco naumanni** (Lesser Kestrel) (**VU**)	None on site: Non-breeding Palaearctic migrant. Forages preferentially in pristine open grassland but also hunts in converted grassland such as small scale pastures provided the conversion is not as total as in plantation forestry or in areas of consolidated agricultural monoculture (Barnes, 2000; Hockey *et al.* 2005) such as maize, sorghum, peanuts, wheat, beans and other crops (Tarboton & Allan 1984) where they hunt for large insects and small rodents, but avoid wooded areas except on migration. They roost communally in tall trees, mainly *Eucalyptus*, in urban areas (Barnes, 2000), often in towns or villages, but also in farm lands (pers. obs). Favour a warm, dry, open or lightly wooded environment, and are concentrated in the grassy Karoo, western fringes of the grassland biome and southeast Kalahari. Generally avoids foraging in transformed habitats but occurs in some agricultural areas, including croplands, in fynbos and renosterveld of the Western Cape (Hockey *et al.* 2005). Large numbers congregate in sweet and mixed grasslands of the highveld regions.	Highly unlikely Due to a lack of suitable habitat. Localised summer migrant (Marais & Peacock, 2008)
*Falco biarmicus** (Lanner Falcon) (**NT**)	None on site: Most frequent in open grassland, open or cleared woodland, and agricultural areas. Breeding pairs generally favour habitats where cliffs are available as nest and roost sites, but will use alternative sites such as trees, electricity pylons and building ledges if cliffs are absent (Hockey *et al.* 2005). Mountains or open country, from semi desert to woodland and agricultural land, also cities (Maclean, 1993), even on forest-grassland ecotones. Generally a cliff nesting species and its wider distribution is closely associated with mountains with suitable cliffs. Able to breed on lower rock faces than Peregrine Falcon *Falco peregrinus* and also utilises the disused nests of other species, such as crows, other raptors and storks, on cliffs, in trees and on power pylons, and also quarry walls (Tarboton *et al.* 1987). Generally prefers open habitats e.g. alpine grassland and the Kalahari, but exploits a wide range of habitats – grassland, open savanna, agricultural lands, suburban and urban areas, rural settlements – in both flat and hilly or mountainous country. Also breeds in wooded and forested areas where cliffs occur (Harrison *et al.* 1997a).	Highly unlikely Due to a lack of suitable breeding habitat, could hunt over the study site on rare occasions. Uncommon resident in open areas in Gauteng (Marais & Peacock, 2008)
Falco peregrinus (Peregrine Falcon) (**NT**)	None on site: Resident *F. p. minor* mostly restricted to mountainous riparian or coastal habitats, where high cliffs provides breeding and roosting sites. Breeding pairs prefer habitats that favour specialised, high speed, aerial hunting, e.g. high cliffs overhanging vegetation with raised and/or discontinuous canopy (eg forest, fynbos, woodland), or expanses of open water. Also uses quarries and dam walls, and frequents city centres, e.g. Cape Town, where tall buildings substitute for rock faces.	Highly unlikely Due to a lack of suitable breeding habitat. Could move through the area or rare occasions. Uncommon resident and summer migrant in Gauteng (Marais & Peacock, 2008)

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
	Migrant *F. p. calidus* in more open country, often coastal, even roosting on ground on almost unvegetated salt flats.	
*Phoenicopterus ruber** (Greater Flamingo) (**NT**)	None on site: Breeds at recently flooded, large, eutrophic wetlands (favoured foraging habitat), shallow salt pans; at other times, at coastal mudflats, inland dams, sewage treatments works, small ephemeral pans and river mouths (Hockey *et al.* 2005). Usually breeds colonially on mudflats in large pans (Harrison *et al.* 1997a). Shallow pans, especially saline pans when they have water; also occasionally on other bodies of shallow water such as dams and vleis (Tarboton *et al.* 1987). Large bodies of shallow water, both inland and coastal; prefers saline and brackish water (Maclean 1993). Occasionally forages along sandy coasts.	<u>Highly unlikely</u> Due to a lack of suitable foraging and breeding habitat. Mainly restricted to the south-eastern Gauteng (Marais & Peacock, 2008)
Phoenicopterus minor (Lesser Flamingo) (**NT**)	None on site: Primarily open, shallow eutrophic, wetlands and coastal lagoons and may occur on water bodies which are more saline and more alkaline than those used by *Phoenicopterus ruber* (Greater Flamingo). Breeds on saline lakes, salt pans and mudflats far out in pans and lakes (Harrison *et al.* 1997). Non-breeding birds aggregate at coastal mudflats, salt works and sewage treatment works where salinities are high. Small, ephemeral freshwater wetlands very important for birds dispersing from breeding grounds (Hockey *et al.*, 2005). Shallow pans, especially saline pans when they contain water (Tarboton *et al.*, 1987). Large brackish or saline inland and coastal waters (Maclean, 1993).	<u>Highly unlikely</u> Due to a lack of suitable foraging and breeding habitat.
Mycteria ibis (Yellow-billed Stork) (**NT**)	None on site: Utilises diverse wetlands and permanent and seasonal habitats, including alkaline and freshwater lakes, river, dams, pans, flood plains, large marshes, swamps, estuaries, margins of lakes or rivers, flooded grassland and small pools or streams where there are areas of shallow water free of emergent vegetation (Tarboton *et al.*, 1987); less often marine mudflats and estuaries (Hockey *et al.*, 2005). Nests colonially on large trees adjacent to productive wetlands, but only locally and erratically during ideal conditions.	<u>Highly unlikely</u> Due to a lack of suitable habitat. Common at large wetlands within Gauteng; erratic elsewhere (Marais & Peacock, 2008)
Anastomus lamelligerus African Openbill (**NT**)	Wetlands, including flood plains, temporarily flooded pans, marshes, swamps, ponds, river shallows, streams, rice fields, dams, lake edges, lagoons and intertidal flats; occasionally in ploughed fields. Mainly < 1 500 m.	<u>Highly unlikely</u> Due to a lack of suitable habitat
*Ciconia nigra** (Black Stork) (**NT**)	None on site: Dams, pans, flood plains, shallows of rivers, pools in dry riverbeds, estuaries and sometimes on marshland and flooded grassland; uncommon at seasonal pans lacking fish. Associated with mountainous regions (Hockey *et al.*, 2005) where they nest (Maclean, 1993) on cliffs (Harrison *et al.* 1997a). Feeds in shallow water, but occasionally on dry land, in streams and rivers, marshes, floodplains, coastal estuaries and large and small dams; it is typically seen at pools in large	<u>Highly unlikely</u> Due to a lack of suitable breeding and foraging habitat

SCIENTIFIC NAME	PRESENCE OF SUITABLE HABITAT AND HABITAT REQUIREMENTS	LIKELIHOOD OF OCCURRENCE ON STUDY SITE
	rivers.	
Mirafra cheniana (Melodious Lark) (**NT**)	None on site: Occurs in grassland dominated by *Themeda triandra* grass in South Africa. Occasionally in planted pastures of *Eragrostis curvula* and *E. tef.* Avoids wet lowlands, favouring fairly short grassland (< 0.5 m), with open spaces between tussocks, at 550 – 1 750 m.a.s.l. with annual rainfall of between 400 – 800 mm p/a (Hockey *et al.*, 2005).	Highly unlikely Due to a lack of suitable habitat Localised resident in Gauteng (Marais & Peacock, 2008) where suitable habitat occur

*Priority Red Data bird species according to GDARD.

6. FINDINGS AND POTENTIAL IMPLICATIONS

6.1 Red Data avifaunal species confirmed from the study site (excluding the 500 m extended study area) for which suitable foraging, breeding and roosting habitat was confirmed:

None

6.2 Red Data avifaunal species confirmed within the 500 m extended study site for which suitable foraging, breeding and roosting habitat was confirmed:

None

6.3 Red Data avifaunal species confirmed outside the 500 m extended study site for which suitable foraging, breeding and roosting habitat was confirmed:

None

6.4 Red Data avifaunal species for which suitable foraging habitat was confirmed from the study site and within the 500 m extended study site:

None

6.5 Red Data avifaunal species for which suitable foraging habitat was confirmed within the 500 m extended study site:

None

The habitat systems on site will not favour any of the mentioned Red Data avifaunal species due to a lack of suitable breeding, roosting and/or foraging habitat on and surrounding the study site. The avifaunal species observed on or that are likely to occur on the study site are the more common avifaunal species associated with the various habitat systems and species that are able to adapt to areas transformed by man.

Particular reference was made for the occurrence of **White-bellied Korhaan** (*Eupodotis senegalensis*) on or surrounding the study site.

African Grass-Owl (*Tyto capensis*):

Criteria for IUCN threatened category: Status: Vulnerable.
Habitat: The African Grass Owl is found exclusively in rank grass at fairly high altitudes (Cyrus & Robson 1980) and has been recorded breeding in permanent vleis. It will also breed in long grass usually close to some kind of wetland system but according Tarbonton (*in litt*) their breeding habitat is or not necessarily associated with wetlands. They nest within a system of tunnels on the ground in tall grass with the peak breeding season being between February to April which usually coincides with maximum grass cover (Steyn 1982). In years when rodents are abundant they will hunt during the night over adjacent grassland and dry savanna, which is typically regarded as a sub-optimal habitat (Kemp & Calburn 1987). Their hunting does not extend to agricultural croplands or to short grasslands and seems to be confined to tall grasslands (Kemp & Calburn 1987).
Threat: Land-use change, habitat loss and fragmentation of their ecological requirements are the largest factors that impact this species negatively (Barnes 2000).
On site conclusion: No suitable breeding, roosting and foraging habitat was identified for this species on the study site.

7. LIMITATIONS, ASSUMPTIONS AND GAPS IN KNOWLEDGE

The Galago Environmental team has appropriate training and registration, as well as extensive practical experience and access to wide-ranging data bases to consider the derived species lists with high limits of accuracy. In this instance the biodiversity of all Alignments has to a greater or lesser extent been jeopardized, which renders the need for field surveys unnecessary. In instances where uncertainty exists regarding the presence of a species it is listed as a potential occupant, which renders the suggested mitigation measures and conclusions more robust.

Even though every care is taken to ensure the accuracy of this report, environmental assessment studies are limited in scope, time and budget. Discussions and proposed mitigations are to some extent made on reasonable and informed assumptions built on *bone fide* information sources, as well as deductive reasoning. Deriving a 100% factual report based on field collecting and observations can only be done over several years and seasons to account for fluctuating environmental conditions and migrations. Since environmental impact studies deal with dynamic natural systems additional information may come to light at a later stage. Galago Environmental can thus not accept responsibility for conclusions and mitigation measures made in good faith based on own databases or on the information provided at the time of the directive. This report should therefore be viewed and acted upon with these limitations in mind.

The general assessment of species rests mainly on the 1987 atlas for birds of the then-Transvaal (Tarboton *et al*. 1987) and comparison with the 1997 SABAP atlas (Harrison et al. 1997), so any limitations in either of those studies will by implication also affect this survey and conclusions.

The general assessment of species rests mainly on the 1997 SABAP1 atlas data (Harrison et al. 1997) for comparison with the current SABAP2 atlas, so any limitations in either of those studies will by implication also affect this survey and conclusions.

Furthermore the number of atlas cards received and the diversity of habitat systems surveyed for avifaunal species within a q.d.g.c. or pentad or lack thereof could also have an effect on the avifaunal diversity that could potentially occur on the study site. 534 atlas cards were received for the 2528CD q.d.g.c. over the SABAP1 project period, 1008 cards for the entire 2528CD q.d.g.c. over the current SABAP2 project period and 17 cards for the 2545_2825 pentad since 1 July 2007.

