**PROPOSED VERKYKERSKOP RURAL VILLAGE DEVELOPMENT IN THE PHUMELELA LOCAL MUNICIPAL AREA**

**ENGINEERING SERVICES REPORT**

*CIVIL & GEOTECHNICAL & TRANSPORTATION & ENERGY*

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# 1. INTRODUCTION

## 1.1 Terms of Reference

Verkykerskop Township Development (Pty) Ltd is the owner of certain land in and around the existing village of Verkykerskop in the Phumelela Local Municipal area in the eastern Free State.

The company has joined forces with the other land owners in the subject area to jointly embark on the development of the existing village. The Verkykerskop Development Consortium was established with the view to lodge a joint township establishment application.

The Consortium has participated in the public participation process steered by LMV Engineers and Town Planners, who has a mandate from the local municipality to submit a rural Spatial Development Framework for Verkykerskop. The mandating letter is included in **Annexure A**.

This report has reference to an assignment by Verkykerskop Township Development (Pty) Ltd (herein after referred to as the Developer) to a team of professionals for delivering all the necessary professional engineering and support services in regard to the subject project.

## 1.2 Purpose of this Report

In terms of the SDF process, the viability of the proposed development needs to be verified from a services point of view. This report aims to provide the necessary engineering information on which such judgement can be made.

The report is also intended to serve as basis for the negotiation of service mandates and agreements with the authorities.

The report states the engineering standards proposed for the development, determines the infrastructure requirements, and makes cost estimations of the initial capital investment, the maintenance cost, and subsequently the equitable contribution to the financing of the cost of services. In the engineering design, environmental aspects are also considered and addressed.

The scope of this report includes all services.

The Developer appointed specialist consultants to provide inputs to the development planning and engineering design. All the reports from the specialists have been received. Extracts from the specialist reports are included where necessary. For

further information, reference should be made to the specialist reports referred to in this report.

### 1.3 Project Team

The engineering professional team consists of the following responsible principals:

- Alf Raspi PrEng (Civil)
- Louis Grobler PrEng (Roads)
- Dr Gawie van der Merwe (Green Energy)
- CG Siza Consulting Engineers (hereinafter referred to as CG siza) (Electrical)

The scope of engineers' assignment covers the initial engineering services investigation (contained in this report), and subsequently also the detail design, documentation, tendering and construction supervision for the installation of the civil and electrical engineering services and infrastructure, including coordination with the other specialists on the team.

In addition to the team of engineers, the Developer appointed the following engineering and related professional consultants for specialist disciplines and assignments, referred to in this report:

- Piet Rheeder Land Surveyors for land surveying
- Trinmap for aerial photography and orthophoto mapping
- Geo-Logic for geohydrological studies
- Schalk Jacobzs PrEng for the dam design and dam construction application
- Schoeman en Vennote Consulting Engineers for the water licence application
- Soilcraft cc for geotechnical engineering
- Mlimisi for the agricultural and natural resources study.

The other built environment consultants for the project that were appointed by the Developer are as follows:

- MDA Environmental Consultants for the Environmental Framework, Scoping Report and Environmental Impact Assessment for both the village and the dam
- Gary White Architects for urban form and urban architecture
- Insight Landscape Architects for landscape architecture.

## 2. PROJECT DESCRIPTION

### 2.1 Brief Description and Location

The locality of the land earmarked for development is shown on the **Locality Plan 1**.

The extent of the land included in the study, the ownership, as well as the existing buildings and features, are shown on the **Current Status Plan 2**.

A master plan development framework for the proposed village has not been compiled yet, since that is to be the product of the SDF process.

However, the Developer envisages a development scenario that comprises of the densification and extension of the existing village (on a small scale), surrounded by larger erven and agricultural plots on the perimeter of the village, and with a small residential hamlet a short distance outside the main village.

Within this envisaged development concept, an illustrative layout of roads and services was developed, to be adjusted and refined following the SDF finalization, and to be finalized at township establishment stage.

However, the services design and layout as described herein is adequate to indicate the feasibility and viability at this stage, and conforms to engineering standards.

## 2.2 Development Scenario

The proposed development concept and assumed schematic layout on which the engineering analyses are based, is shown on the **Development Concept Plan 3**. In summary, the development scenario entails the following:

**Assumed development scenario**

| Component | Existing | Additional | Total |
|---|---|---|---|
| Residential high income (units) | 12 | 288 | 300 |
| Residential medium income (units) | 7 | 60 | 67 |
| Retail (m2) | 1500 | 3000 | 4500 |
| Filling station (pumps) | 2 | 0 | 0 |
| Restaurant/pub/bar (seats) | 100 | 200 | 300 |
| Storage and sheds (m2) | 3500 | 2500 | 6000 |
| Light industry (m2) | 2000 | 1000 | 3000 |
| Police station (m2) | 5000 | - | 5000 |
| Community hall (seats) | 200 | 200 | 400 |
| Guest house/hotel/lodge (rooms) | 12 | 88 | 100 |
| Sports/club house (m2) | - | 1000 | 1000 |
| Church (seats) | - | 60 | 60 |
| Public offices and services e.g. post office, clinic, welfare (m2) | 60 | 340 | 400 |
| School (learners) | - | 50 | 50 |
| Auction kraals (ha) | 2 | - | 2 |

*Note: surface area refers to Gross Building Floor Area (assuming all buildings are one story only)*

## 2.3 Terrain, Topography and Geology

The typical environment consists of the rural village surrounded by extensive farmlands, as can be seen on the **Current Status Plan 2**.

The agricultural land use and land features can be seen on the **Topographical Plan 4** and on the **Agricultural Potential Study General Layout Plan 5**. Approximately 20 percent of the land area was earlier cultivated, leaving 80 percent of the land in a virgin state.

The topography is rolling to hilly, with the village lying on the saddle between two plateaus, dropping down into a fairly deep gorge on the east of the village. From a development point of view the landscape is very forgiving, as illustrated by the following:

- There is adequate elevation close to the village to accommodate a reservoir from where potable water can be gravitated to the whole development.
- A valley runs out to the east from the village centre, presenting north facing slopes ideal for residential development.
- The whole development lies within only one large and one small drainage basin, making storm water management and water borne sewage collection very viable.
- The larger of the two catchments has an ideal dam site just before the stream exits the land.

It can be concluded that the installation of reticulation services for the proposed extended village does not pose any significant engineering challenges, since all development will be on the saddle, and on the gentle slopes and natural terraces running off the plateau.

A scan of the scale 1:250,000 Geological map series is included in **Annexure B**. The following geological description of the area is given from the map:

- Apart from the Dolerite intrusions, there are two base formations namely the Verkykerskop Formation, and the underlying Normandien Formation.
- The Verkykerskop Formation, lying within the Tarkastad Subgroup, has remained on the plateaus and comprises 80% of the land area in the study area. The soils of the Verkykerskop Formation are typified by fine to course grained veldspathic sandstone, subordinate siltstone and brown-red mudstone.
- The Normandien Formation, lying within the Adelaide Subgroup, is exposed along the slopes of the valleys below an altitude of 1825 (covering the

remaining 25%). The soils of the Normandien Formation are typified by olive-green and grey mudstone, and subordinate sandstone.

- The base formations originate from the late Triasic period, while the intrusions originate from the much younger Jurasic period.
- Both formations form part of the Beafort Group which is part of the Karoo Sequence.
- There are three main intrusions on the land (see **Topographical Plan 4**), all running from west to east and separated by about 700m. The southern intrusion is the largest, stretching from the dolerite koppie on the high ground in the west, visible again in the form of two kloofs intersecting the gorge in the east.
- On the lower valley floors on the farm, subsequent layered alluvium is found, with origins ranging from dolerite, sandstone and mudstone.
- Adjacent to the subject land, the higher table top maintains are far in between remainders of the Elliot Formation, with a very small cap of the Clarence Formation left.
- The Meul River Valley down below is covered with an extensive sandy loamy alluvium that originates from all of the formations as well as the extensive dolerite intrusions described above.

Regarding the geology, it can be concluded that the formations are forgiving, not posing any significant engineering challenges for development.

## 2.4 Current Use and Natural Resources Potential of the Land

The land included in the study area covers a total size of approximately 860 ha owned by six different land owners in the form of 15 different title deeds, as shown on the **Current Status Plan 2**.

The buildings and amenities in the village are concentrated on approximately 43 ha of land in the study area, which portion of land can broadly be regarded as the existing village. The type and extent of these developments are described in section 2.2 above. The following is a further detailed description of the buildings and amenities in the village:

- The 12 high income residential houses (permanent residences and rented accommodation) include the Afsluit guest house, the Umgidi guest house and back packers rooms, residential apartments annexed to the general dealer, two farm houses, the old blacksmith shop which is currently used as residence, and six houses as part of the police station complex.
- There are seven permanent medium income residences on two of the titles.
- In addition to the restaurant in the general dealer, there is also a “pub” bar, and 1500 m2 retail area. This is made up by the general dealer and the Afgri shop.

- The Afgri shop also has diesel and petrol pumps and 3500m2 of storage sheds and an open material storage yard.
- There is a camping site next to the pub, with permanent ablution block and semi-permanent chalets.
- Next to the general dealer there is an old mill, planned to be rehabilitated to working order, as well as a carpentry workshop, with a total floor area of 2000m2.
- The old post office is currently used as art studio. The old one man school is used as a barn. Then there is the Boeresaal with amenities and the auction kraals, and lastly, the police station.
- There is an old school which is currently being renovated to be used as a cottage.
- There is an old homestead east of the village in the valley.
- There is a mobile phone tower in the village.

The current usage of the undeveloped land outside the village is described in detail in the **Agricultural Potential Study Report**[1] that was done for Verkykerskop Township Development (Pty) Ltd by Mlimisi Agricultural Consultants. In summary, the agricultural land outside the village comprises the following:

- 47 ha of land currently being cultivated
- 212 ha of un-rehabilitated old lands not having been cultivated for a long time
- 54 ha of steep slopes not readily accessible for grazing by domestic animals
- 41 ha of wetlands that is not to be utilized for grazing or any other purpose
- the remainder, approximately 465 ha, being natural veldt usable for grazing.

One of the stated primary objectives of the developer is to instate best-practice land use policies comprising the protection and rehabilitation of sensitive natural areas and the sustainable use of the natural resources. The developers intend to continue utilizing the land as a working farm, and to even intensify farming activities in a sustainable manner as part of the lifestyle of the township residents. Within this brief, the consultants developed a land use and farming plan to be implemented within the context of the proposed township and common land. The plan comprises reclamation of old unused lands and low potential currently used lands, and a new farming plan for all of the land.

The economic potential of the land was modelled for the present undeveloped situation as well as for the proposed land utilization and farming plan within the context of the proposed development in order to determine the impact of the development on the agricultural potential of the land.

The following conclusions were drawn:

- The state of the land is poor due to years of ineffective and unsustainable utilization. The current economic potential of the land is a potential net profit of

only R134 000 per annum. The total land cluster in the study area is thus not an economical agricultural unit.

- The development will result in 55 ha of the total land area being effectively lost for agricultural use. Since the areas to be developed are situated on the lower potential zones, the economic impact will be negligible (the total current potential is reduced by R2 000 per annum, which is 1,4%).
- The proposed land reclamation and farming plan, including the impact of the development, will increase the sustainable net annual profit from farming activities by 2,8%.
- Not accounted in the above is the significant additional economic potential of the natural resources of the land that will be brought about by the proposed development in the form of ecotourism and recreational activities.

The current land use of agricultural land, as well as the proposed reclamation and intended usage, are shown on the **Agricultural Potential Study General Layout**, included as **Plan 5** at the back.

# 3. ENGINEERING STANDARDS AND INFRASTRUCTURE

## 3.1 Water

### 3.1.1 Demand

*Guidelines for Engineering Services and Amenities* [2] recommend the levels of service to be used in design of engineering services. Level of Service 3: *on site provision and on site metering*, was accepted as standard for the provision of water for all residential and non-residential erven of the development.

