VAST MINERAL SANDS (Pty) Ltd

HEAVY MINERAL SANDS PROJECT, ALEXANDER BAY, NORTHERN CAPE

SURFACE AND GROUNDWATER ASSESSMENT

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1. Surface and Groundwater Resources

1.1 Introduction

The VAST Heavy Mineral Sand prospecting project is situated in the coastal zone between Alexander Bay and the coastal area just south of Port Nolloth. The west coast of South Africa in this extreme north-west corner of the country is an arid area. Rainfall here is generally low and highly variable. Alexander Bay normally receives about 41mm of rain per year. It receives most of its rainfall during winter and thus falls within the Mediterranean climate zone of Southern Africa. It receives the lowest rainfall (0mm) in January and the highest (6mm) in June. Port Nolloth has recorded an average rainfall of 63mm during the past few decades. The average annual evaporation rate for this area is measured at 2,524mm and the combined effect of low rainfall and high evaporation rates result in extremely dry conditions. The monthly distribution of average daily maximum temperatures shows that the average midday temperatures for Alexander Bay range from 20.6°C in July to 27.5°C in January. The region is the coldest during July when the mercury drops to 8.3°C on average during night time.

From September to early April, late morning to afternoon south-westerly winds can reach gale force velocities in excess of 70km/h. North-westerly winds are the dominant wind in winter when cold fronts reach the coast from the southern Atlantic Ocean. In winter, between cold fronts, fog in the late afternoon till late morning is a common occurrence. Occasional hot, dry easterly katabatic winds, locally known as “berg winds”, in winter can result in drastic temperature increases during these events reaching 40°C and resulting in extreme temperature variations of up to 30°C.

This prospecting area falls within Water Management Area (WMA) 6 – Lower Orange, and straddles the catchment divide between quaternary catchments F50G and F40H (DWAF 2004). The natural mean annual runoff of all the coastal catchments in the WMA, which stretch some 285km from Strandfontein in the south to Alexander Bay at the mouth of the Orange River in the north, is estimated to be 24 million cubic metres (Mm^3). All rivers in the area except the Orange River are ephemeral / episodic, and flow only sporadically in response to high rainfall events, mostly in their upper catchments, remote from the coast, where annual rainfall can exceed 100mm. As a result, available reliable yield from surface water sources in all the coastal catchments is estimated to be zero, while reliable yield from groundwater from the catchments is estimated to be a total of 3 Mm^3/a. Approximately 6 Mm^3/a of water is transferred into the southern part of the area from the Orange River to meet the urban / domestic requirements in the Alexander Bay, Port Nolloth and Kleinzee area (DWAF 2004).

1.2 Surface water

The perennial Orange River border the prospecting area to the north (Figure 1) without transecting it. Two episodic rivers, the Holgat River and Kamma River flow from east to west through the central and southern part of the prospecting area respectively (Figure 1).