8. RECOMMENDED MITIGATION MEASURES

The following mitigation measures are proposed by the specialist:

- Areas with natural woodland vegetation should be left undisturbed to ensure future avifaunal biodiversity on the study site.
- It is recommended that no fences be erected on the borders of the various erfs or lots to allow free movement of fauna species through the area.
- Where possible, **work should be restricted to one area at a time**, as this will give the smaller birds, mammals and reptiles a chance to weather the disturbance in an undisturbed zone close to their natural territories.
- **No vehicles should be allowed to move in or across the wet areas or drainage lines and possibly get stuck.** This leaves visible scars and destroys habitat, and it is important to conserve areas where there are tall reeds or grass, or areas were there is short grass and mud.
- With proper cultivation of specific indigenous plant species, the bird numbers and species in the area could even increase. Indigenous plant species that attract birds to gardens or that are natural to the area could be obtained from the local nurseries surrounding the area. The area must however be kept as natural as possible.
- It is important to note that birds inhabiting one of the named microhabitats on site will not move, in most cases, into a different habitat. In other words, birds found in the open woodland will not now, with the development, move into the grassland areas or the wetland area. If the objective is to keep these species on site, suitable open woodland must be kept for these species.
- The contractor must ensure that no fauna is disturbed, trapped, hunted or killed during the construction phase. Conservation-orientated clauses should be built into contracts for construction personnel, complete with penalty clauses for non-compliance.
- It is suggested that where work is to be done close to the drainage lines, these areas **be fenced off during construction,** to prevent heavy machines and trucks from trampling the plants, compacting the soil and dumping in the system.
- During the construction phase, noise must be kept to a minimum to reduce the impact of the development on the fauna residing on the site.
- Alien and invasive plants must be removed.

9. CONCLUSIONS

The habitat on the study site will not favour any Red Data avifaunal species, however the woodland and drainage line vegetation will favour a variety of typical bushveld avifaunal species as well as some of the more common aquatic avifaunal species. Development will result is habitat loss for these avifaunal species and areas should be left undisturbed and undeveloped to ensure future avifaunal diversity on the study site.

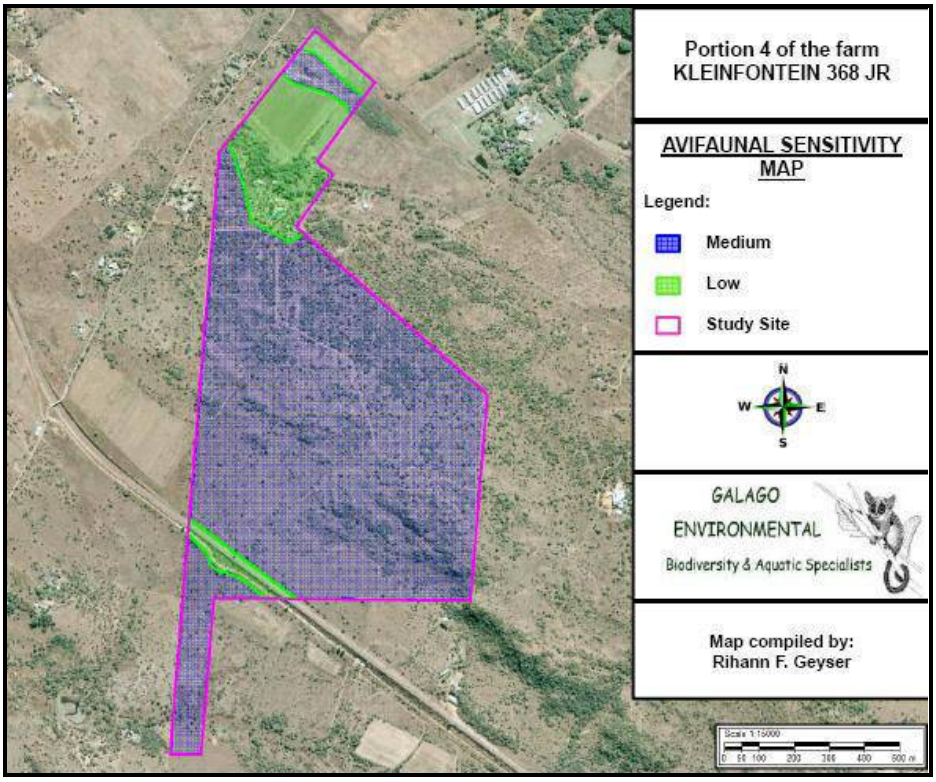

Figure 12: Avifaunal sensitivity map

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Herpetofaunal Habitat Assessment

of

PORTION 31 AND 38 AND THE REMAINDER OF KLEINFONTEIN 368 JR AND PORTION 14, 63 AND 68 OF DONKERHOEK 365 JR

February 2012

Report author: Mr. **W.D. Haacke** (Pri. Sci. Nat: M.Sc)

Declaration of Independence:

I, **Wulf D. Haacke** (361215 5016 081) declare that I:

- am committed to biodiversity conservation but concomitantly recognize the need for economic development. Whereas I appreciate the opportunity to also learn through the processes of constructive criticism and debate, I reserve the right to form and hold my own opinions and therefore will not willingly submit to the interests of other parties or change my statements to appease them

- abide by the Code of Ethics of the S.A. Council for Natural Scientific Professions

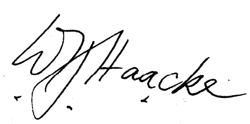
- act as an independent specialist consultant in the field of herpetology

- am subcontracted as specialist consultant by Galago Environmental CC for the proposed Kleinfontein & Donkerhoek development project described in this report

- have no financial interest in the proposed development other than remuneration for work performed

- have or will not have any vested or conflicting interests in the proposed development

- undertake to disclose to the Galago Environmental CC and its client as well as the competent authority any material information that have or may have the potential to influence the decision of the competent authority required in terms of the Environmental Impact Assessment Regulations, 2006.



Wulf D Haacke

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1. INTRODUCTION

Galago Environmental CC was appointed to undertake a reptile and amphibian habitat survey on Portions 31 and 38 and the Remainder of the farm Kleinfontein 368-JR and Portions 14, 63, 67 and 68 of the farm Donkerhoek 365-JR (hereafter referred to as the study site), scheduled for development into an eco estate with residential areas, open spaces, gape park areas etc.

The objective was to determine which species might still occur on the site. Special attention had to be given to the habitat requirements of all the Red Data species which may occur in the area. This survey focuses on the current status of threatened herpetofaunal species occurring, or which are likely to occur, on the proposed development site, and a description of the available and sensitive habitats on the site.

2. OBJECTIVES OF THE HABITAT STUDY

- To assess the current status of the habitat component and current general conservation status of the property;
- To provide lists of reptiles and amphibians which occur or might occur and to identify species of conservation importance;
- To highlight potential impacts of the development on the herpetofauna of the study site; and
- To provide management recommendations to mitigate negative and enhance positive impacts should the proposed development be approved.

3. SCOPE OF STUDY

This report:

- is a reptile and amphibian survey based on sightings and literature, with comments on preferred habitats;
- comments on ecologically sensitive areas;
- evaluates the conservation importance and significance of the site, with special emphasis on the current status of resident threatened species;
- offers recommendations to reduce or minimise impacts, should the proposed development be approved.

4. STUDY AREA

This site of 808 ha lies southeast of Pretoria in the quarter degree grid cells 2528CD and 2528DC, in the Cullinan district south of the N4 Highway and the Donkerhoek Pass. A narrow southern section extends across the railway line to Sentrarand. Due to the fact that it consists of a conglomerate of eight portions of two farms it has an irregular shape which extends from the southern slope of the Magaliesberg southwards with a sharply pointed extension into the undulating lowland. It is a rural community with the majority of the houses unfenced and some released antelope wander around freely. The study site lies in Rand Highveld Grassland and Gold Reef Mountain Bushveld (Mucina *et al*, 2006). The site is extremely invaded by exotics, such as agricultural weeds, gumtrees and extensive stands of Black Wattle.

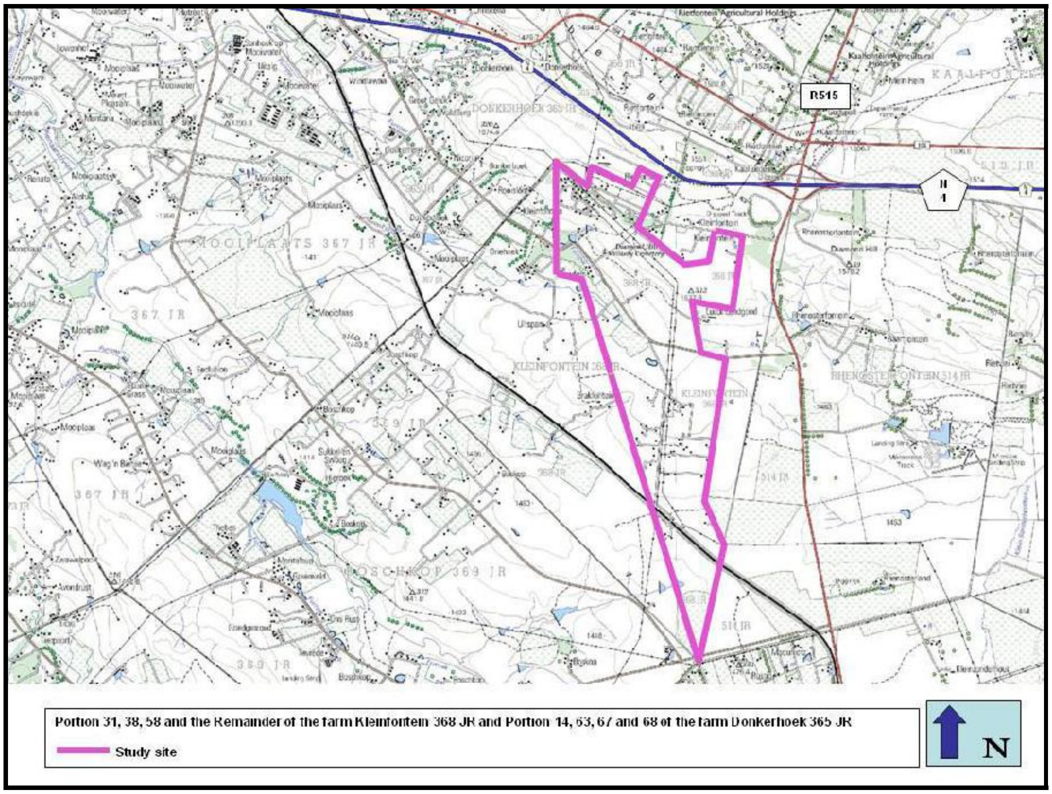

Figure 1: Locality map of the study area

Figure 2: House on lower slope of Magaliesberg, in natural grassveld.

Figure 3: View southeastwards across grassveld with a stand of gumtrees around ruins of a former farmhouse.

Figure 4: View southwards on rocky top of the ridge towards the community hall and Black Wattle thickets.

Figure 5: View northeastwards from near the main drainage line near the western border of the site through mountain bushveld towards the Magaliesberg ridge past the Diamond Hill military cemetery.

Figure 6: View northwards across grassveld of the southern tip of the site south of the railway line.

Figure 7: View of entrance to property in woodland in the southern section.

Figure 8: View northwards from southern section across grassveld to mountain bushveld.

5. METHOD

A site visit was conducted on 26 March 2011 and again on the 9 April 2011 in the company of other specialists of the Galago Environmental team. During these visits the habitat types of the study site were recorded in order to deduct which herpetofaunal species might possibly be associated with them. This was done with due regard to the known distributions of Southern African herpetofauna (Minter *et al,* 2004. SARCA Reptile Survey, 2006 – 9).

The following GPS coordinates spatially define the site:

- Diamond Hill Military Cemetery, along a row of houses with the uphill slope and the ridge (25°48'37" S, 28°29'43" E.1534m) (Figures 1 + 2).
- The upper dam in the drainage line (25°48'11" S, 28°29'19" E. 1501m).
- Open grassveld on the rocky top of the ridge (Figure 3).
- Eastern edge (25°49'09" S,28°30'18,2" E.1522m).
- Drainage line (25°48'54" S, 28°29'33" E. 1498m)
- Railway line crossing (25°50'45,4" S, 28°30'29,6" E)

The 500 meters of adjoining properties were scanned for important faunal habitats. The slope and the ridge of the Magaliesberg have rocky substrate with some extended dense stands of Black Wattles. Lower down, still on rocky substrate, Gold Reef Mountain Bushveld takes over. The undeveloped sections of this area appear to show that they are unsuitable for ploughing. On the eastern side of the southern extension of the site are some irrigation spillpoints in the Rand Highveld Grassland. No important herpetofaunal habitats were noticed beyond the border of the site.

5.1 Field Surveys

During the site visits it was attempted to identify reptiles and amphibians visually during random transect walks. Possible burrows or other reptile retreats (stumps or rocks) were inspected for any inhabitants. Amphibians may also be identified by their calls but none were vocalising.