**High income residential**

The residential water demand for the high income component is based on the average household consumption of 1500 litres per day of the typical farmhouse in the area, providing for the following downscale factors when calculating the annual daily demand:

- Factor of 0.6 to take account of the anticipated recreational use character of the largest portion of the development.
- Factor of 0.6 to take account of the demand management rules that are anticipated to be enforced regarding garden watering (see 3.1.7)

The average annual daily demand for the high income component then works out at 540 litre per stand per day.

As a comparison, recently researched [3] per capita consumption figures of a number of Western Cape villages were reviewed. Consumption varied between 100 l/c/d and 310 l/c/d for the 48 communities reported, with an average of 201 l/c/d. The most comparable villages, being inland rural villages with a high component of holiday homes, are those of Riebeeck West and Riebeeck, with daily per capita consumption of 100 l. An average home occupation of four to six persons could be expected. This would give an average daily per household consumption of 500 l.

The average annual daily demand for the high income component is thus taken as 540 litre per stand per day, as calculated from the first reference with the downscaling factors.

**Medium income residential**

The residential water demand for the medium income component is taken as the upper value of the recommended range in the *Guidelines for Engineering Services and Amenities* [2] for multiple tap household connection of 250 litres per household per day.

**Calculation of total annual water demand of development**

Working on the values recommended in the *Guidelines* for non-domestic uses, supplemented by assumed values where values are not recommended, the water demand of the development is calculated as follows:

**Calculation of total annual water demand**

| Component | Total units | Average daily demand (l) | Total annual demand (kl) |
|---|---|---|---|
| Residential high income (units) | 300 | 540 | 59,000 |
| Residential medium income (units) | 100 | 250 | 9,000 |
| Retail (m2) | 4500 | Assume 1 litre | 1,600 |
| Filling station (pumps) | 5 | Assume 100 litre, no car wash | 200 |
| Restaurant/pub/bar (seats) | 300 | 90 | 9,900 |
| Storage and sheds (m2) | 6000 | Assume 1 litre | 2,200 |
| Light industry (m2) | 3000 | Assume 3 litres | 3,300 |
| Police station (m2) | 5000 | Assume 2 litre | 3,700 |
| Community hall (seats) | 400 | Not included, own borehole | - |
| Guest house/hotel/lodge (rooms) | 100 | Assume 100 | 3,600 |
| Sports/club house (m2) | 1000 | Assume 4 litres | 1,500 |
| Church (seats) | 60 | 25 | 600 |
| Public offices and services e.g. post office, clinic, welfare (m2) | 400 | Assume 10m2/person, 40 litre / person | 600 |
| School (learners) | 300 | 10 | 1,100 |
| Auction kraals (ha) | 2 | Not included, own borehole | - |
| **Total annual water demand** | | | 96,300 |

**Average daily demand**

From the above, dividing by 365, the average annual daily demand is 264 kl/day.

**Peak demand**

It is deemed not economically justified to design the extraction and delivery works for the worst case scenario of peak demand, i.e. where the garden watering demand peaks at the same time as the visiting seasonal peak (Easter and December). It is also not likely that the two demand peaks will occur simultaneously, since December and April fall within the rainy season. During these seasonal peak periods, garden watering will be restricted if necessary in terms of the demand management measures as described in 3.1.8 below.

The design peak demand parameters are thus calculated as follows:

- Design daily peak demand:
  Average daily demand of 264 kl/day
  Seasonal peak flow rate for holiday season: 1.6
  Design daily peak demand = 422 kl/day

- Design peak extraction rate to be delivered from all sources together:
  Design daily peak demand of 422 kl/day
  In order to optimize on the delivery works, 24 hour pumping is assumed
  Design peak extraction rate = 422 kl/day / 24 / 3.6
  = 4,9 l/s

- Clean water gravity main design peak flow:
  = 4,9 l/s x Peak time factor of 1.5
  = 7.3 l/s

### 3.1.2 Alternative Sources

**Current situation**

The current land uses are serviced from on-site boreholes of low yield. The police station recently ran out of water after their borehole dried up, and they are carting water from town. Other current land uses all make use of low yield boreholes as well, situated on the plateau where the village is. A more reliable source of water needs to be developed urgently for the village as it is now already. Any substantial extension of the village will hasten this requirement.

Following from discussions with the other land owners in the study area, they would all prefer to connect to the village water supply system, with the exception of the Boerevereniging, owning the auction kraals and community hall. Their borehole supply and storage has been adequate over the years for their low and intermittent demand.

During the open public meeting as part of the SDF process, the Area Commander of the Police stated that they have a serious water supply problem, and look forward to the water supply from the development. In discussions with the Engineer, the newly appointed station commander supported negotiations with the view to lead to supply of water by the Developer to the police station as a matter of urgency. Save for continuous communication at station level, no formal discussions have been conducted between the Developer and the Department of Public Works or the SAPS at higher level.

**Possible sources**

The Developer identified the following possible sources of water:

- Underground water on the land owned by the Developer
- Storage on site, of surface run-off from the land owned by the Developer
- Augmentation of the above on-site sources during dry cycles by extracting from the alluvium aquifer of the Meul River approximately 3km downstream of the south boundary of the Developer's land
- Roof water collected in tanks at individual stands for garden watering
- Irrigation of common areas and fodder for farm animals using grey water produced by the village.

**Meul River**

While no studies have been conducted on this source, the following can be reported:

- Water will have to be extracted from below the surface since the river runs dry during dry cycles. To extract the peak demand of 4,9l/s, a well field or a number of shallow boreholes connected to a single extraction pipe will be necessary.
- No recharge calculations have been made, but the average daily demand of 264 kl seems an insignificant quantity relative to the size of the aquifer.

This source was ruled out as an option at an early stage due to the adequacy of more economical and more viable sources on the developer's land close to the village.

**Underground source**

The Developer appointed Geo-Logic Consultants to conduct a *Geohydrological Assessment Study* [4] with the view to determine the underground water potential on the land owned by the Developer. Their study reported the following findings:

- The geophysical study identified three areas of potential. Exploration drilling was done in two of the areas. The last area had a large risk of being unsuccessful and was subsequently not drilled.
- Constant yield tests were done in the dry season of 2007, which happened to be one of the driest years in 30 years, confirming the following yields:

| Borehole | abstraction rate | recommended daily yield | annual yield |
|---|---|---|---|
| | (l/s) | (kl/day) | (kl pa) |
| 1. Valley 1 | 1 | 86 | 48,000 |
| 2. Valley 2 | 1.7 | 147 | 48,000 |
| 3. Village | regarded as interim boreholes only | | |
| Total | 2.7 | 233 | 111,800 |

The use of any of the above sources is subject to obtaining a water licence (see 3.1.9 below). Preparation of an application for a water use license is dependent on this engineering report. Secondly, the application of a water use license will be lodged only once the layout plan has been approved. However, in the analysis of the author, permission to use the underground source is not likely to be withheld, but an analysis of the chances of obtaining permission to extract surface water is not within the expertise of the author. For this reason, the viability of the underground source as only source at this stage was necessary.

Borehole extraction was hence designed independent of the storm water dam source, meaning that underground abstraction must be capable of meeting the demand as far as possible in the event that the storm water dam source is not available, or fails.

Boreholes 1 and 2 in the valley are capable of delivering 233 kl/day jointly, when pumping for 12 hours per day alternating. From the recharge models, the geohydrologist estimates that the above abstraction is sustainable in the long term. This is just adequate for the off-peak period for the whole development, but is only 55% of the design peak demand of 422 kl/day in the peak season.

The shortfall in supply will have to come from the surface storm water source if the development is to be extended to the full planned extent.

**Surface water source**

A dam site was identified, a dam hydrological study done, and a detailed engineering design developed. The information related to the dam is as follows:

- The most viable location for collection of surface water is below the confluence of the two gorges on the south boundary of the land. This location not only maximises the catchment of the dam but the area presents economical dam site options. The dam basin is fairly steep which will reduce evaporation and minimize the effect of water level fluctuations from a recreation and aesthetics point of view.
- There are no other surface water use licences between the dam site and the confluence with the Meul River approximately 3km down stream.

- The 665 ha dam catchment area almost entirely falls within the land owned by the Developer.
- Illustrative dam sizes were modelled on the topographical 3-D terrain model. The spillway will accommodate the 1:100 year storm flood totalling 125 m³/s.
- The selected dam has a capacity of 327 200 m³. The full supply surface area is 6,95 ha.
- The maximum dam wall height is 13,3m.

The localities of the boreholes and dam, the catchment of the dam, and the full supply surface area of the dam, are indicated on the **Water Resource Plan 6**.

The preliminary **General Layout** of the Main Water Supply Reservoir and the preliminary **Wall Sections and Detail Design** of the dam are shown on **Drawings 7 and 8** respectively.

The main results from the *Hydrological Analysis report* [5] are summarized as follows:

- The firm yield of the dam is 105 061 m³ per annum as compared to the demand of 96 300 m³ pa. This capacity margin is very small, so that lowering the capacity of the dam should not be considered without concomitant curtailment of the project development.
- Surface water abstraction needs to be supplemented by ground water abstraction in order to ensure sustained supply during periods of peak demand, drought, and other unknown factors.
- Only 17% of the available surface water and 6% of the available borehole water are consumptively used by the development. Another 6% of the surface water is lost due to evaporation from the dam, letting through 77% of the surface water source. This amount of water is six times the guideline reserve amount for the environment.

**Conclusions**

The main conclusions from the report are as follows:

- For the water resource development plan as proposed and as was modelled in the hydrological investigation, the proposed development is viable from a water resource viewpoint.
- The abstraction, size of dam and quantity of surface run-off are in balance from an assurance of supply point of view, and from an environmental point of view.
- The specialist report recommends that the approval of the dam and proposed abstraction be favourably considered from a hydrological point of view.

- Both the dam hydrologist and the geohydrologist recommended that the surface water source and the underground water source be seen as a singular source due to the closeness of the boreholes to the dam, and that abstraction be managed in an integrated manner. On its own, neither of the ground water or the surface water sources are adequate to meet the water demand of the proposed development in a sustainable way, but together, the two sources provide an acceptable level of supply assurance.

### 3.1.3 Purification and Quality

Raw water abstracted from the two primary boreholes as well as the raw water abstracted from the storm water storage dam will be impounded in the same clear water storage reservoir.

The ground water source complies with potable water standards. The water test results are included in the Geohydrological Assessment report, confirming the pristine quality of the water. No filtration or purification is needed other than chlorination of the stored water before use. For the kick-off stage of the development where the boreholes will probably be the only source, no filtration will be necessary.

The raw water quality of the storm water source will be fairly good as well since no significant amount of sediment is expected to be carried to the dam. The catchment is pristine, with very limited active erosion. The grass coverage is good. The cultivated land is on the far side of the catchment, with adequate grassland and wetland buffer zones on the overland flow path to the dam. On the entrance to the dam, there is a significant wetland where final settlement will take place. The abstraction from the dam will be into an inlet tower of which the intake will be well above the floor of the dam to prevent intake of silted water, and which will also be well below the average operating level of the dam to prevent intake of floating debris.

Treated water from the sewage treatment package plants will comply with DWAF standards for letting water back into the environment. In addition, it is envisaged that most of the outflow will most of the time be irrigated onto pastures and gardens on the plateau well before filtered water reaches the streams leading to the storage dam. It is highly unlikely that the closed system of receiving treated sewage water into the storage dam will lead to build-up of contaminants in the source, for the following reasons:

- The extensive grass cover in the upper zones of the catchment where the treated water will be discharged combined with the wetlands that buffer the storage dam from the feeding streams, will act as a very large and effective filter of any water reaching the dam over land.
- The find sandy loamy subgrade will act as a very large filter on any seepage water that reach both the underground or the surface water source.

- The filtering effect as described above is strengthened by the distance between the discharge points and the sources of several kms.
- The volume of used water discharged into the catchment of the surface water source is insignificant in relation to the size of the storage dam. The total sewage effluent is in the region of 60 000 $m^3$ pa compared to the 327 000 $m^3$ volume of the storage dam, which will be 70% full on average.
- Concentration of any contaminants that might reach the storage dam will be continually diluted, making build-up unlikely. The average annual runoff in the catchment to the dam is 546 000 $m^3$ as compared to the total sewage production of 60 000 $m^3$ pa.

Abstraction from the two sources (underground and storage dam) will be manually selected with the view to sustain the minimum outflow for the environment and to minimize fluctuating water levels in the dam. A sand filter will be fitted on-line on the dam delivery pipe delivering to the pump house, so that filtered water is pumped from the dam. The borehole water will be pumped unfiltered.

Since the pump main will go through the reticulation network on its way to the reservoir, the water delivered into the system must be adequately sterile. An on-line chlorine dosage installation will be fitted on the pump main from the dam pump, and on each of the pump mains from the two boreholes. The reason why separate dosage installations instead of one installation after the confluence of the pump mains from the various sources is recommended, is that the need for chlorination will be different for the different sources. It will in all probability not be necessary to chlorinate the borehole water, except possibly during long dry spells when contaminated dam water could affect the underground source. Dosage will be manually adjusted according to monitoring results.

To prevent sediment built-up and to clean the system of any dirty water contamination that might have taken place during dry cycles, the delivery pipe under the dam wall will be used to do scouring during wet cycles and whenever high levels of storage prevail. For this purpose, the sand filter on the delivery line will have a by-pass.

It can thus be concluded that the quality of raw water from the storm water source will be very good, and does not pose any engineering challenges or special treatment.

Even though the water pumped into the clean water storage reservoir will be adequately sterile when impounded, it might be possible that the water become contaminated while stored. This is pertinently so because of the low demand of the village during off-peak season. Therefore, another chlorine dosage facility is necessary so that the stored water can again be dosed before let back into the network.

### 3.1.4 Clean Water Storage Capacity

The storage requirement for the kick-off phase of the development can be met by the existing reservoir near the position of the proposed new reservoir. The existing reservoir will be disengaged once the new reservoir is built.

The capacity of the clean water reservoir is calculated as follows:

- Average daily demand of 264 kl/day
- Two days storage
- No seasonal peak factor for holiday season is deemed necessary since all three pumps will feed directly into the reticulation system, and since demand management can be applied if necessary
- Capacity of clean water reservoir = 264 kl/day x 2 days
  = 530 kl

No additional storage capacity is deemed necessary for fire fighting purposes since the delivery pumps supply directly into the network at an adequate pressure (hydraulic head of approximately 100m) and at an adequate flow rate (3 l/s if one pump; 12 l/s if all three pumps).

A cylindrical reservoir with a diameter of 15m and height of 3m will be excavated into the ground on the hill. It will be lined with sheeting and provided with an earth berm to make it inconspicuous, and it will be fenced for protection. Due to the clean environment and the good grass cover surrounds, it will not be necessary to cover the reservoir.

The locality of the existing reservoir, the proposed new reservoir, the main line, and sand filters and the chlorine dosage installations are all shown on the **Water System Plan 9**.

### 3.1.5 Reticulation Network and Analysis

The reticulation network is shown on the **Water System Plan 9** in the context of the above described abstraction and storage facilities. The functioning of the water system with its direction control valves and pressure control valves is schematically described on the same drawing.

It is highlighted again that the reticulation layout is illustrative since the township layout will be subjected to the SDF process, after which the detail design of the network will be reviewed. At this stage, it is foreseen that the main water network will work as follows:

- The pumping main will run up the valley through the village, then turns northwards up the hill to the proposed new reservoir north of the village.
- A booster pump is provided halfway up the rise to the clean water reservoir.
- No secondary reservoirs will be required.
- The clean water reservoir will deliver by gravity back into the pumping main, which will serve also as the main delivery line gravitating back into the reticulation network.
- Between the source and the village there will be no connections on the pumping main. The hotel and the hamlet in the floor of the valley will instead be served from a reticulation gravity line from the village.
- Between the clean water reservoir and the village centre, the pump main will act as gravity main from which connections will be made to the part of the village to the west of the main road as well as to the hamlet on the northern face of the valley.
- From the village centre, the gravity main will run south through the inner village towards the southern part of the village west of the main road. Since this part of the village is lying highest and furthest from the reservoir, this part of the network comprises the lowest pressure zone and thus determines the minimum elevation of the reservoir.
- With the outlet level of the clean water reservoir at elevation 1,950m and the elevation of the highest point of delivery at elevation 1,925m, the whole network is under gravitation from the one reservoir.
- Pressure control valves will be necessary only on the reticulation lines serving the lowest lying hamlets and the hotel.
- Bulk water meters will be fitted so as to monitor logical sections of the network for leakages and reconciliation of individual usage.
- Scour valves are provided at all low points of the network and air valves are provided on crests in the vertical alignment.

It is not economical to extend the water network to the facilities in the south eastern corner of the development. Water for the shooting facility will have to be carried by sportsman, while water for the sand cutting operation will be provided by water cart or local additional borehole to be investigated in future.

The reticulation network was analysed with the Civil Designer computer suite. Hydrostatic pressures of between 2,5 and 12,5 Bar prevail in the reticulation network, which will be contained to a maximum of 9,0 Bar by means of pressure control valves.

The reticulation network will consist of uPVC pipes of classes 3 up to 9, which will vary between 35 and 90 mm nominal diameters.

The proposed erf water meters are 20mm OPTIMA 2000 with a meter box or similar, all SABS approved.

The works will be designed according to the *Guidelines for the Provision of Engineering Services and Amenities*[2] components and the components will be specified under the standards of the SABS1200 series.

### 3.1.6 Specifications of Delivery Lines and Pumps

**Description of delivery lines**

The delivery lines will operate as follows:

- The boreholes and the storage dam are close together and will thus share the same rising main from the point of confluence.
- Borehole 1 is located on the outside fill toe of the dam wall at a surface elevation of 1754m. The submersible pump will be at elevation 1739m, 15m below surface, which is at the first water strike level.
- Borehole 2 is located within the dam basin at a surface elevation of 1756m. The borehole will have an elevated encasement of 7m that rises up to the elevation of the dam wall of 1763m. The borehole service access will be a jetty from the west bank that will also serve as pipe bridge from which the pipe and electrical supply will be supported. The jetty will be used by fishermen and as moor for small vessels. The borehole encasement will be stabilized against the jetty tower. The submersible pump will be at elevation 1728m, 28m below surface, which is at the first significant water strike level.
- The intake to the storage dam abstraction pump will be by means of an intake tower connected to the pump house by means of the drain and delivery pipe underneath the dam wall. The intake tower level is around 1754m, which is 3m above the floor of the dam basin at that position.
- Each abstraction line (the two boreholes and the dam drain and delivery pipe) will have a non-return valve.
- An online sand filter with a bypass pipe will be fitted to the dam delivery pipe.
- Each of the three abstraction pipes will be fitted with a chlorine dosage facility before the confluence of the abstraction lines into the pumping main.
- Non-return valves are provided all along the rising main so as to reduce water hammer effect.
- Halfway up the rise between the source and the clean water reservoir, a booster pump will be provided on the pump main, at elevation 1850m.

**Pump line specifications**

In economizing on the pumping cost, the following pipes are needed:

| | Working pressure | Pipe Class | Diameter |
|---|---|---|---|
| | (kPa) | | (mm) |
| • Borehole abstraction pipes: | 1220 | 16 | 90 |
| • Dam delivery pipe: | 1260 | 16 | 110 |
| • First lift to booster pump: | 1260 | 16 | 110 |
| • Second lift to reservoir: | 1260 | 16 | 110 |

**Pump specifications**

For flexibility of source utilization, the supply pumps are designed for the worst of the following two source scenarios:

- Where the underground source is the only source, and for the borehole utilization plan as described in 3.1.2 above.
- Where the storm water dam is the only source.

In case of failure of the electric motor or power supply failure, only at Borehole 1 will there be a standby diesel motor. No standby pumps are deemed necessary at the abstraction points. In addition to a standby pump, the electric motor booster pump installation is to be fitted with a standby diesel motor.

The pump specifications in order to cater for the design peak flow rates and hydraulic heads, and allowing for 25% over capacity of flow, are as follows:

| **Position** | **Energy supply** | **Abstraction rate** (l/s) | **Pump duration** (hrs/day) | **Hydraulic head** (m) |
|---|---|---|---|---|
| Borehole 1 | electric & diesel | 3,1 | 24 | 20 |
| Borehole 2 | electric | 3,1 | 24 | 20 |
| Dam | electric | 6,2 | 24 | 180 |

### 3.1.7 Operations and Maintenance

Elements that will require routine monitoring, operation and maintenance are as follows:

- Securing the jetty on which Borehole 2 abstraction is fitted
- Underwater cleaning of the grid sieve on the dam intake tower
- Inspecting the borehole submersible pumps

- Servicing the pumps, electric motors, and electricity connections of the abstraction points
- Checking the starter battery charging of the standby engines
- Checking the diesel engines and diesel levels of the standby engines
- Inspecting the air valves on the rising main
- Inspecting the closing ball-valve in the clean water reservoir, which switches off the pumps by means of back pressure
- Inspecting the reticulation network for leakages
- Scouring of the reticulation network
- Inspecting and reading the water meters

The following sophisticated elements in the network will require special attention:

- Backwashing the sand filter on the dam delivery pipe
- Manual bypassing of the sand filter whenever scouring of the dam delivery pipe is done
- Servicing and calibrating the chlorination dosage
- Manually adjusting the dosage of the chlorinators depending on climate changes and water quality
- Manually switching between the dam pump and the borehole pumps
- Calibrating and checking the engagement switches on the abstraction pumps.

The resources required for operation and maintenance are as follows:

- Part-time contracted electric-mechanical technician
- Full-time caretaker and labourers
- Part-time contracted administrator.

Alternatives for assuming the responsibilities of operation, maintenance and fee collection are as follows:

- The Developer may establish a utility company who will be contracted
- The home owners association may establish a section 21 company that will be contracted or a common law association that will be tasked
- The municipality may decide to do it in-house.

The municipality indicated during cursory discussions that they would prefer not to be involved in any of the above. The Developer has indicated that he is willing to assume the responsibility. This is a matter of negotiation and agreement between the Developer and the municipality.

### 3.1.8 Water Demand Management

The Developer envisages a waterwise water use regime to be incorporated into the rules of the home owners association. This is not only to make responsible use of this scarce resource, but on a number of accounts it fits into the development theme that is envisaged. Water demand management mechanisms that are proposed include the following:

- Parks and trees in common areas will be designed to be independent of watering after establishment.
- Building regulations will enforce roof water collection by means of gutters, and collecting tanks will be encouraged.
- Garden watering rules will be set, e.g. garden watering from the potable water system will be prohibited during peak demand seasons (December holiday season and Easter weekend).
- Pertinent to the more rural erven (in the hamlets), the size of lawns and acres will be restricted, leaving the natural veldt undisturbed as far as possible. A list of waterwise trees will form part of the Home Owners' Association rules.
- A small number of agricultural stands to the south west of the inner village will have irrigation rights for agricultural gardening on a small scale. Other than this, no large scale irrigation will be done from the potable water system, i.e. no common areas or parks or paddocks or fields.
- The Developer will install an irrigation system to irrigate common parks, paddocks and sports fields using grey water and water from secondary boreholes.

The raw water abstraction system was designed by taking into account the above water demand management measures in order to retain the cost of the water infrastructure.

### 3.1.9 Water Use Licence

The following activities, listed in the National Water Act and regulations as controlled activities for which approval from DWAF is needed, are applicable to this development:

- Storage of water in a dam
- Use of a dam for recreational purposes
- Impeding the flow of water in a water course in any other way
- Take water from a water source for domestic use
- Discharging waste or water containing waste into a water source through a pipe, canal sewer or other conduit
- Irrigation of grey water.

The following circumstances applicable to this development warrant the application for an integrated water use licence:

- Even in respect of current water rights, a water license will be required since the intent of use will change from agriculture to domestic.
- The land ownership will change from the stage of application to the stage of use.
- As the land will be subdivided and sold as a larger number of smaller units, the licence needs to be issued to a water service provider rather than to the current land owners or developers.

**Surface water source**

The only existing lawful water user pertaining to the surface water running from the land, is Rand Water Board. The land falls within the upper reaches of the Vaal River system, the use of which is allocated to RWB in its entirety, save for other smaller lawful water users. Any consideration for granting a water use licence for the use of surface water will thus imply a reallocation of water from RWB to the village.