5.2 Desktop Surveys

As the majority of reptiles and amphibians are secretive, nocturnal and/or poikilothermic or seasonal, distributional ranges and the presence of suitable habitats were used to deduce the presence or absence of these species based on authoritative tomes, scientific literature, field guides, atlases and databases. This can be done irrespective of season.

The probability of occurrences of herpetofaunal species was based on their respective geographical distributional ranges and the suitability of on-site habitat. In other words, *high* probability would be applicable to a species with a distributional range overlying the study site as well as the presence of prime habitat occurring on the study site. Another consideration for inclusion in this category is the inclination of a species to be common, i.e. normally occurring at high population densities.

Medium probability pertains to a herpetofaunal species with its distributional range peripherally overlapping the study site, or required habitat on the site being sub-optimal. The size of the site as it relates to its likelihood to sustain a viable breeding population, as well as its geographical isolation is also taken into consideration. Species categorised as *medium* normally do not occur at high population numbers, but cannot be deemed as rare. A *low* probability of occurrence will mean that the species' distributional range is peripheral to the study site <u>and</u> habitat is sub-optimal. Furthermore, some herpetofauna categorised as *low* are generally deemed rare.

Based on the impressions gathered during this visit and records in the Transvaal Museum, the documentation of the herpetofauna of the then Transvaal by Dr N. H. G. Jacobsen (Unpublished Ph.D. thesis, University of Pretoria, 1989) and his internal report for the Gauteng Province (1995), the "Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland" (Minter, *et al*, 2004) and the SARCA reptile survey (2006 – 9), the following list of species which may occur on this site was compiled. The vegetation type was analysed according to the standard handbook by Mucina and Rutherford (eds) (2006).

5.3 Specific Requirements

During the visits the sites were surveyed and assessed for the potential occurrence of Red Data species such as:

- Giant Bullfrogs (*Pyxicephalus adspersus*); only recorded from 2528Dc.
- Striped Harlequin Snake (*Homoroselaps dorsalis*); not recorded and no termitaria seen.
- Southern African Python (*Python natalensis*); Beyond range and not recorded.

6. RESULTS

Amphibians:
This site is only partially suitable for Bullfrogs. The rocky slope and ridge of the Magaliesberg is not suitable at all. The extension into the lowlands, probably the area south of the road crossing the site, appears flat enough for the formation of shallow breeding ponds. In patches, the substrate there appears suitable as dipersal area, in which these frogs may feed and burrow to aestivate and hibernate. Existing records indicate that this frog has been recorded in the eastern quarter degree grid cell 2528DC, which suggests a possible marginal presence in the eastern section of the southern extension of the site. This frog would potentially have more suitable conditions in the area adjacent to the east of the site and the central area of this grid cell, both currently have very little development. At present no actual sightings with GPS readings are available, although a local resident confirmed that bullfrogs have been seen on the site. The other listed amphibians may benefit from the earthen dams, small wetlands and the drainage line across the centre of the site.

Reptiles:
No targeted Red Data species have been recorded in the two quarter degree grid cells of the site. The known range of the python does not extend as far as the site. The Striped Harlequin Snake is unlikely to occur here as no termitaria, which in moribund form usually provide ideal retreats, were noticed.

The requirements for reptiles differ from those of amphibians and cannot be defined as feeding, dispersal and breeding areas. All southern African reptiles, except for terrestrial tortoises, are predators. The available habitats on the site should provide an adequate variety of prey species for the listed reptiles, which are mainly grassland generalists.

Table 1: List of amphibians and reptiles which may still occur on this site:-

SCIENTIFIC NAMES	COMMON NAMES	PROBABILITY OF OCCURRENCE
CLASS: AMPHIBIA	**AMPHIBIANS**	
Order: ANURA	**FROGS**	
Family: Bufonidae	**Toads**	
Amietophrynus gutturalis	Guttural Toad	Medium
Amietophrynus rangeri	Raucous Toad	Medium
Schismaderma careens	Red Toad	Medium
Family: Pipidae	**Platannas**	
Xenopus laevis	Common Platanna	Low
Family: Microhylidae	**Rubber and Rain Frogs**	
Breviceps adspersus	Bushveld Rain Frog	Medium
Family: Pyxicephalidae	**Common Frogs**	
Amieta angolensis	Common River Frog	High
Phrynobatrachus natalensis	Snoring Puddle Frog	High
Kassina senegalensis	Bubbling Kassina	High
Tomopterna cryptotis	Tremolo Sand Frog	Medium
Tomopterna natalensis	Natal Sand Frog	Low
Cacosternum boettgeri	Common Caco	High
CLASS: REPTILIA	**REPTILES**	
Order: SQUAMATA	**SCALE-BEARING REPTILES**	
Suborder: LACERTILIA	**LIZARDS**	
Family: Gekkonidae	**Geckos**	
Pachydactylus capensis	Cape Thick-toed Gecko	Low
Pachydactylus affinis	Transvaal Thick-toed Gecko	Medium
Family: Chamaeleonidae	**Chameleons**	
Chamaeleo dilepis	Flap-necked Chameleon	Low
Family: Agamidae	**Agamas**	
Agama atra	Rock Agama	Low
Agama distanti	Distant's Ground Agama	Low
Family: Scincidae	**Skinks**	
Trachylepis punctatissima	Speckled Skink	Medium
Trachylepis capensis	Cape Skink	Low
Afroblepharus wahlbergii	Wahlberg's Snake-eyed Skink	Medium
Mochlus sundevallii	Sundevall's Writhing Skink Low	Low
Family: Lacertidae	**Lacertids**	
Pedioplanis lineoocellata	Spotted Sand Lizard	Low
Nucras holubi	Holub's Sand Lizard	Low
Nucras ornata	Ornate Sand Lizard	Low
Family: Gerrhosauridae	**Plated Lizards**	
Gerrhosaurus flavigularis	Yellow-throated Plated Lizard	Low
Family: Cordylidae	**Girdled Lizards**	

SCIENTIFIC NAMES	COMMON NAMES	PROBABILITY OF OCCURRENCE
Chamaesaura aenea	Coppery Grass Lizard	Low
Chamaesaura anguina	Cape Grass Lizard	Low
Cordylus jonesii	Jones' Girdled Lizard	Low
Cordylus vittifer	Common Girdled Lizard	Low
Family: Varanidae	**Monitor lizards**	
Varanus albigularis	Rock Monitor	Low
Suborder: SERPENTES	**SNAKES**	
Family: Typhlopidae	**Blind Snakes**	
Typhlops bibronii	Bibron's Blind Snake	Low
Family: Leptotyphlopidae	**Thread Snakes**	
Leptotyphlops s.scutifrons	Peters' Thread Snake	Medium
Family: Atractaspididae	**African Burrowing Snakes**	
Atractaspis bibronii	Bibron's Stiletto Snake	Low
Apparalactus capensis	Cape Centipede-eater	Medium
Family: Colubridae	**Typical Snakes**	
Lamprophis capensis	Brown House Snake	Medium
Lycodonomorphus rufulus	Brown Water Snake	Low
Lycophidion capense	Cape Wolf Snake	Medium
Pseudaspis cana	Mole Snake	Low
Psammophis brevirostris	Shortsnouted Sand Snake	Low
Psammophris crucifer	Cross-marked Sand Snake	Low
Psammophis trinasalis	Fork-marked Sand Snake	Low
Psammophylax rhombeatus	Rhombic Skaapsteker	Medium
Psammophylax tritaeniatus	Striped Skaapsteker	Low
Telescopus semivariegatus	Eastern Tiger Snake	Low
Dispholidus typus	Boomslang	High
Dasypeltis scabra	Rhombic Egg-eater	High
Family: Elapidae	**Cobras, Mambas, other Elapids**	
Naja annulifera	Snouted Cobra	Medium
Naja mossambica	Mozambique Spitting Cobra	Low
Hemachatus haemachatus	Rinkhals	Low
Elapsoidea s. media	Highveld Garter Snake	Low
Family: Viperidae	**Adders**	
Bitis arietans	Puff Adder	High
Causus rhombeatus	Rhombic Night Adder	Low
Order: CHELONIA	**TORTOISES**	
Suborder: PLEURODIRA	**SIDE-NECKED TERRAPINS**	
Family: Pelomedusidae	**Side-necked Terrapins**	
Pelomedusa subrufa	Helmeted Terrapin	Low

7. FINDINGS AND POTENTIAL IMPLICATIONS

This site has a variety of habitats, due to a combination of substrate and vegetation types, drainage lines and earthen dams.

This variety of available habitat types provides suitable situations for habitat-specific reptiles and some frogs. The rocky outcrops on the slope and the crest of the ridge provide a habitat for the rock agama, the common girdled lizard and some skinks.

Further downhill the herpetofauna consists of grassveld generalists. As several taxa have only been recorded from one of the two quarter degree grid cells which cover this site, this indicates that the resident populations of these reptiles and amphibians tend to be small and disrupted.

As this site lies in a contact zone between Highveld Grassveld and the Savannah Bushveld, there is a potential overlap between some of the typical marker species, such as the northern cobras of tropical savannah, with the Rinkhals representing the southern Highveld species.

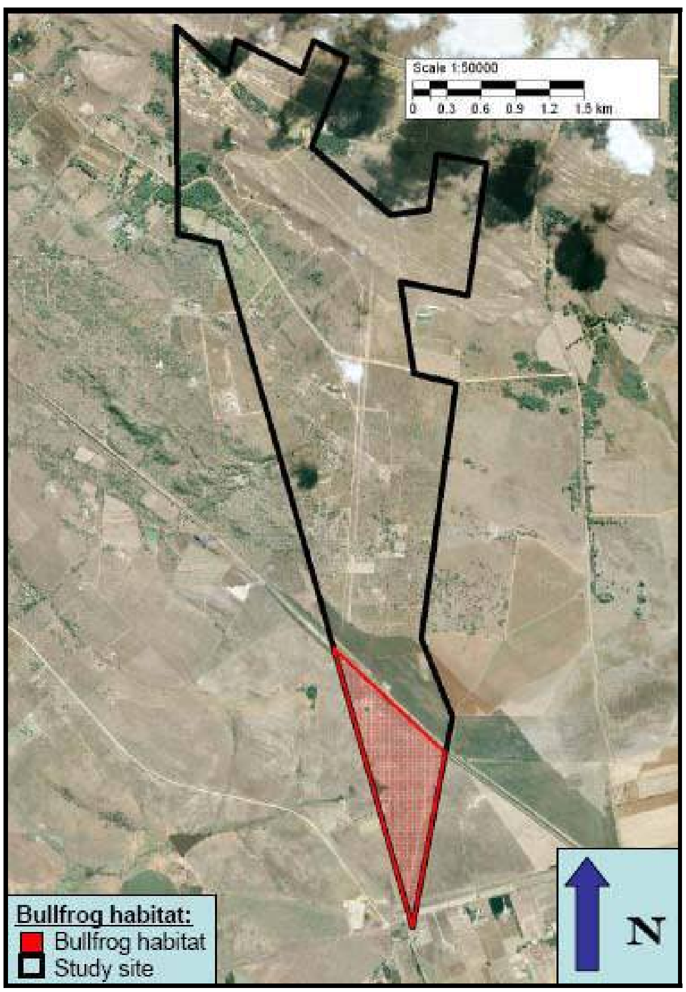

Figure 9: Bullfrog Habitat map

8. LIMITATIONS, ASSUMPTIONS AND GAPS IN KNOWLEDGE

This site in the two adjacent quarter degree grid cells has been residentially occupied for some time and a fairly high density housing complexes developed. Some areas have been taken over by dense stands of exotic plants, such as black wattles and gumtrees, and earthen dams have been built, therefore the original indigenous herpetofauna may have been affected.

9. RECOMMENDED MITIGATION MEASURES

Mitigation measures proposed by the specialist:

- It is important to note that the trenches for the water pipeline and even those for sewage lines do not need to be wide, which means that the environmental damage caused by the actual digging can be reduced to a minimum. However, while they are open their presence will mean that wildlife of any size may fall into them, from where it will be difficult to escape and death may be caused by drowning, excessive exposure to the sun or by being buried alive during the final construction work.
- Environmental damage caused by these trenches may be kept to a minimum by good forward planning and thereby reducing the actual length of time that they are open. Possible damage to wildlife is in direct proportion to the time that these trenches are open and may destroy amphibian and reptilian species.
- The design of the stormwater lines is not known. If large diameter cement pipes are used and the trenches are closed again, potential danger become reduced by filling in the trenches. Open stormwater channels are dangerous, as they will continuously contribute to wildlife destruction.