It would seem that the justification for such reallocation of the surface water source from RWB to the village will hinge on the following:

- The merits for extension of the village in this locality as opposed to further urban growth in the service area of RWB.
- The relative weight of the rights of the people of the two areas in terms of the right to access to water, and the right to choose where to live.
- The question of the relative weight of a right to a water source when comparing an upstream user to a downstream user.

It is the author's opinion that the above arguments point toward a good case for the village to access the surface water source that originates on the land.

**Ground water source**

The land owner has a current water right in terms of the "General Authorization" [6]. The de facto water right is determined for the particular land (catchment C81 L) as 75 $m^3$/ha per annum. This authorization is interpreted to imply the following annual volume:

- Total land size covered by the development: approximately 1,000 ha
- 75 $m^3$/ha per annum
- Current annual water use right = 1,000 ha x 75 $m^3$/ha = 75,000 kl per annum

Pertinent in the motivation for such license however, it is significant to note that the total annual water demand of the entire future village exceeds the current water use right in terms of the General Authorization by only 28%. It is further important to note that the annual water demand includes the existing South African Police Services, other public and community facilities, as well as a medium income subsidy housing component.

The authors therefore deem the granting of abstraction rights from the ground water source to the extent of the needs of the development as equitable and not constituting a significant alteration of current allotted rights.

**Combined sources**

This report shows that in combination, the proposed groundwater and surface water sources when developed will have more than enough water to sustain the development. The demand is in fact insignificant in relation to the size of the combined source.

The studies have also indicated that the two sources are actually the same source, since the storage dam will directly recharge the ground water source. A motivation for a water use license will thus address the two sources as one.

### 3.1.10 Dam Construction Licence and Safety

Under the National Water Act 36 of 1998, the following statutory requirements are applicable to the development:

- No dam construction is allowed without DWAF approval.
- All new dams with an effective depth of more than 5 m or a storage capacity of more than 50,000 $m^3$ must be approved from a dam safety point of view. The proposed dam falls into this category.
- The designer must issue a dam safety manual upon completion of construction, and annual dam safety inspections must be carried out.

The dam site and sizing presented in this report were scrutinized by a hydrological engineer, Schoeman & Vennote [5], who recommended that the dam as proposed be favourably considered.

The dam was surveyed, a geotechnical inspection done on the foundation and construction materials, and a detail design done by a dam engineer approved by DWAF. The dam engineer has registered with DWAF as engineer for the dam, and is in the process of lodging an application for the categorization of the dam.

Once the integrated water use license is granted, then an application to allow the construction of the dam will be lodged by the dam engineer.

### 3.1.11 Water Services Authority and Water Services Provider

It is much more desirable from DWAF's viewpoint to issue a water use licence to an institutional body such as a home owners association or a utility company or a municipality than to different cadastral units. A water services provider must thus be registered, who will be authorized to charge fair rates to cover the cost of water provision.

Current water services providers in the area in which Verkykerkop falls are Rand Water Board, the District Municipality and the Local Municipality. Any of these could, by agreement with the developer, be the water services provider for the village. In doing so, they could develop the water supply infrastructure from the outset per agreement with the Developer, or take over the water supply infrastructure after developed by the Developer. Any one of these could manage and maintain the infrastructure on behalf of the owner.

It is the Developer's intention and preference however to establish a utility company which will develop and own the water supply infrastructure, and provide the water services per agreement with the municipality to the residents of the village.

### 3.1.12 Environmental Impact

The water network will be underground. The only elements for which environmental impact must be considered are the following:

**Reservoirs**

The site for the clean water reservoir on the plateau north of the village was chosen to be inside an old borrow pit with a depth of approximately 2m. The reservoir will be dug into the ground, lined with water proofing, and surrounded by an earth berm. It will thus be very inconspicuous from the road or from any direction.

**Storage Dam**

The following serves as indication of the relatively small environmental impact that the dam and abstraction from it will have on the environment and downstream river system:

- In the worst case scenario of water abstraction, that is where all water needed for the development is abstracted from the dam, abstraction is limited to 10% of the total precipitation in the catchment.
- For this scenario, as much as 45% of the total run-off in a dry year will still be released downstream.
- Since the dam size, abstraction and evaporation are insignificant relative to the volume of surface run-off, the dam will be full most of the time. Therefore, the recreational and aesthetical requirements of the development are well served by the dam.

The dam will have the following positive environmental impacts:

- It will stabilize the active erosion that has taken place in the dam basin. It impounds the upper tail of the active erosion, preventing it from creeping up into the wetland.
- It acts as a storm water retention dam, impeding energy dissipation, the main cause of erosion in the valley floor.
- It will charge the alluvium downstream of the dam wall even during the dry season.
- As the dam will have a net retention of water even at the end of a dry year, and since it will be fitted with a scour pipe, the dam can be used to provide a base flow to the valley down stream, whichwas not there before.

## 3.2 Sewage

### 3.2.1 Effluent Generation

The average daily effluent generation is calculated as a fraction of the water demand as follows:

- The average daily water demand is 264 kl/day (from 3.1.1 above)
- Considering that the high income residential water consumption constitutes more than 60% of the total water consumption, and considering that a fair portion of that is consumption other than sanitation (garden watering, cooking etc.) a reduction factor of 0.5 is assumed.
- The average daily effluent generation is calculated at 158 kl/day.

The effluent peak flow rate is calculated as follows:

- Average daily effluent generation of 158 kl/day
- Seasonal peak flow rate for holiday season of 1.7

- Peak hour factor of 1.5
- Effluent peak flow rate = 158 kl/day / 24 / 3.6 x 1.7 x 1.5
  = 4.7 l/s

### 3.2.2 Alternative Means of Disposal

Alternative means of disposal are as follows:

- Conventional toilets with individual stand septic tank and soak-away.
- Conventional toilets with several collected septic tanks and soak-aways.
- Conventional toilets with central collection and treatment (Category 3, *Guidelines for Engineering Services and Amenities* [2]).

The third option is preferred for the following reasons:

- Water availability makes water borne sewage disposal feasible.
- From a service level point of view, water borne sewage disposal is perceived by the user as the superior alternative.
- Several localized treatment plants as opposed to one central plant is more cost effective due to the low density of the development.
- This arrangement also makes better use of the natural filters to further filter treated effluent.
- By using several treatment plants there will be no need for sumps and pump stations. This arrangement will reduce the risk for contaminating the storage dam catchment.

### 3.2.3 Effluent Treatment Plants

Due to the topography and layout of the development, there will be a need for five new treatment package plants with soak-aways. The newly constructed treatment package of the police station will remain to operate independent from any new infrastructure.

The following sewage treatment arrangement is envisaged:

- The development includes a light industries component which will be served by a separate treatment package into the south western catchment. This treatment package will be designed to suit the specific needs at the time of development.
- For the village itself, separate treatment packages will be provided for the central village, the Green Fingers west of the central village, and the northern high density residential component just north of the police station.

- The hamlet and hotel to the east of the central village will have a separate treatment package.

Although the effluent from the different drainage basins is not equally divided a similar system can be used for all of them, while designing each to the required capacity.

The most popular system used at the moment is the septic tank to dispose solid waste with the eco-friendly evaporation system to treat the grey water. Also known as the Bio-Mite system, this system incorporates a biological process to clean waste water that flows from the septic tank. In this process a biomass of bacteria breaks down biodegradable waste and converts it into carbon dioxide and water. Any non-biodegradable material collects at the bottom of the tank and is periodically removed in the same way as the septic tank is pumped out.

The biomass is a colony of self-regenerating bacteria that will survive as long as they have a suitable food source (the waste) and a comfortable environment (sufficient oxygen and no harsh materials). The septic tank provides the food source and the Bio-Mite the comfortable environment. Inside the Bio-Mite is a matrix of plastic media upon which the slimy bacteria cling. As the waste water circulates through the media floor it is delivered to the bacteria. An air blower aerates the waste water, introducing oxygen into the system and ensuring that the waste stream is continuously circulated through the media.

Once the waste has been treated it then can be passed into a drain field or be used for irrigation. If the effluent is used for irrigation it will be necessary to chlorinate the waste stream which will kill any pathogenic organisms that may be present. This is done in a specially constructed chlorination capsule.

If assumed that all used water at all stands is released into the water borne system, the capacity of the treatment plants combined can be taken as equal to the average daily effluent generation of 158 kl/day. In order however to accommodate any unforeseen effluent demand and/or future densification of the village or permanency of occupation, a design capacity of 200kl/day is proposed. The combined effluent design flow rate is calculated as follows:

- Average daily effluent generation of 200 kl/day
- Seasonal peak flow rate for holiday season of 1.7
- Peak hour factor of 1.5
- Effluent peak flow rate = 200 kl/day / 24 / 3.6 x 1.7 x 1.5
  = 5.9 l/s

It is indeed an economical alternative to provide one single treatment plant at a central location at an altitude lower than all the living areas, to which all sewage is gravitated. This decision will determine on the ultimate phasing plan and construction cost of the options.

### 3.2.4 Network Layout and Analysis

Site effluent will be collected and carried to the treatment plants though water borne sewers located within road servitudes where possible, and in sewer servitudes where necessary.

As recommended in the *Guidelines*, Level of Service 4 is provided for the medium income component, viz. site connected to a water borne sewage system with a capacity of 750 litres per day. For the high income component, Level of Service 5 is provided for, viz. site connected to a water borne sewage system with a capacity of 1000 litres per day.

On the north western tip of the village there are three erven on the west side of the main road that lie outside the main drainage basin. Since it is not economical to pump sewage over the water shed for such a small number of erven, these erven will be serviced by individual septic tanks and soak always.

Also, it is not economical to extend the sewer system to the facilities on the south eastern side of the farm. The sandstone cutting operations and the shooting range will be provided with individual septic tanks and soak aways.

The village is topographically divided into five areas each with their own treatment plant at the lowest point. The first area is the main village; from the main entrance to the south all the stands to the west up to the polo field. The treatment plant is situated near the proposed open theatre site. The area consists of 110 private units and 15 commercial units and generates a design flow of 1.6 l/s.

The second area contains all the hamlets, the lodge site and the most southern part of the main village below the polo field. The treatment plant is situated between the stream and the road to the main storage dam downstream of the Brakdal dam. The hamlets north of the stream will cross the stream via a pipe bridge. The area consists of 120 private stands and one lodge and generates a design flow of 2.0 l/s

The third area is the area west of the main road called Green Fingers. The treatment plant is situated just west of the existing dam wall. The area consists of 40 private stands and 5 commercial units and generates a design flow of 0.9 l/s.

The forth area is the medium income component north of the police station, including 60 private units, the public school and the stables. The treatment plant is situated just north of the stables and generates a design flow of 0.8 l/s.

The fifth area is the Zwartkoppies units and the light industrial area east of the main road. The treatment plant is situated near the most southern point of the study area. This zone consists of 16 private units and 20 commercial units and generates a design flow of 0.7 l/s. This excludes the possible abattoir, which will receive a separate dedicated plant to be designed at the stage of development of the abattoir.

The sewage system, showing the location of the main collection network and the location of the treatment plants, is shown illustratively on the **Sewage and Solid Waste Plan 10**.

### 3.2.5 Disposal of Grey Water by Irrigation

Most of the grey water will be irrigated back onto the horse sports fields between the treatment plant and the village where it will evapo-transpire. During very dry spells, some of the grey water may also be irrigated onto common park areas, paddocks and the golf course, from where it will evapo-transpire or slowly soak away until part of it finds its way to the stream after having been naturally filtered from any remaining solids and most dissolved substance.

The grey water will be irrigated directly from the surface of the settlement pond.

The design irrigation rate is calculated as follows:

- Average daily effluent generation of 158 kl/day
- Assume seepage in the storage pond is minimal
- Assume evapo-transpiration factor of 0.8
- Average daily grey water retention after evaporation in the settlement pond = 126 kl/day
- Assume all grey water is irrigated back
- Assume irrigation is done every day
- Assume irrigation time of 8 hours
- Design irrigation rate = 126 kl/day / 8 hours / 3.6 = 4,4 l/s

A 75mm diameter pipe will be more than adequate to dispose of the grey water by irrigation.

The irrigation potential of the grey water is calculated as follows:

- Average daily irrigation volume available = 126 kl/day
- Assume a crop or field is irrigated on average every 3rd day
- Assume the daily irrigation is 4mm
- The annual irrigation is then 365 / 3 x 4mm = 487mm, which is in the order of the irrigation requirements of fodder or turf in this area

- The surface area that can be kept under irrigation in this way is then 126 kl/day / 0.004m  x 3 day cycle = 9,5 ha.

The 9,5 ha potential is large enough to cover the horse sports fields, the golf course greens, the common  park area, and there is water left to also irrigate fields for the production of horse fodder.

The irrigation system can be economized significantly if the grey water is first pumped up into an irrigation dam on higher ground, from where it is irrigated at a lower pressure and rate, and as and when desired. This dam can be roughly sized as a multiple of the average grey water retention of 126 kl/day. E.g. an irrigation dam of 10,000 m3 (100m x 50m x 2m deep) will keep three months' outflow. This will allow seasonal optimization of irrigation.

During any times that there might be when no irrigation done and if assumed that the retention pond is full (such as during long wet spells), grey water will be released into the environment, and the environmental impact of this eventuality needs to be checked. The average daily release rate of grey water into the stream system is then as follows:

- Average daily grey water release rate whenever no impoundment or irrigation takes place = 158 kl/day / 24 / 3.6 = 1.8 l/s
- Annual grey water release volume should no impoundment or irrigation is done for the whole year = 158 kl/day X 365 days = 58,000 kl pa

Before the outflow from the treatment plant is impounded in the retention pond, the effluent must first be put through settlement ponds. The sludge generation and size of settlement ponds are calculated as follows:

- average daily effluent generation of 158 kl/day
- depth of settlement ponds of 300mm
- settlement rate of 50mm per day
- settlement duration = 6 days
- surface area of settlement ponds = 6 x 158 kl / 0.3 = 3160 m²
- size of settlement ponds required =  3 dams of 60m x 20m

### 3.2.6 Environmental Impact

To put the volume of grey water production into perspective, the following parameters are informative:

- "Grey" water will comply with DWAF standard release quality. It will however not be released into the stream directly but will be filtered through the

grassland and natural vleis just outside the natural drainage path first before reaching the stream.

- The average flow rate that will be let out into the environment in this way is 1,8l/s, that is if no grey water is irrigated or impounded. This is an insignificant quantity relative to the natural drainage of the vleis that lead into the storage dam.
- Any back irrigation that is done will significantly improve the above regime. Due to the economy thereof, it is highly likely that most grey water will indeed be irrigated.

### 3.2.7 Operations and Maintenance

There are no sophisticated elements in the network. The package treatment plants are serviced per maintenance agreement by the agents, at a routine basis and on call. Maintenance will mostly comprise of cleaning of blocked erf connections and smaller end branches of little used sewer lines. Elements that will require special monitoring, operation and maintenance are as follows:

- Cleaning of manholes
- Cleaning of intake filters at treatment plants
- Intermittent manual recording of intake flow rate
- Monitoring of package plants
- Monitoring of retention pond level and engagement of irrigation pump
- Irrigation management from the irrigation dam.

The following operation and maintenance resources, shared with the water supply services listed in 3.1.7, are necessary:

- Part-time contracted electric-mechanical technician
- Part-time contracted administrator

In addition, the following resources are specific to the operation and maintenance requirements of the sewage system:

- Full-time caretaker and labourers

Irrigation management will resort under the parks and farming manager.

### 3.2.8 Sewage Services Provider

The Local Municipality is the sewage services provider in a number of townships in the municipal area. They could, by agreement with the developer, be the sewage

services provider for the village. In doing so, they could develop the sewage treatment infrastructure from the outset per agreement with the Developer, or take over the infrastructure after developed by the Developer. They could manage and maintain the infrastructure on behalf of the owner.

It is the Developer's intention and preference though to establish a utility company which will develop and own the sewage treatment infrastructure, and provide the sewage services to the residents of the village per agreement with the municipality.

## 3.3 Solid Waste

### 3.3.1 Waste Generation

### 3.3.2 Waste Generation Management

The level of service for waste collection is as follows:

- For residential customers, waste will be picked up at cluster points of about 20 to 30 stands, with a maximum walking distance of about 100m
- For agricultural plots the carrying distance might be significantly longer.
- Erf boundary collection will only be done for corporate or institutional customers such as the police, the clinic, and the schools.
- No collection will be done at the industrial sites which generate large volumes of waste. These customers will be required to deliver their waste at the waste site. A volume-based charge will be implemented for non-residential customers as an incentive to dispose of their waste directly at the district waste site.
- The service area will not be limited to the village but the customer base will include the farms in the district. These customers will be required to take deliver their waste to the waste site themselves. No collection will be done outside the village.

It is the intention of the developer to implement a waste generation management plan which will be enforceable in terms of the home owners association rules. The intention is to implement the following standards:

- Organic matter will not be collected at individual erfs but customers must take whatever waste is not composted on the erf to the common compost heap for use in common gardens.
- No hazardous waste will be handled by the waste site in the village. Customers will be responsible for removal of hazardous waste and dispose of it in accordance with common regulations.

- Streams of non-hazardous inorganic waste will be separated by the customer before taking it to the collection point, separating glass, plastic, metal, paper and organic matter.
- Penalties will be charged to the bill of the erf owner for non-compliance with the waste separation rules.

The annual production of waste received by the waste site is estimated as follows:

| | |
|---|---|
| • 340 village erven x 50kg per week x 52 weeks | 884 tons pa |
| • 40 rural agri industry customers x 500kg per week x 52 weeks | 1 040 tons pa |
| **Total annual waste production** | **1 942 tons pa** |

### 3.3.3 Solid Waste Disposal and Recycling Site

The solid waste site is situated in the south-west corner of the village as shown on the **Sewage and Solid Waste Plan 10.** The facility is for collection, separation, recycling and transfer only, and no waste will be land filled or accumulated permanently or semi-permanently on site.

The site will have a high mesh fence around it to prevent wind blown contamination. Facilities for separated containment and recycling as well as for compaction of the remainder of the waste will be provided.

### 3.3.4 Waste Disposal Management

The developer proposes the following disposal management plan:

- Residential customers will put their separated waste into large colour-coded bins at dedicated collection points.
- The bins will be picked up at the collection points and taken to the waste site.
- Further separation and recycling of valuable waste streams will be done on site by local entrepreneurs for their own profit.
- The remaining low-value material or bulk waste will be compacted separately and removed off site to end users of usable separated bulk waste or to an approved land fill site.

### 3.3.5 Solid Waste Services Provider

The Developer intends as follows:

- A utility company will be responsible for rendering the service of collection and disposal at the waste separation and transfer site, and for management of recycling at the site.
- The utility company may contract a specialist contractor for managing the waste site, compacting, and removal to the landfill site or end users.

## 3.4 Traffic Roads and Stormwater

### 3.4.1 Vehicular Traffic Generation

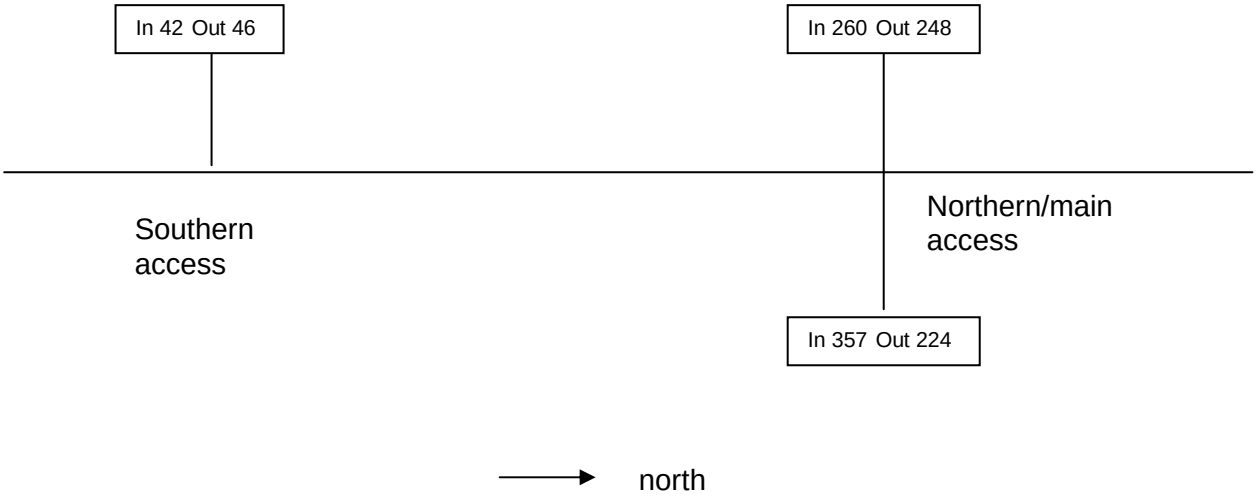
For the two main access points to the development being the southern access (T-junction to the west) and the northern access (main access junction), the traffic generation is estimated as follows from the *South African Trip Generation Rates* [7]:

**PM Peak Traffic Generation at the two main access points**

| Component | Units | PM Peak hour traffic generation rate | PM Peak hour volumes (in/out) |
|---|---|---|---|
| Residential high income (dwellings) | 340 | **1.5**<br>**65% in 35% out** | Northern access:<br>West 66/36<br>East 265/142 |
| Retail (100 m2 GLA) | 45 | **4.2**<br>**50% in / out** | Northern access:<br>West 95/95 |
| Filling station (adjacent traffic) | 150 vph | **4%**<br>**50% in / out** | Northern access:<br>West: 3/3 |
| Restaurant/pub/bar (100 m2) | 3 | **59**<br>**50% in / out** | Northern access:<br>West 60/60<br>East 30/30 |
| Storage and sheds (100 m2) | 60 | **0.8**<br>**35% in 65% out** | Northern access:<br>West 10/20<br>Southern access:<br>6/12 |
| Light industry (100 m2) | 30 | **0.9**<br>**30% in 70% out** | Northern access:<br>West 6/14<br>Southern access:<br>3/7 |
| Police station | - | Estimate **10**<br>**50% in / out** | Northern access:<br>East 5/5 |
| Community hall | - | Excluded (weekend off-peaks mainly) | - |
| Guest house/hotel/lodge (rooms) | 100 | **0.8**<br>**45% in 55% out** | Northern access:<br>West 20/20<br>East 20/20 |
| Sports/club house (100 m2) | 5 | **21**<br>**55% in 45% out** | Northern access:<br>East 57/47 |
| Church | - | Excluded (weekend off-peaks only) | - |
| Public offices and services e.g. post office, clinic, welfare (100 m2) | 4 | **4**<br>**25% in 75% out** | Southern access:<br>4/12 |
| School | - | No pm peak | - |
| Auction kraals | - | Excluded (special events only) | - |

It can be assumed that the generated southbound and northbound traffic is equal. From the above table, the peak hour traffic volumes generated by the development, including the existing uses, is as shown in the figure below:

**PM Peak Hour Traffic Generation (vph)**




## 3.4.2 Road Network

Due to the special nature of the development, the road classes and functional hierarchy as described in the *Guidelines* [2] were not found useful. Instead, the internal network is defined in terms of the following road classes:

- Main Roads, comprising surfaced and unsurfaced provincial roads going through the village, and to which the Village Roads connect
- **Village Roads**, comprising the *Local Access Roads* into the main village that also function as main access streets, surfaced or unsurfaced
- **Village Streets**, comprising the main collector streets inside the living areas and industrial area, branching off from the Village Roads, mostly unsurfaced
- **Village Streets**, comprising the internal distribution streets branching off from the Village Streets, unsurfaced. Farm Roads that connect outlying hamlets to the main village also fall into this category.
- **Village Path**, being a Village Street serving a. These paths sometimes serve a cul de sac, or are short-cut streets to serve a smaller number of houses
- **Pedestrian walkways**, being very narrow paths created to provide services servitudes midblock, and at the same time serving pedestrians and non-motorized modes of transport to gain access to back yards.