The following mitigation measures were developed by GDACE (Directorate of Nature Conservation, GDACE, 2009) and are applicable to the study site.

- When Giant Bullfrogs / Giant Bullfrog habitat will be retained in an open space system of a development situated within the urban edge, Giant Bullfrogs should be prevented from leaving the site and entering unsuitable habitat through the erection of an impermeable wall or appropriately designed fence prior to construction commencing. The wall/fence should be solid (i.e. without openings) below ground to the level of the foundations and for at least 20cm above ground.
- The crossing of natural drainage systems should be minimized and only constructed at the shortest possible route, perpendicular to the natural drainage system. Where possible, bridge crossings should span the entire stretch of the buffer zone.
- Disturbance to any wetlands during construction should be minimized. A plan for the immediate rehabilitation of damage caused to wetlands should be compiled by a specialist registered in accordance with the Natural Scientific Professions Act (No. 27 of 2003) in the field of Ecological Science. This rehabilitation plan should form part of the EMP and a record book should be maintained on site to monitor and report on the implementation of the plan.
- All storm water structures should be designed so as to block amphibian and

reptile access to the road surface.

- A comprehensive surface runoff and storm water management plan should be compiled, indicating how all surface runoff generated as a result of the road development (during both the construction and operational phases) will be managed (e.g. artificial wetlands / storm water and flood retention ponds) prior to entering any natural drainage system or wetland and how surface runoff will be retained outside of any demarcated buffer/flood zones and subsequently released to simulate natural hydrological conditions. This plan should form part of the EMP.
- Where roads are routed past expected or confirmed Giant Bullfrog breeding areas, road signs warning motorists to slow down on account of Giant Bullfrogs should be erected (in accordance with applicable legislation).

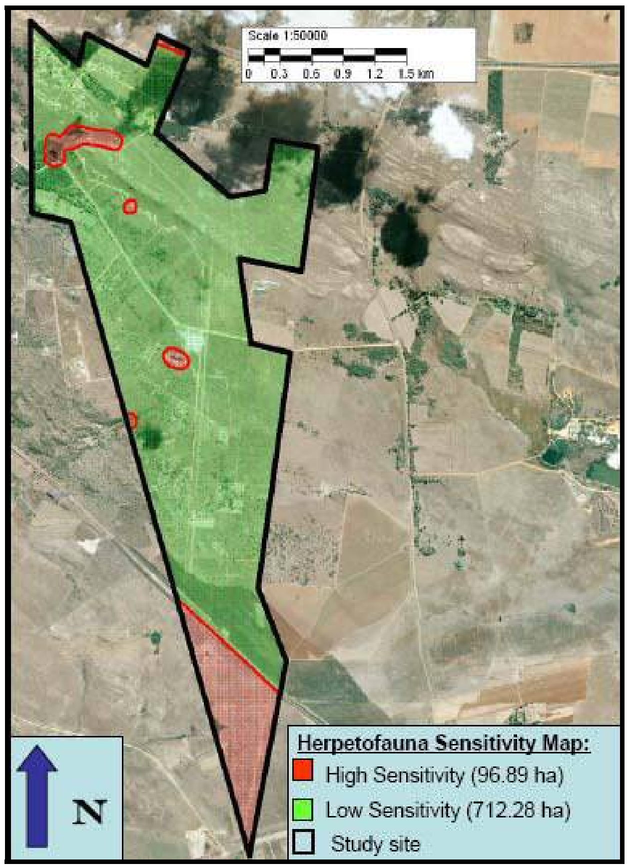

Figure 10: Herpetofaunal sensitivity map

10. CONCLUSION

This site has been occupied for some time and the northwestern corner is densely covered by houses. In parts it has been seriously disturbed by introduced exotic plants such as Black Wattle and Eucalyptus trees, which occur in thick stands on and around the site. The eastern section of the rocky ridge is relatively undisturbed. The entire site is run as a communal project and houses may have some gardens surrounding them but no walls or fences are allowed. Some antelopes have been introduced and these move freely on the site. As this system does not allow walls, bullfrogs would be able to move freely, mainly in the area near the southeastern border, where this frog has been recorded. The middle of this narrow site appears to have been subdivided into small plots for residential purposes. Some cattle were seen and some ploughing has been done. The long grassveld south of the railway line appears undisturbed.

The Giant Bullfrog occurs in the eastern quarter degree grid cell on this site. The wetlands and an adjacent open area should remain undeveloped for this frog. The rest of the listed species should be fairly well distributed, although in low densities. The proposed further development on this site will not have any seriously detrimental effects on the herpetofauna. Some commensal species, such as Speckled Skinks, which are able to live in association with human activities and structures, may benefit from this development.

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Invertebrate Fauna Habitat Survey

PORTION 31 AND 38 AND THE REMAINDER OF KLEINFONTEIN 368 JR AND PORTION 14, 63 AND 68 OF DONKERHOEK 365 JR

February 2012

Report author: Reinier Terblanche (M.Sc, Pr.Sci.Nat)

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1. INTRODUCTION

A habitat survey of invertebrates, of known high conservation priority, was required for Portion 31 and 38 and the remainder of Kleinfontein 368 JR and Portions 14, 63, 67 and 68 of Donkerhoek 365 JR. The survey focused on the possibility that invertebrate species of conservation concern, known to occur in the Gauteng Province are likely to occur within the proposed development site (with its alternatives) or not. Species of conservation concern include Threatened species (Critically Endangered, Endangered, Vulnerable), Near Threatened species, Critically Rare species or Rare species.

1.1 Objectives of the habitat study

The objectives of the habitat study are to provide:

- A detailed butterfly habitat survey;
- A detailed habitat survey of possible threatened or localized chafer beetles, mygalomorph spiders and rock scorpions;
- Evaluate the conservation importance and significance of the site with special emphasis on the current status of threatened invertebrate species;
- Recording of possible host plants of the larvae of butterfly species;
- Literature investigation of possible species that may occur on site;
- Identification of potential ecological impacts on invertebrates that could occur as a result of the development; and
- Make recommendations to reduce or minimise impacts, should the development be approved.

1.2 Scope of study

- Four site visits at the specific site of key elements of habitats on the site, relevant to invertebrate conservation.
- Recording of any sightings and/or evidence of existing butterflies and selected fruit chafers, mygalomorph spiders and rock scorpions.
- An evaluation of the conservation importance and significance of the site with special emphasis on the current status of threatened species.
- Recording of possible host plants of the larvae of butterfly species.
- Literature investigation of possible species that might occur on site.
- Integration of the literature investigation and field observations to identify potential ecological impacts that could occur as a result of the development.
- Integration of literature investigation and field observations to make recommendations to reduce or minimise impacts, should the development be approved.

2. STUDY AREA

The study site is situated at the intersection of the Savanna - and Grassland Biomes (Mucina & Rutherford 2006). Landscape at the site could be divided into a west-east directed rocky ridge and flatter areas with very few rocks on gentle slopes. The vegetation type at the rocky ridge is Gold Reef Mountain Bushveld but with a relatively low cover of indigenous trees. Grassland at the flats is represented by Rand Highveld Grassland (Mucina & Rutherford 2006). The site is part of the summer-rainfall region with dry winters. Frost is frequent in the winter, but less common on the ridges and hills (Mucina & Rutherford, 2006). Mean annual precipitation varies from 600 – 750mm a year. The ridge at the site is surrounded by thornveld, grassland at the flats, some cultivated fields, wetland vegetation along streambeds and built-up areas. A highway (N4) cuts between the northern section of the ridge at the site and other ridges further to the north. A smaller tar road exists between the ridge at the site and a chain of ridges to the east.

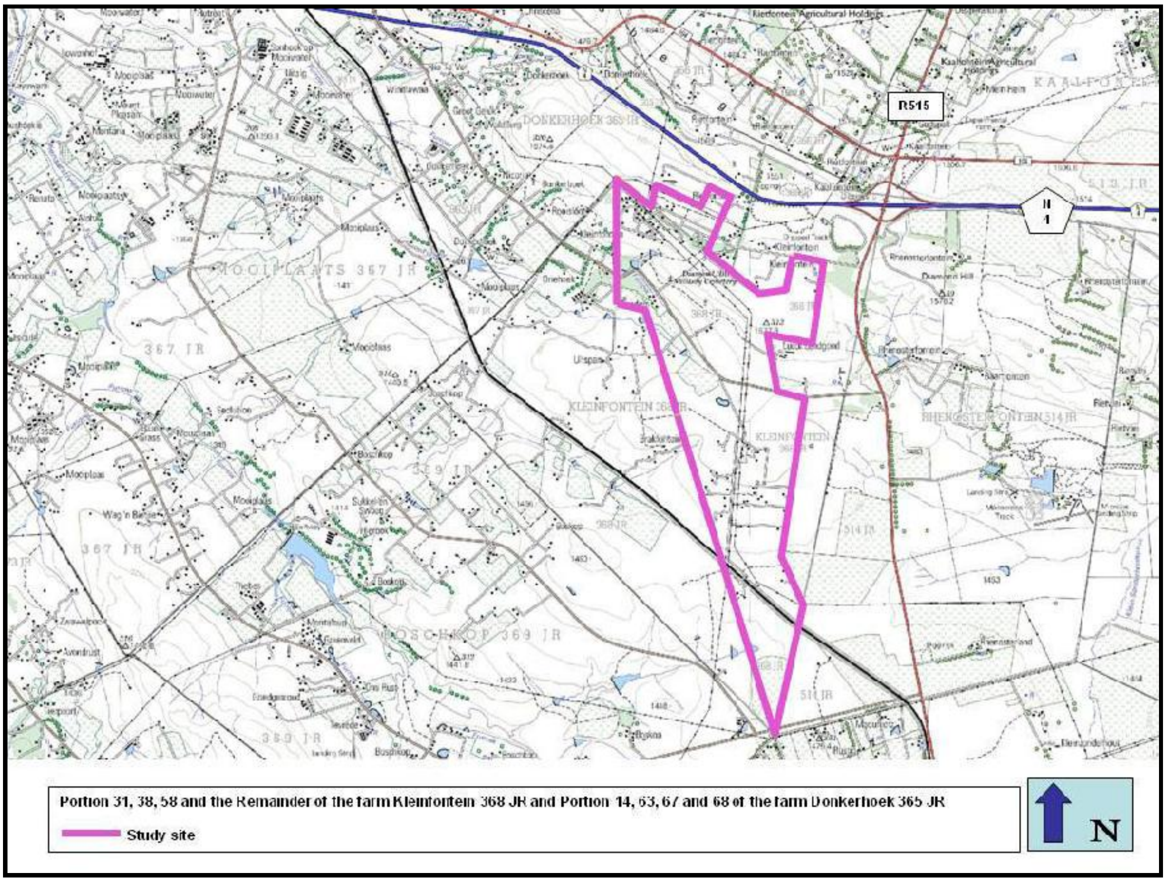

Figure 1: Locality map of the study area

3. METHODS

Surveys were conducted on 31 March 2011, 29 April 2011, 15 May 2011 and 12 September 2011.

3.1 Habitat characteristics and vegetation

The habitat was investigated by noting habitat structure (rockiness, slope, plant structure/physiognymy) as well as floristic composition. Voucher specimens of plant species were only taken where the taxonomy was in doubt and where the plant specimens were of significant relevance for invertebrate conservation. Field guides such as those by Van Oudtshoorn (1999), Van Wyk & Malan (1998) and Van Wyk & Van Wyk (1997) were used to confirm the taxonomy of the species. In this case no plant specimens were needed to be collected as voucher specimens or to be sent to a herbarium for identification.

3.2 Butterflies

Butterflies were noted as sight records or voucher specimens. Voucher specimens are mostly taken of those species of which the taxa warrant collecting due to taxonomic difficulties or in the cases where species can look similar in the veldt.