The road network comprises a total of 1.2 km of Village Roads (of which 800m will be cobble stone or seal surfaced), 8.5 km of Village Streets (of which 125m surfaced) and 4.5 km Village Paths, and 10 km of shaped farm roads, all as shown on the **Transportation Layout Plan 11.**

## 3.4.3 Road Access Approval to Provincial Network

The Engineer for the project appointed a specialist transportation engineering firm, Rudnat of Harrismith, to manage the approval process in respect of road access, internal road layout, and wayleaves for services crossing the provincial roads.

The Engineer found it prudent to select specifically Rudnat for this aspect since they happen to be the appointed roads engineers for the design and construction of the Harrismith-Memel road upgrading project. Their prior knowledge of the geometric design for the road where it goes through the village proved to be very useful in facilitating an assessment by the provincial roads authorities.

The transportation layout plan was discussed during a meeting and site inspection on 1 June 2010 which was attended by Mr Piet Wagenaar (Rudnat), Mr Dawie de Lange (Department of Police, Roads and Transport) and Mr Jako Viviers (LMV). Following the assessment that followed and the comments received, Rudnat proposed certain technical changes to the road access points, which then resulted in a final layout as contained in this report.

The Engineer received a letter for the approval of wayleaves to cross the provincial roads.

### 3.4.4 Taxi and Bus Bays

A taxi/bus bay will be provided on both sides of the main road just south of the main northern intersection.

### 3.4.5 Provision for Horses, Bicycles, and Pedestrians

On the internal road network, provision will be made for non-motorized transport by means of avenues where vehicular traffic is prohibited.

“Lean-to” and drinking troughs will be provided for horses on both sides of the road at the main intersection.

### 3.4.6 Traffic Impact Statement

It is proposed that the speed restriction on the main road be applied as follows:

- 80km/h speed restriction zone from the entrance to the study area in the south (just south of the access to the industrial area) up onto the hill on the Memel Road in the north.
- 60km/h speed restriction zone within the above 80km/h speed restriction zone, from the Warden road turnoff in the south to just past the Vrede road turnoff in the north.

For the above speed restriction regime, the proposed access points on the main road conform to accepted standards regarding access spacing and site distance.

None of the access intersections will require 4-way stop control from a traffic safety or capacity point of view.. Priority will always remain in favour of the main road, except that a pedestrian crossing at the main access intersection is proposed.

Due to the high right turn volumes in the fully developed stage, right turn bays might be needed to reduce the impedance on through traffic. The provincial roads department however felt that the installation of such turn lanes should only be considered at such point in future where it becomes evident that it is required from a capacity point of view.

It is not foreseen that signalization of the main intersection will meet the warrants, even in the fully developed scenario, although side road delays may reach level of Service D during seasonal peak hours.

### 3.4.7 Geometric Design

The following geometric standards will apply to internal roads:

- **Village Roads**

  60km/h design speed

  7m wide surfaced width

  Surfacing will be mostly single seal, but with cobblestone close to the main intersection

  paved pedestrian sidewalks in built-up areas

  gravelled pedestrian sidewalks outside built-up areas

  subsurface storm water system

  edge channels and storm water drop inlets

- **Village Streets**

  40km/h design speed

  un-surfaced, round shaped and covered with a wearing course 6m wide

  gravelled pedestrian sidewalks

  no subsurface storm water system, except for road culverts where streams are crossed

sidewalks separated from the roadway by concrete interception drains (V-shaped, where necessary, delivering to natural water ways

- **Village Paths**

  no particular design speed standard, alignment to follow topography

  un-surfaced, round shaped and covered with a wearing course 5m wide

  wheel tracks will be provided with grass blocks on steep slopes

  due to low traffic pedestrians will use the roadway as path

  interception side drains will be limited to the minimum so that overland flow is not disrupted by the road profile

  culverts will be provided only where absolutely necessary; instead, use will be made of berms and ditches on the roadway

- **Farm Roads**

  The same geometry will apply as for the Village Roads, but the surface may not be gravelled.

All public roads including gravel roads will be trafficable by normal sedan vehicle as well as single unit truck. Some Farm Roads will however only be trafficable by 4x4 vehicles.

### 3.4.8 Flood Line Determination

The *Guidelines for Engineering Services and Amenities*[2] suggests that all residential development and other buildings are to be provided outside the 1:50 year flood line, and that the implications of the 1:100 year flood line be carefully considered. Developments such as a golf course are permissible in the flood plain for example.

The only defined water course on the land close to which any development will take place is the one starting in the village on the saddle just east of the main road, going down to where the gorge exits the land downstream of the proposed dam.

The *Sinotech drainage software* [8] was used to determine the 1:100 year flood plain fringes in the valley, as indicated on the **Road Network and Stormwater Layout Plan 11**. All residential and other developments are outside the 1:100 year flood plain fringes.

The middle slopes of the valley are steep and the water course well defined with a deep river course that accommodates the storm flood for most part. Where the valley opens up in the area upstream of the dam, the storm flood spreads out over the wetlands.

### 3.4.9 Storm Water Design

Route alignments were designed to avoid marshy areas as well as rocky outcrops, and follow natural contours as far as possible so as to avoid interference with natural water courses. Grades are limited to 8%.

Township storm water infrastructure will be designed for the 1:10 year flood. There are no significant water courses to be crossed by any of the roads. The road storm water design is described in 3.4.7 above.

Between the village and the main storage dam a number of smaller dams are proposed in the two existing water courses. These dams have mainly two functions viz to serve as retention ponds for flush floods and to serve as silting dams for the rehabilitation of active erosion. By retaining a part of the storm flood in the dam the flood will be smaller downstream. This way the chance of potential erosion done by the storm is reduced.

Also by reducing the flow speed of the storm water in a dam sedimentation will take place. By clearing most of the solids out of the storm water flow before it reaches the main storage dam the life span of the main storage dam will be longer and the water quality better.

The overflow of the main storage dam is designed for the 1:100 year flood. The dam design makes provision for a spillway on either end of the dam wall. After exiting a grassed spillway, the flood is spread out over a large enough horizontal grassed plain before it goes back to the stream overland.

### 3.4.10 Pavement Design

The subgrade along most road alignments is excellent and no treatment after shaping is necessary.

The main access road from the main road to the east, including the plain, will be cobble-stoned and provided with cut stone kerbing. Single seal surfacing will be applied to the Distributors Roads in the village. The Village Streets will receive a wearing course which is left un-surfaced. Outside the village, the Access Roads will be un-surfaced, except for a few steeper slopes that will be provided with grass block tracks.

A 150 mm G7 quality wearing course is adequate to carry the light traffic on gravel roads. On surfaced roads, the base course will be stabilized to a depth of 150 mm.

### 3.4.11 Ownership and Maintenance

All roads except Farm Roads are public roads. All roads including Farm Roads, which are private roads, will be owned by the Home Owners Association and maintained by the utility company.

## 3.5 Geotechnical Standards and Materials

### 3.5.1 Founding Conditions for Building Structures

A *Regional Geotechnical Mapping* [9] was done by Soilcraft for the study area. The findings are summarised as follows:

- From a foundation point of view, valley floors are to be avoided since that is where finer, less stable alluvium have been deposited. These areas are also soaked with seepage water.
- Most erven are placed within the course grained sandstone cap of the plateau, and to a lesser extent within the finer siltstone upper slopes of the valley, all within the Verkykerskop Formation and well above the less stable Normandien Formation. No foundation problems are foreseen in this zone. On the plateau, the underlying sandstone is a few metres deep so that excavatability for services is expected to be favourable.
- On the downslopes just off the plateau, the underlying un-weathered sandstone gets shallower and daylights at places. Lower down the slopes, rock fabric overburden might cause instability, and provisionally, foundations should go down to base rock. A smaller number of erven were initially located within this zone. Due to the risks, these stands were abolished.
- No erven are situated near the cliff edge where the sandstone layers are exposed or covered by a thin layer of sensitive topsoil.

It can be concluded that no significant founding problems are expected, however, certain special engineering designs are expected to be necessary at construction stage in the case of any stands that are situated on the steep downslopes.

### 3.5.2 Road Building Material Requirements

A total volume 20,000 m³ of gravel wearing course material is needed for road construction.

A G7 quality material would be adequate both for the wearing course in the case of un-surfaced roads and for the stabilized base where roads are to be sealed.

The road formation will be shaped from in situ materials, which ranges from G6 to G8 quality. Unsuitable subsoil to be removed and replaced is very limited.

There are no major cut to fill earthworks required.

### 3.5.3 Borrowpits for Road Construction

The only viable site that could be found on site that is suitable for adequate quantities of gravel for road building is on the koppie next to the mobile phone tower. The locality of the borrow pit is indicated on the **Topographical Plan 4**. Adequate quantities of G7 and selected G6 quality gravel are available in this source. The material is suitable for both wearing course and base course.

The gravel will be excavated from the lower slopes of the koppie and rehabilitated in such a way that the scar will not be visible easily from the main road.

### 3.5.4 Dam Building Materials

Core drilling in the basin was done as part of the geohydrological study. This was followed up by a dam wall centre line test pit investigation. The cores and test pits indicated that suitable clay deposits for the core of the dam exist along the alignment of the dam where the foundation excavation is to be done.

The structural section of the earth dam will be built from G6 gravel that will be sourced from the side slopes of the valley within the dam basin impoundment.

The rubble rock for the rip rap blanket to protect the inside of the dam wall will come from the cut offs of the cut stone mine.

All materials for dam construction will thus be sourced on site.

### 3.5.5 Cut Stone Quarry for Buildings

A significant quantity of sandstone will be required in line with the anticipated architectural style. It is not economical to haul cut stone from existing commercial quarries. Adequate quantities of stone from old buildings and ruins in the area might also not be obtained legally.

Therefore, the viable option is to extract cut stone from the land owned by the Developer. As can be seen on the **Topographical Plan 4**, there are numerous exposed sandstone reefs and cliffs on the land. The proposed sandstone quarry area is shown on Plan 4, situated in an inconspicuous location.

Quarrying will be done from above the vertical cliff in an inward direction towards the plateau, mining the horizontal shallow layers to a depth of 2m. The topsoil that is removed before mining will be placed back. No depressions that can accumulate water will be left against the slope.

### 3.5.6 Mining Permits for Borrow Pits and Quarries

The Developer plans to extract gravel for road building and for quarrying stone for building. There are no viable sources of building sand on the land owned by the Developer and use will be made of commercial sand sources.

Clause 106 (3) of the Mineral and Petroleum Resources Development Act, Act 28 of 2002 states that "any landowner or lawful occupier of land who lawfully takes sand, stone, rock, gravel or clay for farming or for effective improvements in connection with such land or community development purposes, is exempted from the provision of subsection (1) as long as the sand, stone rock, gravel or clay is not sold or disposed of."

In this case, the Developer will subdivide first, possibly sell off stands before building starts, and then extract materials for building. Therefore, the Developer will likely be required in terms of the Act to apply for mining permits for extracting gravel for road building and for quarrying stone for building.

The Developer has hence appointed Lidwala Environmental and Planning (Pty) Ltd to submit mining permit applications for the above.

## 3.6 Electricity

### 3.6.1 Institutional Aspects of Provision of Grid Electricity

**Grid Electricity Provider**

ESKOM is currently the authority providing electricity to the Verkykerskop region.

The envisaged new developments will require a fairly small additional amount of power.

It is not viable to consider any other source of power supply, as the existing ESKOM network may be easily extended to serve the new developments.

ESKOM is also the authority providing electricity directly to all the townships in the Phumelela local municipal area. It is recommended that this model be applied to the Verkykerskop township as well.

**Construction of Infrastructure**

CG siza is the electrical engineer for all connection and reticulation infrastructure in Verkykerskop. Design drawings, layouts and specifications are subject to approval by ESKOM before construction is commenced with.

**Capital Cost**

The Developer will be responsible for the cost of electrical reticulation to be installed to all new developments, excluding the Nguni Cultural Village which is designated as a subsidized low cost housing zone.

It is foreseen that, in line with government policy and ESKOM mandate, ESKOM will provide the PoD, reticulation and pre-paid meters to the Nguni Cultural Village as is done for rural low cost ("RDP") type villages, without a contribution from the land owner.

The sharing and redemption of capital cost will be addressed in the Services Agreement that needs to be established.

**Operation and Maintenance**

The completed network will be handed over to ESKOM, who will be responsible for the operation and maintenance of the system.