Many butterflies use only one species or a limited number of plant species as host plants for their larvae. Myrmecophilous (ant-loving) butterflies such as the *Aloeides*, *Chrysoritis*, *Erikssonia, Lepidochrysops* and *Orachrysops* species (Lepidoptera: Lycaenidae), which live in association with a specific ant species, require a unique ecosystem for their survival (Deutschländer & Bredenkamp, 1999; Terblanche, Morgenthal & Cilliers, 2003; Edge, Cilliers & Terblanche, 2008; Gardiner & Terblanche, 2010). Known food plants of butterflies were therefore also recorded. After the visits to the site and the identification of the butterflies found there, a list was also compiled of butterflies that will most probably be found in the area in all the other seasons because of suitable habitat. The emphasis is on a habitat survey.

3.3 Fruit chafer beetles

Different habitat types in the areas were explored for any sensitive or special fruit chafer species. Selection of methods to find fruit chafers depends on the different types of habitat present and the species that may be present. Fruit bait traps would probably not be successful for capturing *Ichnestoma* species in a grassland patch (Holm & Marais 1992). Possible chafer beetles of high conservation priority were noted as sight records accompanied by the collecting of voucher specimens with grass nets or containers. Voucher specimens are taken where the relevant species belongs to taxa that warrant collecting due to taxonomic difficulties or possible confusion of identity in the veldt.

3.4 Mygalomorph spiders and rock scorpions

Relatively homogenous habitat / vegetation areas were identified and explored to identify any sensitive or special species. Selected stones that were lifted to search for Arachnids were put back very carefully resulting in the least disturbance possible. The area was searched for possible signs of trap door spiders or other mygalomorph spiders (for example traces of wafer-lids, cork-lids or silk-lined burrows). Investigations by brushing the soil surface with a small broom/paint brush, scraping or digging into the soil with a spade, were made. All the above actions were accompanied by the least disturbance possible.

3.5. Limitations

It should be emphasized that the survey is by no means an exhaustive list of the butterflies or other invertebrates present on the site, because of the time constraint. The on site butterfly and invertebrate survey was conducted during March 2011, April 2011, May 2011 and September 2011 which is an optimal time series of the year to find sensitive butterflies as well as other invertebrates of high conservation priority. Weather conditions during the visits were favourable for recording butterflies and invertebrates. However, the focus remains the habitat survey that focused on the probability of threatened species being present at the site.

4. RESULTS

4.1. Habitat and vegetation characteristics

Table 1: Outline of the main habitat and vegetation characteristics of the proposed site.

HABITAT FEATURE	DESCRIPTION
Topography	The site comprises a rocky ridge section with an upper plateau at the northern parts of the site and a flat area that covers the central and southern parts of the site.
Rockiness	Rocky ridges are found in the northern part of the site which include a plateau that contain rocky outcrops and sheet rock.
Presence of wetlands	A wetland and dam are present at the southern slope of the rocky ridges.
Vegetation in general	Vegetation at the site is a mosaic of different areas depending on the land use. Cultivated fields, gardens with exotic and indigenous plant species, patches of exotic trees are found in and around present developed areas. Remnants of grassland or *Acacia karroo* woodland are found in the valley bottom with its gentle slopes (flat area). Rocky ridge vegetation that contains pristine patches of rocky ridge vegetation is found in the northern parts of the site at a conservation area. Wetland patches of which most have been invaded or surrounded by exotic trees (*Eucalyptus,* exotic *Acacia, Populus*) are found at the site. One wetland is also partly invaded by kikuyu (*Pennisetum clandestinum*). Extensive patches of exotic invasive tree species are present at the site. Patches of the exotic *Eucalyptus camaldulensis* (red river gum, "bloekom") trees are present. Extensive patches of exotic invasive *Acacia decurrens* (green wattle) are present. Grassland at the rocky ridge contain a variety of indigenous grass species including *Loudetia simplex*, *Tristachya rehmannii*, *Aristida junciformis* subsp. *galpinii*, *Aristida transvaalensis*, *Digitaria monodactyla*, *Digitaria diagonalis* var. *diagonalis*, *Schizachyrium sanguineum*, *Panicum natalense* and *Monocymbium ceresiiforme*. A number of succulents including *Adromischus umbraticola*, *Euphorbia davyi* and *Aloe pretoriensis* are found in the rocky ridge vegetation. In addition shrubs such as *Clutia pulchella* (lightning bush), *Parinari capensis* (dwarf mobola), *Searsia magalismontana*, *Xerophyta retinervis* (monkey's tail) and *Protea welwitschii* are also recorded. Patches or clumps of indigenous trees are also found.
Signs of disturbances	The residential environment is obviously modified (containing roads, built up areas, fences) whilst vegetation in residential areas contain many exotic plant species. Patches of exotic *Eucalyptus* trees and exotic *Acacia decurrens* (green wattle) are present. High frequencies of *Seriphium plumosum* (bankrupt bush) in some parts suggest possible overgrazing.
Characteristics of surrounding areas (with a view to buffer zones, corridors and connectivity of habitats with more natural vegetation)	The rocky ridge area could be very important as stepping stones in a conservation corridor. Remnant patches of indigenous grassland and woodland could also be important stepping stones of natural corridors in an increasingly urbanised area.

Photo 1: View of the quartzite ridge. Vegetation consists of grassland with trees that are only found in favourable secluded areas.
Photo: September 2011, R.F. Terblanche

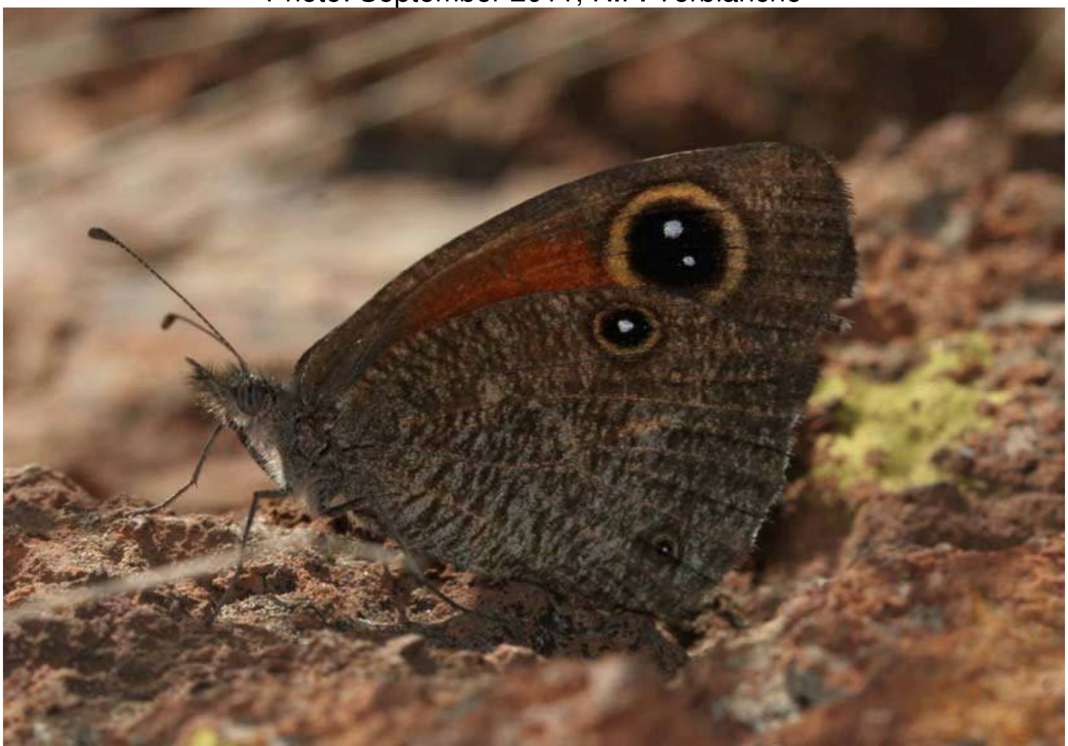

Photo 2: An example of *Stygionympha wichgrafi*, a butterfly that exclusively favours rocky ridges.
Photo: R.F. Terblanche.

Photo 3: Rocks, grasses and *Clutia pulchella* (lightning bush).
Photo: September 2011, R.F. Terblanche.

Photo 4: *Crematogaster* species at the rocky ridges where the host plant of *Chrysoritis aureus* (Heidelberg Copper butterfly), *Clutia pulchella* is present at the site.
Photo: September 2011, R.F. Terblanche.

4.2. Threatened invertebrate species

4.2.1. Butterflies

Table 2: Butterfly species in the Gauteng Province that appear in the present revised red data book of butterfly species in South Africa (Henning, Terblanche & Ball, 2009).
Invertebrates such as threatened butterfly species are normally very habitat specific and residential status imply a unique ecosystem that is at stake. No = 0; Yes = 1.

SPECIES	COMMON NAMES	GLOBAL CONSERVATION STATUS	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Chrysoritis aureus	**Golden Copper/ Heidelberg Copper**	Vulnerable	0	1
Aloeides dentatis dentatis	**Roodepoort Copper**	Vulnerable	0	1
Lepidochrysops praeterita	**Highveld Blue**	Endangered	0	1
*Metisella meninx**	**Marsh Sylph**	Vulnerable	0	1
*Platylesches dolomitica***	**Hilltop Hopper**	Vulnerable	?	?
*Orachrysops mijburghi****	**Mijburgh's Blue**	Vulnerable	0	1

* *Metisella meninx* is no longer treated as a threatened species based on valid new information on its distribution and abundance. *Metisella meninx* is at present regarded as a species of conservation concern in the Rare category (which is not a formal IUCN category): rare habitat specialist. Mecenero, S. et al. *In prep.* South African butterfly atlas. Part of SABCA: South African Butterfly Conservation Assessment: A joint project of the Animal Demography Unit (ADU) of the University of Cape Town, the South African National Biodiversity Institute (SANBI) and the Lepidopterist's Society of Africa (LepSoc). http://sabca.adu.org.za.

** *Platylesches dolomitica* is no longer treated as a threatened species based on valid new information on its distribution. Mecenero, S. et al. *In prep.* South African butterfly atlas. Part of SABCA: South African Butterfly Conservation Assessment: A joint project of the Animal Demography Unit (ADU) of the University of Cape Town, the South African National Biodiversity Institute (SANBI) and the Lepidopterist's Society of Africa (LepSoc). http://sabca.adu.org.za.

*** This entity may prove to be a different taxon of which only one or possibly two localities in Gauteng are known up to date. At present it is recognised as the Suikerbosrand population of *Orachrysops mijburghi* (Terblanche & Edge 2007).

4.3. Invertebrate species of high/special conservation significance

4.3.1. Butterflies

Table 3: Butterfly species of high conservation priority in the Gauteng Province due to localized distribution and habitat specificities.
The conservation priority of these butterflies is largely based on the unpublished Gauteng butterfly atlas work (G.A. Henning, P. Roos, M. Forsyth) and own records and analyses. No = 0; Yes = 1.

SPECIES	TRIVIAL NAME	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Lepidochrysops letsea	Free State Blue	0	1
Lepidochrysops tantalus	King Blue	0	1
Thestor basutus basutus	Basutu Skolly	0	1
Gegenis hottentota	Marsh Hottentot Skipper	0	1
Lepidochrysops procera	Potchefstroom Blue	0	1
Lepidochrysops ketsi ketsi	Ketsi Blue	0	1
Lepidochrysops ignota	Zulu Blue	0	1
Kedestes nerva nerva	Scarce Ranger	?	?
Lepidochrysops ortygia	Koppie Blue	0	1
Acraea anacreon	Orange Acraea	?	?

4.3.2. Fruit chafers

Table 4: Fruit chafer species (Coleoptera: Scarabaeidae: Cetoninae) in Gauteng Province that are known to be of high conservation priority. No = 0; Yes = 1.

SPECIES	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Ichnestoma stobbiai	1	0
Trichocephala brincki	0	1

4.3.3. Baboon spiders

Table 5: Baboon spiders species (Araneae: Teraphosidae) that are of known high conservation priority in the Gauteng Province. No = 0; Yes = 1.

SPECIES	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Brachionopus pretoriae	0	0

4.3.4. Trapdoor spiders

Table 6: Front-eyed or spurred trapdoor spiders species (Araneae: Idiopidae) that are of known high conservation priority in the Gauteng Province. No = 0; Yes = 1.

SPECIES	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Galeosoma pilosum	0	1
Galeosoma robertsi	0	1
Galeosoma scutatum	0	1
Segregara monticola	0	1

4.3.4. Rock scorpions

Table 7: Rock scorpion species (Scorpiones: Ischnuridae) that are of known high conservation priority in the Gauteng Province. No = 0; Yes = 1.

SPECIES	RESIDENT AT SITE	NOT FOUND/ UNLIKELY TO OCCUR AT SITE
Hadogenes gracilis	0	1
Hadogenes gunningi	1	0

4.4 Invertebrate biodiversity

Though many parts of the site have been modified, a variety of habitats still remain and the invertebrate diversity is suspected to be high. Invertebrate diversity at the rocky ridges is interesting and more additions could be made to the present species list.

5. DISCUSSION

5.1. Status of threatened butterfly species at the site

Studies about the vegetation and habitat of threatened butterfly species in South Africa showed that ecosystems with a unique combination of features are selected by these often localised threatened butterfly species (Deutschländer and Bredenkamp 1999; Edge 2002, 2005; Terblanche, Morgenthal & Cilliers 2003; Lubke, Hoare, Victor & Ketelaar 2003; Edge, Cilliers & Terblanche, 2008). Threatened butterfly species in South Africa can then be regarded as bio-indicators of rare ecosystems.

Six species of butterfly in Gauteng are listed in the revised red list and South African Red Data Book: butterflies (G.A. Henning, Terblanche & Ball, 2009). The expected presence or not of the threatened butterfly species follows.

***Chrysoritis aureus* (Golden Opal/ Heidelberg Copper)**
The proposed global red list status for *Chrysoritis aureus* according to the most recent IUCN criteria and categories is Vulnerable [VU B1ab(ii,iv)+2ab(ii,iv); D2] (G.A. Henning, Terblanche & Ball, 2009). *Chrysoritis aureus* (Golden Opal/ Heidelberg Copper) is a resident where the larval host plant, *Clutia pulchella* is present. However, the distribution of the butterfly is much more restricted than that of the larval host plant (S.F. Henning 1983; Terblanche, Morgenthal & Cilliers 2003). One of the reasons for the localised distribution of *Chrysoritis aureus* is that a specific host ant *Crematogaster liengmei* must also be present at the habitat. Research revealed that *Chrysorits aureus* (Golden Opal/ Heidelberg Copper) has very specific habitat requirements, which include rocky ridges of upper slopes with a steep southern slope (Terblanche, Morgenthal & Cilliers (2003). Though *Clutia pulchella*, the host plant is present in similar rocky landscapes as at the habitats of *Chrysoritis aureus*, it is highly unlikely that the butterfly is present. The host ant *Crematogaster liengmei* appears to be absent – only another *Crematogaster* species (Photo 4) has been found at the rocks where the host plant is present. Nectar sources at the rocky ridges also appear to be relatively poor. *Chrysoritis aureus* has never been found at rocky ridges with *Clutia pulchella* in the Magaliesberg, despite exploration by a number of butterfly collectors of this mountain series over decades. *Chrysoritis aureus* has not been found during the present surveys.

***Aloeides dentatis dentatis (*Roodepoort Copper)**
The proposed global red list status for *Aloeides dentatis dentatis* according to the most recent IUCN criteria and categories is Vulnerable [VU B2ab(ii,iii); D2] (G.A. Henning, Terblanche & Ball, 2009). *Aloeides dentatis dentatis* colonies are found where one of its host plants *Hermannia depressa* or *Lotononis eriantha* is present. Larval ant association is with *Lepisiota capensis* (S.F. Henning, 1983; S.F. Henning & G.A. Henning, 1989). The habitat requirements of *Aloeides dentatis dentatis* are complex and not fully understood yet. See Deutschländer and Bredenkamp (1999) for the description of the vegetation and habitat

characteristics of one locality of *Aloeides dentatis* subsp. *dentatis* at Ruimsig, Roodepoort, Gauteng Province. Recently new colonies of *Aloeides dentatis dentatis* have been discovered in the new section of the Suikerbosrand Nature Reserve (Terblanche & Edge 2007). There is no ideal habitat for *Aloeides dentatis* subsp. *dentatis* on the site and it is highly unlikely that the butterfly is present at the site.

Lepidochrysops praeterita **(Highveld Blue)**
The proposed global red list status for *Lepidochrysops praeterita* according to the most recent IUCN criteria and categories is Endangered [E A2c; B1ab(iv)+2ab(iv)] (G.A. Henning, Terblanche & Ball, 2009). *Lepidochrysops praeterita* is a butterfly that occurs where the larval host plant *Ocimum obovatum* is present (Pringle, G.A. Henning & Ball, 1994), but the distribution of the butterfly is much more restricted than the distribution of the host plant. *Lepidochrysops praeterita* is found on selected rocky ridges and rocky hillsides in parts of Gauteng, the extreme northern Free State and the North-West Province. The site falls outside the known extent of occurrence of *Lepidochrysops praeterita* (G.A. Henning, Terblanche & Ball, 2009). No ideal habitat appears to be present for the butterfly on the site. It is highly unlikely that *Lepidochrysops praeterita* would be present on the site.

Metisella meninx **(marsh sylph)**
The marsh sylph butterfly, *Metisella meninx*, is listed as a threatened species by Henning, Terblanche & Ball (2009). It should be noted *Metisella meninx* is at present regarded as a species of conservation concern in the Rare category (which is not a formal IUCN category) as a rare habitat specialist (Mecenero, S. et al. *In prep.* South African butterfly atlas. Part of SABCA: South African Butterfly Conservation Assessment: A joint project of the Animal Demography Unit (ADU) of the University of Cape Town, the South African National Biodiversity Institute (SANBI) and the Lepidopterist's Society of Africa (LepSoc). http://sabca.adu.org.za). Though *Metisella meninx* is more widespread and less threatened than perceived before, it should be regarded as a localised rare habitat specialist of conservation priority, which is associated with suitable patches of grass at wetlands. The larval host plant of *Metisella meninx* is rice grass, *Leersia hexandra* (G.A. Henning & Roos 2001). Unlike many other threatened butterfly species in South Africa no specific association with ant species is present in the early stages of the life cycle of the *Metisella meninx*. The ideal habitat of *Metisella meninx* is treeless marshy areas where *Leersia hexandra* (rice grass) is abundant. No ideal habitat for *Metisella meninx* appears to be present.

Platylesches dolomitica **(Dolomite Hopper)**
The proposed global red status for *Platylesches dolomitica* according to the most recent IUCN criteria and categories is Vulnerable [VU D2] (G.A. Henning, Terblanche & Ball, 2009). *Platylesches dolomitica* is a rare butterfly of which the habitat, presumably dolomite ridges, is still poorly known. *Platylesches dolomitica* could be found at the rocky ridges at the site. This recently described butterfly has been found to be widespread and not threatened or of particular conservation concern (Mecenero, S. et al. *In prep.* South African butterfly atlas. Part of SABCA: South African Butterfly Conservation Assessment: A joint project of the Animal Demography Unit (ADU) of the University of Cape Town, the South African National Biodiversity Institute (SANBI) and the Lepidopterist's Society of Africa (LepSoc). http://sabca.adu.org.za).

Orachrysops mijburghi **(Mijburgh's Blue)**
The proposed global red status for *Orachrysops mijburghi* according to the most recent IUCN criteria and categories is Vulnerable [VU D2] (G.A. Henning, Terblanche & Ball, 2009). *Orachrysops mijburghi* favours grassland depressions where specific *Indigofera* plant species occur (Edge, 2005; Terblanche & Edge 2007; G.A. Henning, Terblanche & Ball 2009). The Heilbron population of *Orachrysops mijburghi* in the Free State uses *Indigofera evansiana* as a larval host plant while the Suikerbosrand population in Gauteng uses *Indigofera dimidiata* as a larval host plant (Edge 2005; Terblanche & Edge 2007). There is

no suitable habitat for *Orachrysops mijburghi* on the site and it is unlikely that *Orachrysops mijburghi* would be present on the site.

Conclusion on threatened butterfly species
There appears to be no threat to any threatened butterfly species if the study site is developed.

5.2. Status of invertebrates of special conservation significance

Table 3 lists the butterfly species (Lepidoptera: Hesperiidae, Papilionidae, Pieridae, Nymphalidae and Lycaenidae) that are of known high conservation priority in the Gauteng Province. None of the above butterfly species were found on the site, or are likely to be resident at the site. There appears to be no threat to the butterfly species of high conservation significance if the developments are approved.

Table 4 lists the fruit chafer beetle species (Coleoptera: Scarabaeidae: Cetoninae) that are of known high conservation priority in the Gauteng Province.

***Ichnestoma stobbiai* (rare fruit chafer beetle)**
Ichnestoma stobbiai is an endangered fruit chafer (Scarabaeidae: Cetoniinae) that occurs in small habitat fragments of South Africa (Kryger & Scholtz, 2008). The adults of this species are short-lived and the females are flightless. Thus, the vagility of these beetles is extremely low (Kryger & Scholtz, 2008). The Cetoniinae (Coleoptera: Scarabaeidae) genus *Ichnestoma* Gory & Percheron, 1833 currently comprises 13 described species and is endemic to South Africa. The species *I. stobbiai* Holm, 1992 is thought to occur in a very restricted area in and around Gauteng Province and all habitat patches should be protected (Kryger & Scholtz, 2008; Deschodt, Scholtz & Kryger, 2009). Unlike most cetoniine larvae, the larvae of this species usually occur in dolomitic to cherty, well-drained soils (Deschodt, Scholtz & Kryger, 2009). *Ichnestoma* larvae feed under the soil surface and also pupate under the soil surface in specific grassland areas (Perissinotto, Smith & Stobbiai, 1999). All the habitat requirements of *Ichnestoma stobbiai* in these grassland patches are not fully understood yet, but it is normally a rocky area (dolomite to chert: see Deschodt, Scholtz & Kryger, 2009), consisting of grassland with a variety of indigenous grass species. From personal experience few trees occur in such patches, with species diverse grassland that are well developed in terms of succession. Rocks, often well-embedded in the soil, are scattered throughout such areas. There is suitable habitat for *Ichnestoma stobbiai* at the site and this beetle has been found previous to this study at the site.

There would be a threat to the rare and localised fruit chafer beetle, *Ichnestoma stobbiai* if some patches of the rocky ridge are developed.

Table 5 lists the baboon spider species (Araneae: Teraphosidae) that are of known high conservation priority in the Gauteng Province. None of the above baboon spider species were found on the site, or are likely to be resident at the site. There appears to be no threat to the baboon spider species of high conservation significance if the development is approved.

Table 6 lists the trapdoor spider species (Araneae: Teraphosidae) that are of known high conservation priority in the Gauteng Province. Most trapdoor spider species in general are regarded as being sensitive to environmental changes. There appears to be no threat to the trapdoor spider species of high conservation significance if the development is approved.

Table 7 lists the rock scorpion species (Scorpiones: Ischnuridae) that are of known high conservation priority in the North-West Province and Gauteng Province. Distribution of

Hadogenes gunningi is wider than perceived in the past and this unique scorpion does not qualify for threatened status (see Engelbrecht 2005). It remains however a localised species of conservation concern. *Hadogenes gunningi* is present at some patches of the rocky ridge at the site. There will be a threat to *Hadogenes gunningi* if some patches of the rocky ridge are developed.

5.3 Invertebrate biodiversity

Though many parts of the site have been modified, a variety of habitats still remain and the invertebrate diversity is suspected to be high. Invertebrate diversity at the rocky ridges is interesting and more additions could be made to the present species list. If a conservation area at the site is maintained and more indigenous plant species is cultivated in residential areas a very valuable contribution to invertebrate conservation can be made.