The Home Owner's Association or body representing the owners will however be responsible for certain aspects of the development affecting the electrical network, such as keeping the vicinity of ESKOM equipment (area around miniature substations and transformer/switchgear miniature substations etc.) clean and free from hazards that could harm the installation, such as high grass and rubble.

**Proposed Recovery of Energy Costs**

It is proposed that existing customers who are currently paying by account be given the choice of converting or not to the pre-payment system. The pre-payment system will however be the only system available in respect of all new developments.

Due to the remoteness and small customer base in Verkykerskop, pre-paid electricity may not be available for purchase at a vending point in the village. Mobile phone and on-line purchasing will accordingly be required.

In respect of both the new freehold stands and the cluster housing complexes, a conventional pre-paid meter will be installed inside each residence (not split meter system).

### 3.6.2 "Green Living" philosophy to energy provision

The living philosophy, with specific reference to energy saving living and use of green energy sources, is described in Appendix D: Green Living Compendium. The marketing materials as well as conditions of establishment are aligned with this compendium.

**Design Plilosophy**

The design philosophy applied for the provision of energy to the entire Verkykerskop development area is based on extensive use of renewable energy sources.

Towards that end three configurations of energy supply are applied, being:

- Conventional grid electricity
- Self-sufficient off-grid energy provision
- Hybrid System: The customer having the option of Green energy supplemented by grid electricity if required.

The salient features of these are discussed below.

**Conventional Grid Electricity**

Selected living areas identified in the urban design planning process will be provided with conventional grid electricity.

It is envisaged that this will be derived from extensions to the existing ESKOM 22kV rural network.

The development theme of Verkykerskop has at its core a rural environment, akin to farm living, along with the typical insecurity of supply inherent to a rural network with its susceptibility to failures due to lightning, heavy rain, wind storms, etc.

Prospective owners will be made aware of this and will have to accept this situation as normal, in the same manner as typical farm home dwellers are accustomed to.

It will accordingly not be expected from ESKOM to upgrade their existing network to provide a higher quality of supply usually applicable to urban townships.

This form of provision of energy will nevertheless apply techniques to reduce electrical demand though the use of solar water heating and gas for cooking hobs.

This form of provision might compel the customer to provide his own renewable energy backup system in accordance with his knowledge and risk.

This approach will ensure that hot water is available and cooking may take place even if mains power is not available due to the insecurity of supply of a rural network.

Acceptance of this level of service forms an integral part of the living philosophy conveyed during the marketing process.

**Self-sufficient Off-grid Energy Provision**

These consumers will not be provided with conventional grid energy at all, and the stands within these designated living areas are marketed as such.

No ESKOM network will therefore be extended to the location of these properties.

Solar water heating and electro-voltaic panels with battery storage and inverters for electrical supply will be used. Gas and/or low-smoke combustion stoves will be used for cooking.

An intrinsic element of the prescribed “smart building code” for the stands in these living areas is building construction and orientation that reduces energy loss in winter and reduces hot house warming in summer.

The more recreational and week-end type living envisaged for these stands would also imply certain constraints in terms of high power appliances such as home workshops, laundry facilities, and large fridges. The marketing material as well as the conditions of establishment will convey this concept.

**Hybrid System: Green Energy supplemented by grid electricity as required**

These consumers will primarily make use of green energy (solar water heating, photovoltaic panels for electricity, log fire heating, gas for cooking etc.) and energy efficient appliances (such as high insulation fridges).

Since no constraints on energy consumption will be included in the building codes for these stands, grid electricity will be available at each stand, providing the option of supplementing their requirements with a grid service connection in instances where the owner wishes to have unlimited power backup and where the capacity of the green energy system is insufficient.

### 3.6.3 Proposed Energy Regime

**Designation of Energy Source per Living Area**

The Energy Matrix applicable to the residential erven appears in **Annexure E** to this document. It records the sources of energy to be applied for every Class of Living.

For the areas that are to receive grid electrical energy, the **Electrical Layout Plan no. 12 (comprising 6 sheets)** shows the elements of the proposed system.

The existing ESKOM rural network is to be extended as shown on the drawing to serve the new customers.

**Basic Design Standards**

The design of the extensions will adhere to the standards prescribed by ESKOM.

Extensions will comprise both overhead reticulation and underground cable, as shown on the drawings. Overhead reticulation is used in areas where overhead reticulation is already provided, whilst underground reticulation is provided mostly inside the township extensions and on the open land in between new township areas.

The scope of the extensions to the ESKOM network will comprise:

- Connection to the existing network, with appropriate equipment. For the purposes of operation and maintenance switchgear will be installed at the new Points of Supply (PoS) according to ESKOM requirements.
- Extension by way of overhead line or underground cable, as shown on the drawings, comprising both MV and LV reticulation.
- Pole transformers for overhead MV lines and miniature substations for underground cable feeders.
- LV service connections by way of underground cable. These are to terminate 1m inside the erf boundary.

- Pre-paid metering throughout, comprising a conventional pre-paid meter inside the residence/building.

**System Configuration**

The new extensions to the existing ESKOM network are shown on the electrical reticulation system drawings annexed, being:

| | |
|---|---|
| Drawing CG320-10#12 Sht 1 r01 | Northern Section |
| Drawing CG320-10#12 Sht 2 r01 | Nguni Village Section |
| Drawing CG320-10#12 Sht 3 r01 | Central Section |
| Drawing CG320-10#12 Sht 4 r01 | Industrial Section |
| Drawing CG320-10#12 Sht 5 r01 | East Cliff Section: Southern Portion |
| Drawing CG320-10#12 Sht 6r01 | East Cliff Section: Eastern Portion |

These drawings also show the points of service connections to the new ESKOM customers to be created. These connections comprise connections to water extraction plant (borehole pumps and river extraction/purification plant) and service connections to erven/plots.

Table E1 below lists the PoDs required in the short term, comprising of certain utility services before township development can start. It also includes a PoD to the workers village which needs to precede the construction of the main village. These points will form part of an application for additional PoD by the existing land owner / customer.

**TABLE E1: POINTS OF DELIVERY TO INITIAL UTILITY SERVICE POINTS**

| Drawing No | PoD Ref | Connect to: | Cadastral Co-ordinates | Function | Anticipated Max Demand (kVA) |
|---|---|---|---|---|---|
| CG320-10#12 Sht 4 r01 | PoD 1 | WVK 345-13/2 | Y - 27 669,955<br>X + 3 090 828,835 | Borehole and workshop | 5,0 |
| CG320-10#12 Sht 4 r01 | PoD 2 | WVK 345-14 | Y - 28 013,755<br>X + 3 090 778,765 | Borehole | 4,0 |
| CG320-10#12 Sht 2 r01 | PoD 3 | WVK 349/4-5 | Y - 27 548,174<br>X + 3 089 506,238 | Farmstead on 1477002 | 10,0 |
| CG320-10#12 Sht 3 r01 | PoD 4 | WVK ?? | Y - 27 642 ,880<br>X + 3 089 494,831 | Workers village to become future Nguni Cultural village | 120,0 |
| CG320-10#12 Sht 2 r01 | PoD 5 | Nguni LV Network | Y - 27 759,410<br>X + 3 089 585.568 | Aansluit Plaaswerf | 10 |
| CG320-10#12 Sht 1 r01 | PoD 6 | WVK 365 | Y - 27 612,465<br>X + 3 088 252,105 | Bankies Plaaswerf & Bankies borehole | 20 |
| CG320-10#12 Sht 6 r01 | PoD 7 | Eastcliff Tee Switch | Y - 29 773,20<br>X + 3 090 614,92 | Dam Extraction | 75,0 |

Table E2 lists the proposed service connections to non-residential erven and the design demand for each group.

**TABLE E2 NON-RESIDENTIAL ERVEN/ PLOTS**

| Drawing No | Development | Number of Erven | LV Power Source | Anticipated Max Demand (kVA) for Group |
|---|---|---|---|---|
| CG320-10#12 Sht 3 r01 | Business 1 | 11 | Existing | 50 |
| CG320-10#12 Sht 3 r01 | Institutional | 6 | Pole Transformers | 50 |
| CG320-10#12 Sht 4 r01 | Light Industrial | 7 | Pole Transformers | 120 |

Table E3 below lists the proposed service connections to residential erven and the design demand for each group.

The effect of the application of the Green Living philosophy is evident in the designation of power source as “Hybrid”, using ESKOM power partly, or no ESKOM power at all, for certain erven.

## TABLE E3 RESIDENTIAL ERVEN/ PLOTS

| Class of Living | Sector Designation | Building Type | Number of Erven | Number of dwelling Units per Erf | Erf Numbers | ESKOM Service Connection Required? | ADMD for Group kVA |
|---|---|---|---|---|---|---|---|
| **1: "Dorp" Living** | | | | | | | |
| 1A | Dorp | Conventional | Existing | | Existing | Existing | Existing |
| 1B | Dorp | Conventional | Existing | | Existing | Existing | Existing |
| | | | | | | | |
| **2: "Farm" Living** | | | | | | | |
| 2A | Aansluit Plaaswerf (forms part of table E1) Green Fingers; Production Yard | Conventional | 1 | 1 | | YES | 10 |
| 2B | Afsluit Farmstead | Conventional | 3 | 1 | | Existing | Existing |
| 2Ci | Green Fingers Farm Village | Productive Home: Row House + Greenhouse | 26 | 1 | 1-2<br>20-21<br>28-49 | YES (Hybrid) | 65 |
| 2Cii | Green Fingers Farm Village | Productive Home: Detached Family House + Barn | 20 | 1 | 22-27<br>50-56<br>58-70 | YES (Hybrid) | 54 |
| 2D | Eastcliff Estate | Free style Contemporary Estate House | 9 | 1 | 308-316 | YES | 70 |
| | | | | | | | |
| **3: "Village" Living** | | | | | | | |
| 3A | Aansluit Village | Studio Apartment (cluster housing) | 1 | 8 | 130 | YES | 40 |
| 3B | Aansluit Village | Townhouse (cluster housing) | 1 | 9 | 129 | YES | 54 |
| 3B | Aansluit Village | Townhouse (cluster housing) | 1 | 8 | 131 | YES | 48 |
| 3C | Aansluit Village | Country Club Complex | 1 | None | 335 | YES | 60 |
| | | | | | | | |
| **4: "Hamlet" Living** | | | | | | | |
| 4A | Annasdale Hamlets | Small Scale Cottage | 59 | | | NO | |
| 4B | Nguni Cultural Village | RDP Type Housing | 27 | 1 | | YES | 40 |
| | | | | | | | |
| **5: "Uittspan" Living** | | | | | | | |
| 5A | Ou Opstal<br>Die Bos<br>De Krantz | Private Herdsman/Fisherman's Cottage | | | | NO | 0 |
| 5B | Aan de Weg Herberg | Hotel Cottage | | | | NO | 0 |
| 5C | Klipkraal | Camp Site | | | | NO | 0 |

## 3.6.4 Estimated System Demand

**Estimated Total System Demand per Load Category**

The additional electrical demand to serve the loads listed in the tables above may be summarised as follows:

| | |
|---|---|
| TABLE E1 | 244kVA |
| TABLE E2 | 220kVA |
| TABLE E3 | 441kVA |
| **TOTAL** | **905kVA** |

**Estimated Total System Demand for Entire Development**

The nature of the entire development, being a mixture of residential, farming and industrial use, means that the sector-specific maximum demands will not coincide.

For the entire development taken together an overall diversity factor may accordingly be applied.

The resultant additional maximum demand is anticipated to be approximately 700-750kVA.

**Network Capacity**

The additional load to be imposed on the existing ESKOM network is small in relation to the total transfer capacity of the existing network.

At a meeting with ESKOM held on 26 November 2007 on site in Verkykerskop, ESKOM officials advised that the existing feeders from Warden have about 1MVA spare capacity.

The anticipated additional load of about 700-750kVA could accordingly be absorbed by the existing network without significant upgrading, still leaving room for some expansion to other customers further along the line in future.

## 3.6.5 Environmental Impact

**Selection of Construction Methods**

The construction methods envisaged for the electrical infrastructure will make minimal impact on the environment.