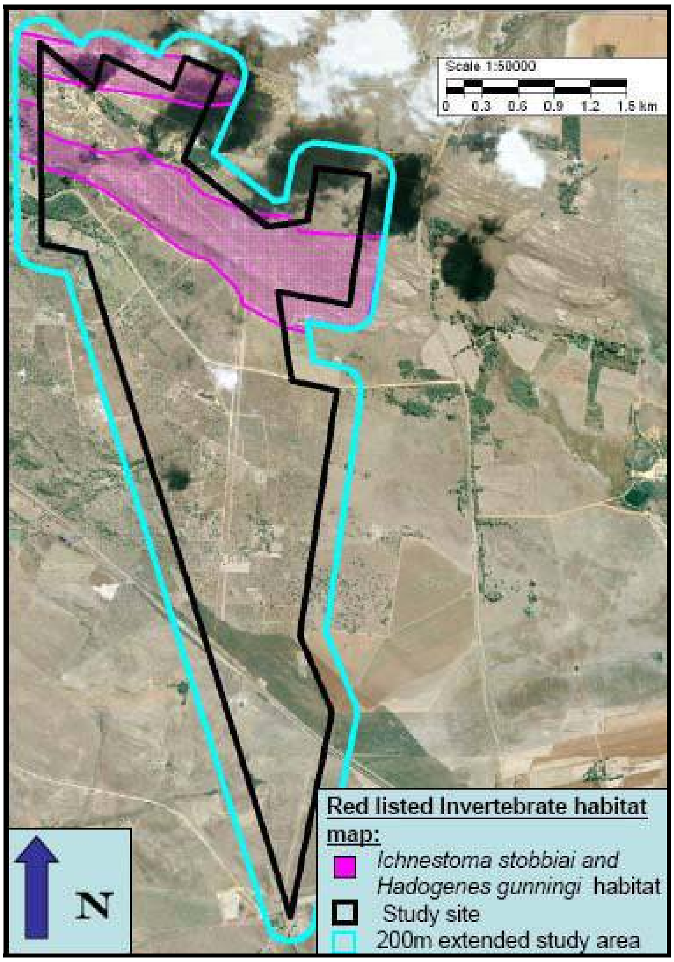

Figure 2: Map with a sensitive area, where the invertebrate biodiversity is high or where extant and potential habitats of *Ichnestoma stobbiai* are present.

6. IMPACTS AND MITIGATION MEASURES

Habitat conservation is the key to the conservation of invertebrates such as threatened butterflies (Deutschländer and Bredenkamp 1999; Edge 2002, 2005; Terblanche, Morgenthal & Cilliers 2003; Lubke, Hoare, Victor & Ketelaar 2003; Edge, Cilliers & Terblanche, 2008). Furthermore corridors and linkages may play a significant role in insect conservation (Pryke & Samways, 2003, Samways, 2005).

Urbanisation is a major additional influence on the loss of natural areas (Rutherford & Westfall 1994). In the Gauteng Province the pressure to develop areas is high since its infrastructure allows for improvement of human well-being in some way. Urban nature conservation issues in South Africa are overshadowed by the goal to improve human well-being, which focuses on aspects such as poverty, equity, redistribution of wealth and wealth creation (Cilliers, Müller & Drewes 2004). Nevertheless the conservation of habitats is the key to invertebrate conservation, especially for those red listed species that are very habitat specific. This is also true for any detailed planning of corridors and buffer zones for invertebrates. Though proper management plans for habitats are not in place, setting aside special ecosystems is in line with the resent Biodiversity Act (2004) of the Republic of South Africa.

Corridors are important to link ecosystems of high conservation priority. Such corridors or linkages are there to improve the chances of survival of otherwise isolated populations (Samways, 2005). How wide should corridors be? The answer to this question depends on the conservation goal and the focal species (Samways, 2005). For an African butterfly assemblage this is about 250m when the corridor is for movement as well as being a habitat source (Pryke and Samways 2003). Hill (1995) found a figure of 200m for dung beetles in tropical Australian forest. In the agricultural context, and at least for some common insects, even small corridors can play a valuable role (Samways, 2005). Much more research remains to be done to find refined answers to the width of grassland corridors in South Africa. The width of corridors will also depend on the type of development, for instance the effects of the shade of multiple story buildings will be quite different from that of small houses.

To summarise: In practice, as far as urban developments are concerned, the key would be to prioritise and plan according to special ecosystems.

In the case of this study site, there appears to be no loss of sensitive species and particularly sensitive habitats if a development, which excludes the ridges and associated rocky plateau, is approved. There would be a loss of connectivity of particular conservation importance if the developments are approved, with the exception rocky ridges.

Impacts:

- The loss of habitat
- The loss of sensitive species. Sensitive species are regarded here as the invertebrate species that are listed in Tables 1-4 and constitutes the invertebrate species that are red listed or of known particular high conservation importance. *Ichnestoma stobbiai*, a rare and endangered beetle species, is present on the site. Another invertebrate species of conservation concern *Hadogenes gunningi* (rock scorpion) is also present on the site. Both these species are associated with the rocky ridge at the site. During the operational phase, the significance of loss of habitat is expected to be high without and low with mitigation.
- The loss of habitat connectivity and open space

Mitigation measures:

- Proposed developments should be strictly confined to the areas planned for development and the remains of semi-natural vegetation along the water course should be conserved.
- No exotic invasive plant species should be planted in the areas to be developed, if the development is approved.

- A buffer zone of at least 30m should be allocated to all rocky ridges, rocky plateaus and wetlands beyond which no disturbance or vehicles should be allowed during the constructional and operational phases.
- Where infrastructural developments cross a wetland zone, the development should be confined strictly to the area where the development crosses over.

7. RECOMMENDATION

- It is highly recommended that the rocky ridges and rocky plateaus <u>not</u> be considered for future development.
- Wetlands if rehabilitated to include more indigenous vegetation could enhance invertebrate diversity at the site.
- If developments are approved the following recommendations apply:
  - It is recommended that where possible within overall conservation goals of this site, exotic vegetation should be removed and eradicated, especially invasive exotic species such as *Acacia decurrens* (green wattle).
  - Indigenous plant species are important for invertebrate conservation and if the development is approved, indigenous trees and vegetation should be conserved where possible.
  - There should be a focus to conserve patches of natural grassland and woodland vegetation.

8. CONCLUSION

The general biodiversity of invertebrates appears to be moderate at the residential areas and very low at patches of exotic trees (exotic *Acacia*, *Eucalyptus*). In contrast diversity of indigenous invertebrate species, such as reflected by beetles, butterflies and scorpions, appears to be high at the rocky ridge. There is considerable scope for the rocky ridges, including the rocky plateau to be corridors of considerable conservation importance.

A localised scorpion species, *Hadogenes gunningi* (rock scorpion) has been found at the rocky ridge. *Ichnestoma* stobbiai, an endangered fruit chafer (Scarabaeidae: Cetoniinae) that occurs in small habitat fragments of South Africa (Kryger & Scholtz, 2008) has been found at the site during previous studies. There is habitat that appears to be suitable for this rare beetle at the site. The adults of this species are short-lived and the females are flightless. Thus, the vagility of these beetles is extremely low (Kryger & Scholtz, 2008). The Cetoniinae (Coleoptera: Scarabaeidae) genus *Ichnestoma* Gory & Percheron, 1833 currently comprises 13 described species and is endemic to South Africa. The species *I. stobbiai* Holm, 1992 is thought to occur in a very restricted area in and around Gauteng Province and all habitat patches should be protected (Kryger & Scholtz, 2008; Deschodt, Scholtz & Kryger, 2009). Unlike most cetoniine larvae, the larvae of this species usually occur in dolomitic to cherty, well-drained soils (Deschodt, Scholtz & Kryger, 2009). *Ichnestoma* larvae feed under the soil surface and also pupate under the soil surface in specific grassland areas (Perissinotto, Smith & Stobbiai, 1999). All the habitat requirements of *Ichnestoma stobbiai* in these grassland patches are not fully understood yet, but it is normally a rocky area (dolomite to chert: see Deschodt, Scholtz & Kryger, 2009), consisting of grassland with a variety of indigenous grass species. From personal experience few trees occur in such patches, with species diverse grassland that are well developed in terms of succession. Rocks, often well-embedded in the soil, are scattered throughout such areas. There would be a threat to this rare and localised fruit chafer beetle, *Ichnestoma stobbiai*, if the rocky ridge is included in future developments.

Efforts by the local community to compile an inventory of invertebrates at the site, is to be commended and would hopefully be continued.

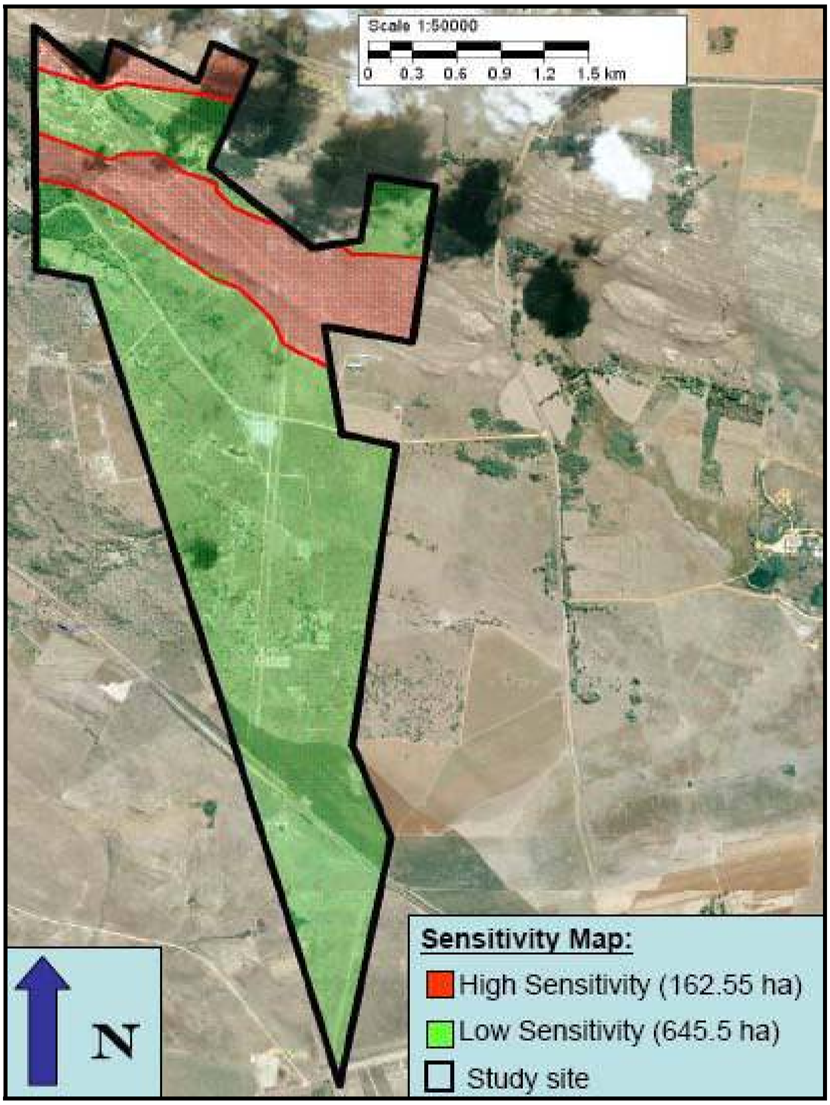

Figure 3: Invertebrate sensitivity map

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Appendix A

List of butterfly species that have been and which are likely to be recorded at the site.

Compiled by R.F. Terblanche
Sources of names and identifications:
Henning, Terblanche & Ball (2009); Pringle, Henning & Ball (1994); Woodhall (2005)

FAMILIES, SUBFAMILIES AND SPECIES	COMMON NAMES ENGLISH/ AFRIKAANS
FAMILY: PAPILIONIDAE	SWALLOWTAIL FAMILY SWAELSTERTFAMILIE
SUBFAMILY PAPILIONINAE	SWALLOWTAILS AND SWORDTAILS SWAELSTERTE EN SWAARDSTERTE
Papilio demodocus (Esper, 1798)	**Citrus Swallowtail** Lemoenswaelstert
Papilio nireus lyaeus Doubleday, 1845	**Green-banded Swallowtail** Groenlintswaelstert
FAMILY PIERIDAE	WHITES, YELLOWS AND TIPS WITJIES, GELETJIES EN PUNTJIES
SUBFAMILY COLIADINAE	YELLOWS AND CLOUDED YELLOWS GELETJIES EN WOLK-ORANJES
Catopsilia florella (Fabricius, 1775)	**African Migrant** Afrikaanse Migreerder
Colias electo electo (Linnaeus, 1763)	**African Clouded Yellow** Afrikaanse Wolk-oranje
Eurema brigitta brigitta (Stoll, 1780)	**Broad-bordered Grass Yellow** Grasveldgeletjie
SUBFAMILY PIERINAE	WHITES AND TIPS SUBFAMILY WITJIES EN PUNTJIES SUBFAMILIE
Belenois aurota aurota (Fabricius, 1793)	**Brown-veined White** Grasveldwitjie
Belenois creona severina (Stoll, 1781)	**African Common White** Afrikaanse Gewone Witjie
Colotis antevippe gavisa (Wallengren, 1857)	**Red Tip** Rooipuntjie
Colotis euippe omphale (Godart, 1819)	**Smoky Orange Tip** Donker-oranjepuntjie
Colotis evagore antigone (De Boisduval, 1836)	**Small Orange Tip** Klein-oranjepuntjie
Colotis evinina evinina (Wallengren, 1857)	**Common Orange Tip** Gewone Oranjepuntjie
Colotis eris eris (Klug, 1829)	**Banded Gold Tip** Goudpuntjie
Colotis subfasciatus subfasciatus (Swainson, 1833)	**Lemon Traveller Tip** Suurlemoensmous
Mylothris agathina agathina (Cramer, 1779)	**Common Dotted Border** Gewone Spikkelrandjie/ Voëlentwitjie
Mylothris rueppelli haemus (Trimen, 1879)	**Twin Dotted Border** Oranjevlerkspikkelrandjie
Pinacopteryx eriphia eriphia	**Zebra White**

(Godart, 1819)	Kwagga
Pontia helice helice (Linnaeus, 1764)	**African Meadow White** Bontrokkie
FAMILY NYMPHALIDAE	BRUSH-FOOTED BUTTERFLIES BORSELPOOTSKOENLAPPERS
SUBFAMILY DANAINAE	MONARCH SUBFAMILY MONARG-SUBFAMILIE
Danaus chrysippus chrysippus (Linnaeus, 1758)	**African Monarch** Afrikaanse Melkbosskoenlapper
SUBFAMILY CHARAXINAE	CHARAXES SUBFAMILY DUBBELSTERT SUBFAMILIE
Charaxes jasius saturnus Butler, 1866	**Saturn Foxy Charaxes** Saturnus-koppiedubbelstert
SUBFAMILY SATYRINAE	BROWNS SUBFAMILY BRUINTJIES-SUBFAMILIE
Paternympha narycia (Wallengren, 1857)	**Spotted-eye Brown** Koloogbruintjie
Stygionympha wichgrafi wichgrafi Van Son, 1955	**Wichgraf's Hillside Brown** Wichgraf-rantbruintjie
SUBFAMILY BIBLIDINAE	BYBLIA SUBFAMILY BIBLIA SUBFAMILIE
Byblia ilithyia (Drury, 1773)	**Spotted Joker** Leliegrasvegter
SUBFAMILY NYMPHALINAE	PANSY SUBFAMILY GESIGGIE SUBFAMILIE
Catacroptera cloanthe cloanthe (Stoll, 1781)	**Pirate** Seerower
Hypolimnas misippus (Linnaeus, 1764)	**Common Diadem** Gewone Na-aper/ Blouglans
Junonia hierta cebrene Trimen, 1870	**Yellow Pansy** Geelgesiggie
Junonia oenone oenone (Linneaus, 1758)	**Blue Pansy** Blougesiggie
Junonia orithya madagascariensis Guenée, 1865	**Eyed Pansy** Padwagtertjie
Precis archesia archesia (Cramer, 1779)	**Garden Commodore** Rots-blaarvlerk
Vanessa cardui (Linnaeus, 1758)	**Painted Lady** Sondagsrokkie
SUBFAMILY HELICONIINAE	ACRAEA SUBFAMILY ACRAEA SUBFAMILIE
Acraea horta (Linneaus, 1764)	**Garden Acraea** Tuinrooitjie
Acraea natalica natalica De Boisduval, 1847	**Natal Acraea** Natal-se-rooitjie
Acraea neobule neobule Doubleday, 1847	**Wandering Donkey Acraea** Dwaalesel-rooitjie
Acraea stenobea (Wallengren, 1860)	**Suffused Acraea** Dorslandrooitjie
Telchinia rahira rahira De Boisduval, 1833	**Marsh Acraea** Moerasrooitjie
Telchinia serena *(=Acraea eponina)*	**Small Orange Acraea**

Fabricius, 1775	Klein-oranjerooitjie
Phalanta phalantha aethiopica (Rothschild & Jordan, 1903)	**African Leopard Butterfly** Afrikaanse Luiperdskoenlapper
SUBFAMILY LIMENITIDINAE	BUSH-GLIDER SUBFAMILY BOSDANSER SUBFAMILIE
Hamanumida daedalus (Fabricius, 1775)	**Guineafowl Butterfly** Tarentaal-skoenlapper
FAMILY LYCAENIDAE	BLUES AND COPPERS BLOUTJIES EN KOPERVLERKIES
SUBFAMILY PORITIINAE	
Alaena amazoula (Boisduval, 1847)	**Yellow Zulu** Geelzoeloe
SUBFAMILY THECLINAE	HAIRSTREAKS AND COPPERS LANGSTERTE EN KOPERVLERKIES
Aloeides henningi Tite & Dickson, 1973	**Henning's Copper** Henning-se-kopervlerkie
Axiocerses tjoane (Wallengren, 1857)	**Common Scarlet** Ralierooivlerkie
Cigaritis mozambica (Bertoloni, 1850)	**Mozambique Bar** Mosambiek-se-streepvlerkie
Cigaritis natalensis (Westwood, 1852)	**Natal Bar** Natal-se-streepvlerkie
Deudorix antalus (Hopffer, 1855)	**Brown Playboy** Bruinspelertjie
Leptomyrina henningi Dickson, 1976	**Henning's Black-eye** Henning-se-swartogie
SUBFAMILY POLYOMMATINAE	BLOUTJIES AND CILIATED BLUES BLOUTJIES EN KORTSTERTJIES
Actizera lucida (Trimen, 1883)	**Rayed Blue** Witstreepbloutjie
Anthene amarah amarah (Guérin-Méneville, 1849)	**Black-striped Hairtail** Swartstreep-kortstertjie
Anthene butleri livida (Trimen, 1881)	**Pale Hairtail** Vaalkortstertjie
Anthene definita definita (Butler, 1899)	**Common Hairtail** Donkerkortstertjie
Azanus jesous jesous (Guérin-Méneville, 1849)	**Topaz-spotted Blue** Hemels-kolbloutjie
Azanus moriqua (Wallengren, 1857)	**Thorn-tree Blue** Doringboombloutjie
Azanus ubaldus (Stoll, 1782)	**Velvet-spotted Blue** Fluweel-kolbloutjie
Cacyreus marshalli Butler, 1898	**Geranium Bronze** Pelargoniumbrons
Cacyreus virilis Stempffer, 1936	**Mocker Bronze** Na-aperbloutjie
Chilades trochylus (Freyer, 1843)	**Grass Jewel Blue** Grasjuweeltjie
Cupidopsis cissus cissus (Godart, 1824)	**Common Meadow Blue** Vleibloutjie
Cupidopsis jobates jobates	**Tailed Meadow Blue**

(Hopffer, 1855)	Aasbloutjie
Eicochrysops messapus mahallakoaena (Wallengren, 1857)	**Grassland Cupreous Copper** Grasveldkoperbloutjie
Lampides boeticus (Linneaus, 1767)	**Longtailed Pea Blue** Langstert-ertjiebloutjie
Lepidochrysops patricia (Trimen, 1887)	**Patricia Blue** Patricia-bloutjie
Lepidochrysops plebeia plebeia (Butler, 1898)	**Twin-spot Blue** Dubbelkolbloutjie
Leptotes brevidentatus (Tite, 1958)	**Short-toothed Blue** Korttandbloutjie
Leptotes pirithous pirithous (Linnaeus, 1767)	**Common Blue** Gewone bloutjie
Pseudonacaduba sichela sichela (Wallengren, 1857)	**Dusky Blue** Dowwebloutjie
Tarucus sybaris sybaris (Hopffer, 1855)	**Dotted Blue** Spikkelbloutjie
Tuxentius melaena melaena (Trimen, 1887)	**Black Pie** Swartbontetjie
Uranothauma nubifer nubifer (Trimen, 1895)	**Black Heart** Swarthartjie
Zintha hintza hintza (Trimen, 1864)	**Hintza Pie** Hintza-bontetjie
Zizeeria knysna (Trimen, 1862)	**Sooty Blue** Duwweltjiebloutjie
Zizula hylax (Fabricius, 1775)	**Gaika Blue** Gaika-bloutjie
FAMILY HESPERIIDAE	SKIPPERS DARTELAARS
SUBFAMILY COELIADINAE	POLICEMEN KONSTABELS
Coeliades forestan forestan (Stoll, 1782)	**Striped Policeman** Witbroekkonstabel
Coeliades pisistratus (Fabricius, 1793)	**Two-pip Policeman** Dubbelkolkonstabel
SUBFAMILY PYRGINAE	SANDMEN AND ELFINS SANDMANNETJIES EN ELWE
Eretis umbra umbra (Trimen, 1862)	**Small Marbled Elf** Umbra-kabouter
Gomalia elma elma (Trimen, 1862)	**Green-marbled Sandman** Asjas-sandmannetjie
Spialia diomus ferax (Wallengren, 1863)	**Common Sandman** Kwagga-sandmannetjie
Spialia dromus (Plötz, 1884)	**Forest Sandman** Woudsandmannetjie
Spialia mafa mafa (Trimen, 1870)	**Mafa Sandman** Mafa-sandmannetjie
Spialia spio (Linnaeus, 1764)	**Mountain Sandman** Bergsandmannetjie
SUBFAMILY HETEROPTERINAE	SYLPHS WALSERTJIES
Metisella meninx	**Marsh Sylph**

(Trimen, 1873)	Moeraswalsertjie
Metisella willemi (Wallengren, 1857)	**Netted Sylph** Willem-walsertjie
Tsitana tsita (Trimen, 1870)	**Grassland Dismal Sylph** Grasveld Donkerwalsertjie
SUBFAMILY HESPERIINAE	RANGERS AND SWIFTS WAGTERTJIES EN RATSVLIEËRS
Gegenes niso niso (Linneaus, 1764)	**Common Hottentot Skipper** Gewone hotnot
Gegenes pumilio gambica (Mabille, 1878)	**Dark Hottentot Skipper** Donkerhotnot
Kedestes barberae barberae (Trimen, 1873)	**Barber's Ranger** Barber-se-wagtertjie
Pelopidas mathias (Fabricius, 1798)	**Black-banded Swift** Swartmerk-ratsvlieër
Pelopidas thrax inconspicua (Bertoloni, 1850)	**White-branded Swift** Witmerk-ratsvlieër
Platylesches ayresii (Trimen, 1889)	**Peppered Hopper** Ayres-se-hoppertjie

GALAGO ENVIRONMENTAL

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Ridge Ecology Assessment

of

Portion 4 of the farm Kleinfontein 368-JR

February 2013

Compiled by: Mr Bertus Fourie (B. Tech Nature Conservation)
Report verified/reviewed by: Dr. A.C. Kemp (Ph.D., Pr.Sci. Nat. (Zoology & Ecology))

i. DECLARATION OF INDEPENDENCE

Bertus Fourie is an ecologist in line with the Gauteng Department of Agriculture and Rural Development (GDARD) requirements and the utmost care was taken with the results provided in this report. To ensure the validity of the report, the report is verified by a second SACNASP-qualified Ecologist.

I, **Bertus Fourie,** declare that -

- I am subcontracted as specialist consultant by Galago Environmental CC for the Portion 4 of the farm Kleinfontein 368 JR Ridge Assessment;
- I will perform the work relating to the application in an objective manner, even if this results in views and findings that are not favourable to the applicant;
- I declare that there are no circumstances that may compromise my objectivity in performing such work;
- I have expertise in conducting the specialist report relevant to this application, including knowledge of the National Environmental Management Act, 1998 (Act No. 107 of 1998), regulations and any guidelines that have relevance to the proposed activity;
- I will comply with the Act, regulations and all other applicable legislation;
- I will take into account, to the extent possible, the matters listed in Regulation 8;
- I have no, and will not engage in, conflicting interests in the undertaking of the activity;
- I undertake to disclose to the applicant and the competent authority all material information in my possession that reasonably has or may have the potential of influencing - any decision to be taken with respect to the application by the competent authority; and - the objectivity of any report, plan or document to be prepared by myself for submission to the competent authority;
- All the particulars furnished by me in this form are true and correct; and
- I realise that a false declaration is an offence in terms of Regulation 71 and is punishable in terms of section 24F of the Act.

Bertus Fourie