New overhead reticulation lines are limited to LV bundle conductor lines in the RDP housing area (“Nguni Kraal” area) for affordability reasons and in the industrial area (where aesthetics do not require underground cables). These poles will be of similar configuration to the existing 22kV network poles, preserving the current rural look and feel.

# 4. COST ESTIMATES

The estimation of the capital cost of infrastructure is based on a detail layout design of the preliminary networks and systems, and industry rates for similar contracts.

The per erf cost allocation is based on a total number of erven of 430, which includes the residential erven as well as all other erven.

A rough estimation is also made of the overall annual operation and maintenance costs of the various services, based on the maintenance costs of similar sized villages.

The figures in this section exclude VAT.

## 4.1 Water

### 4.1.1 Capital Cost of Infrastructure

The capital cost for the development of the water system is made up as follows:

| | |
|---|---|
| • Abstraction, filter and dosage facilities, pumps | R320 000 |
| • Pump main | R376 000 |
| • Clear water reservoir with dosage facility | R300 000 |
| • Fire hydrants | R72 000 |
| • Reticulation | R2 850 550 |
| **Total capital cost** | **R3 888 550** |
| **Capital cost per erf** | **R9 043** |

### 4.1.2 Operation and Maintenance Cost

The annual operation and maintenance cost of the water system is made up as follows:

| | |
|---|---|
| • Staff and labour (pro rata portion of all O&M staff) | R200 000 |
| • Materials for repairs (capital cost over 20 years) | R200 000 |
| • Electricity, diesel and chlorine | R1 032 000 |
| **Total annual O&M cost** | **R1 432 000** |
| **Annual O&M cost per erf** | **R3 330** |

### 4.1.3 Equitable Water Rates

An equitable water rate per erf could be derived by allocating equitable contributions by the various types of erven to make up the total annual O&M cost, as follows:

| Parameter | Commercial & institutional | High income residential | Medium income residential |
|---|---|---|---|
| • No. of erven | 30 | 300 | 100 |
| • O&M alloc. per erf | 16 067 | 3 000 | 500 |
| • O&M cost pa | 482 000 | 900 000 | 50 000 |
| Total annual O&M cost | | | 1 432 000 |
| Cash management buffer allowed | | | 20% |
| • Annual cost recovery | 578 400 | 1 080 000 | 60 000 |
| • Annual consumption (kl) | 28 000 | 59 000 | 9 000 |
| • Ave. unit recovery (R/kl) | 20.66 | 18.30 | 6.67 |

The following equitable rates structure would meet the cost recovery requirement:

| Monthly Consumption (kl per month) | | Rates (basic charge plus per kl) | | |
|---|---|---|---|---|
| From | to | Commercial & institutional | High income residential | Medium income residential |
| • 0 | 6 | fixed 350.00 | 180.00 | free basic water |
| • 6 | 12 | included | included | fixed 20.00 |
| • 12 | 20 | included | 18.00 | 10.00 |
| • 20 | 75 | 22.00 | 20.00 | 12.00 |
| • 75 | up | 25.00 | 25.00 | 25.00 |

The rates are two to four times the norm for such service, but are necessary to cover the cost of water services. It being a village with a recreational character and relative low consumption, it would be affordable though. Water provision in terms of the water system design is thus foreseen to be feasible and viable.

## 4.2 Sewage

### 4.2.1 Capital Cost of Infrastructure

The capital cost for the development of the sewage system is made up as follows:

| | |
|---|---|
| • Waste water treatment plants | R450 000 |
| • Sewage pump and pump main for irrigation | R162 500 |
| • Sewer reticulation | R5 792 375 |
| **Total capital cost** | **R6 404 875** |
| **Capital cost per erf** | **R14 895** |

### 4.2.2 Operation and Maintenance Cost

The annual operation and maintenance cost of the sewage collection and waste water treatment system is made up as follows:

| | |
|---|---|
| • Staff and labour (pro rata portion of all O&M staff) | R200 000 |
| • Materials for repairs (capital cost over 20 years) | R428 000 |
| • Electricity, diesel and treatment agents | R516 000 |
| **Total annual O&M cost** | **R1 144 000** |
| **Annual O&M cost per erf** | **R2 660** |

### 4.2.3 Equitable Sewage Rates

An equitable sewage rate per erf could be derived by allocating equitable contributions by the various types of erven to make up the total annual O&M cost, as follows:

| Parameter | Commercial & institutional | High income residential | Medium income residential |
|---|---|---|---|
| • No. of erven | 30 | 300 | 100 |
| • O&M alloc. per erf | 10 800 | 2 600 | 400 |
| • O&M cost pa | 324 000 | 780 000 | 40 000 |
| Total annual O&M cost | | | 1 144 000 |
| Cash management buffer allowed | | | 20% |
| • Annual cost recovery | 389 000 | 936 000 | 48 000 |
| • Annual production (kl) | 14 000 | 30 000 | 6 000 |
| • Ave. unit recovery (R/kl) | 27.78 | 31.20 | 8.00 |

The following equitable rates structure would meet the cost recovery requirement:

| Monthly Consumption (kl water per month) | | Rates (basic charge plus per kl water reading) | | |
|---|---|---|---|---|
| From | to | Commercial & institutional | High income residential | Medium income residential |
| • 0 | 6 | fixed 500.00 | 310.00 | free basic water |
| • 6 | 12 | included | included | fixed 20.00 |
| • 12 | 20 | included | 31.00 | 10.00 |
| • 20 | 75 | 30.00 | 33.00 | 15.00 |
| • 75 | up | 35.00 | 35.00 | 35.00 |

The rates are two to four times the norm for such service, but are necessary to cover the cost of sanitation services. It being a village with a recreational character and

relative low consumption, it would be affordable though. Sanitation services in terms of the sewage collection and treatment system design is thus foreseen to be feasible and viable.

## 4.3 Solid Waste

### 4.3.1 Capital Cost of Infrastructure

The costs of providing the necessary facilities at the solid waste site are as follows:

- Fencing and gate house R36 000
- Loading ramp and crane and recycling penstocks R450 000

**Total capital cost** **R486 000**

### 4.3.2 Operation and Maintenance Cost

The annual operation and maintenance cost of the solid waste collection and disposal is made up as follows:

- Service provider (assume R200 / ton x 2 000 tons pa) R400 000
- Other staff and labour (pro rata portion of all O&M staff) R40 000
- Materials for repairs (capital cost over 20 years) R24 000

**Total annual O&M cost** **R464 000**

### 4.3.3 Equitable Waste Removal Rates

Any income generated though waste separation and recycling by entrepreneurs allowed on the site will not attribute to the service provider but to the community entrepreneurs.

An equitable waste removal rate per customer could be derived by allocating equitable contributions by the various types of customers to make up the total annual O&M cost. Low and medium income residences will not contribute to waste removal services costs rendered to them, due to the small volumes relative to the other types of use. The cost allocation, allowing for a 20% cash management buffer, is as follows:

| Parameter | Commercial & institutional | High income residential | Agri industry |
|---|---|---|---|
| • No. of customers | 30 | 300 | 40 |
| • Waste generation volume pa | 36 | 780 | 1040 |
| • Annual cost recovery | 11 000 | 234 000 | 312 000 |

The following equitable rates structure would meet the cost recovery requirement:

Rates

| Parameter | Commercial & institutional | High income residential | Agri industry |
|---|---|---|---|
| • Monthly charge | R31.00 | R65.00 | R31.00 |
| • Plus per ton delivered | R300.00 | - | R300.00 |

The above solid waste disposal rates would cover the cost of the services and are within acceptable norms for this service. Solid waste collection and disposal in terms of the planned infrastructure and management plan is thus foreseen to be feasible and viable.

## 4.4 Traffic Roads and Stormwater

### 4.4.1 Capital Cost of Infrastructure

The estimated capital cost of the roads and stormwater infrastructure is summarized as follows:

| | |
|---|---|
| • Road formation and wearing course / base | R2 082 675 |
| • Surfacing of Village roads | R25 000 |
| • Paving of town square | R1 650 000 |
| • Landing strip | R94 500 |
| • Road stormwater systems | R1 371 850 |
| • Stormwater retention dams and erosion weirs | R1 342 375 |
| **Total roads and stormwater capital cost** | **R6 566 400** |

### 4.4.2 Maintenance Cost

The maintenance cost of roads and stormwater infrastructure is taken as the general industry standard in terms of a amount per km per annum.

The annual maintenance cost is estimated as follows:

| Road class | annual maintenance cost | extent | cost |
|---|---|---|---|
| • Paved areas | R20 | 5 000 | R100 000 |
| • Surfaced Distr. Road | R60 000 | 2km | R120 000 |
| • Gravel distr. Roads | R20 000 | 3km | R60 000 |
| • Gravel Village & Access Streets | R10 000 | 10km | R100 000 |
| • Farm Roads | R5 000 | 15km | R75 000 |
| • Retention dams & weirs | allowance | | R50 000 |
| **Total maintenance costs pa** | | | **R495 000** |
| **Total maintenance cost pa / erf** | | | **R1 151** |

### 4.4.3 Cost Recovery for Maintenance Work

At a mere R10 per month per erf, the maintenance cost for roads and stormwater will be charged as part of the commercial services. Since a 20% buffer has been allowed in the estimation of the O&M costs for the latter, no additional cost recovery allowance is made here for maintenance of roads.

## 4.5 Grid Energy

### 4.5.1 Points of Connection

### 4.5.2 Points of Delivery

### 4.5.3 Reticulation

### 4.5.4 Equitable Rates Model

# 5. PROCUREMENT STRATEGY

The Developer plans to undertake the installation of services using its own resources and management.

For subcontracting, the Preferential Procurement Strategy of the Phumelela Municipality will be followed, while targeting local labour and local service providers. The principles of the EPWP will be adhered to.

Sustainable commercial opportunities will be created for local BEE entrepreneurs where possible. One idea is to establish a trust that would obtain the mining licence for quarrying and that would run the stone cutting operations. The idea is to extend the capacity and/or life of the quarry beyond the needs of the development so as to extend the duration of employment. The quarry site might be relocated after the needs of the development have been met, depending on the availability of the resource and the impact on the development.

# 6. CONCLUSIONS

The Developer, Verkykerskop Township Development (Pty) Ltd, appointed Lidwala to prepare this engineering services report for consideration by the Verkykerskop Developers Consortium. The Consortium will provide the report to the town planners for incorporation and consideration as part of the SDF process.

This report indicates that all civil engineering services (electricity is not addressed in this report) required for the proposed development can be provided in a feasible and viable manner. The following are highlighted:

- The water provision plan is dependent on the authorization for the construction of a storage dam and the issuing of a water use license. Meeting the anticipated water demand will not have a notable effect on the hydrology of the stream.
- The waste water treatment plan is dependent on the authorization of the treatment of waste water and the release of treated water into the environment. The quality of treated water will be acceptable, and the volume that will be released into the environment will be insignificant compared to the water regime in that area.
- The Developer is able to install all infrastructure and proposes to establish a not-for-profit service entity for the operation and maintenance of all the services. Equitable service rates were calculated based on the actual cost of services. The cost of water and sanitation services will be relatively high, but given the recreational character and relatively low household consumption, these services will be affordable.
- Other services such as solid waste removal maintenance of roads are also addressed in the report, and are found to be feasible and viable to render.

# 7. RECOMMENDATIONS

Following from the analyses of this study, it is recommended that:

1. The water utilization plan, comprising fitting of two boreholes and the construction of a storage dam as designed and presented herein be approved by DWAF.
2. The integrated water use license application be favourably considered by DWAF.
3. A not-for-profit service entity, governed by the property owners within the SDF area, own the infrastructure and be charged with the delivery of commercial services, the operation and maintenance of infrastructure, and the collection and administration of rates. This company must also be charged with the maintenance of the non-commercial services infrastructure.
4. The solid waste management plan and the waste disposal site in particular be approved by the relevant authority, and that the service entity negotiates with a specialist company for the managing of the waste site and recycling, and the removal of bulk waste.
5. This report be used as basis for the negotiation of a services agreement with the municipality.

6. This report be recognized as adequate technical substantiation that the proposed village development at Verkykerskop is feasible and viable from a services point of view.

## ANNEXURE A: MANDATING LETTER TO SUBMIT A SDF

## APPENDIX B: SCAN OF GEOLOGICAL MAP

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