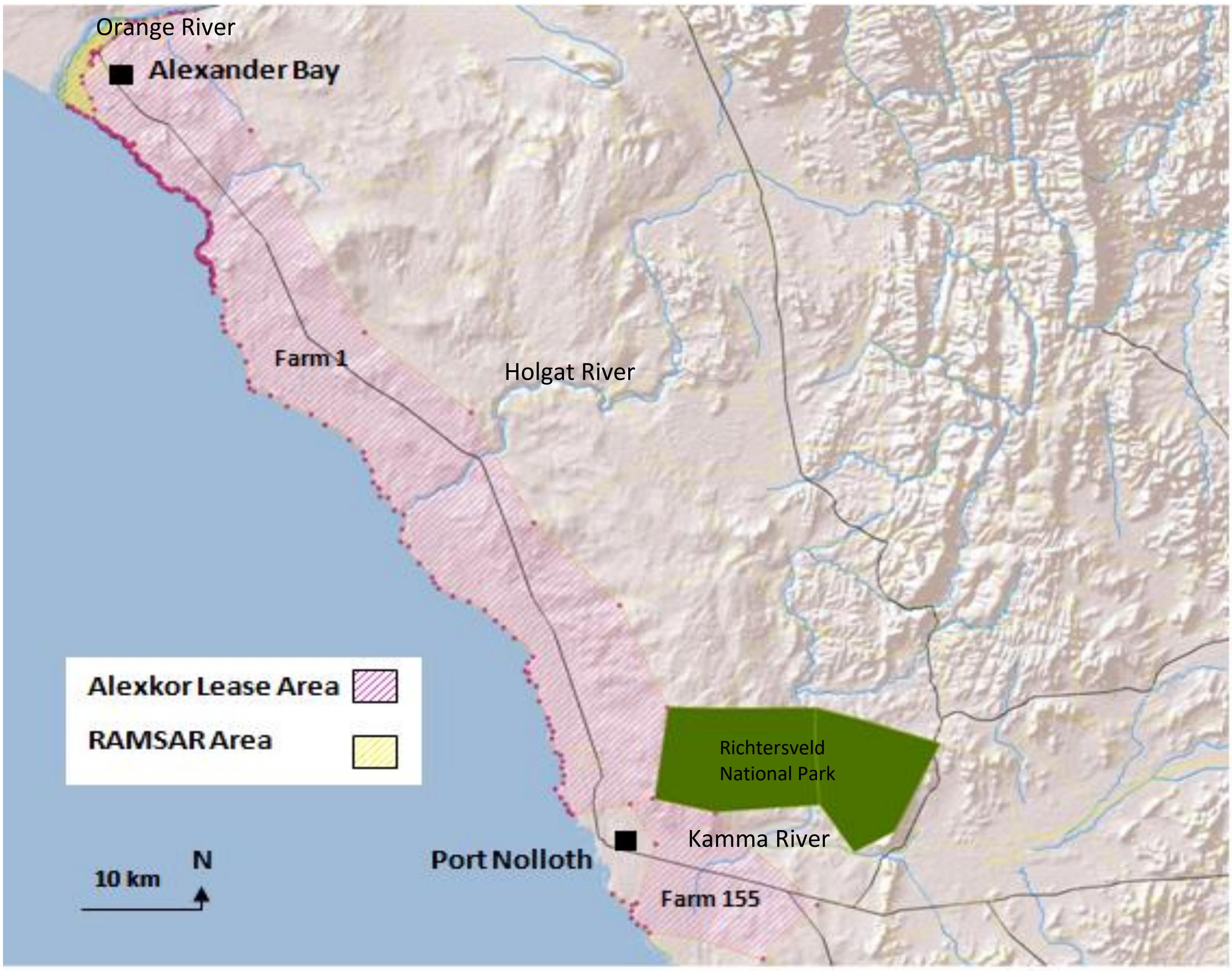

Figure 1: Rivers in the project area

1.2.1 Orange River

The Orange River Mouth forms part of the Orange River Basin (or catchment), the largest river basin in Africa south of the Zambezi, covering an area of approximately 0.9 million km^2 (Maré 2007). The basin stretches over four countries - South Africa, Lesotho, Botswana and Namibia, with the Orange River itself forming part of the border between South Africa and Namibia. The two main tributaries are the Senqu and the Vaal Rivers. The headwaters of the Senqu rise in the Maluti mountain range in the Lesotho Highlands, while the other main tributary, the Vaal River, rises on the eastern highveld escarpment in north-east South Africa (Earle *et al.* 2005). At the confluence of the Senqu and Vaal rivers, the Orange River flows in a westerly direction to the west coast entering the Atlantic Ocean through the Orange River Estuary. A smaller tributary, the Fish River, joins the Orange River in the lower Orange catchment.

The basin plays host to one of the most industrially developed parts of Africa (the region around Johannesburg) and supports a range of commercial and subsistence farming activities. Water demand in the catchment is therefore very high, resulting in substantial changes in natural river flows, particularly in the Lower Orange River with resultant impacts on the estuary.

Following South Africa's accession to the Ramsar convention, the Orange River Mouth was designated as a Ramsar site by South Africa in 1991. After Namibia ratified the Ramsar Convention in 1995, the designated area was enlarged and the Namibian part of the wetland was immediately designated as well. In the same year, the area was put on the Montreux record as part of it had been seriously degraded. The Orange River Mouth Interim Management Committee (ORMIMC) was established in 1995 and has served as an advisory body to the respective competent authorities. The ORMIMC has been the driving force behind current initiatives at the central government level in South Africa to rehabilitate the area, to remove it from the Montreux record, to get the area protected under South African law, and to draft a management plan for the Ramsar site. Despite these initiatives however, active management of the Ramsar site has been limited and has resided largely in the hands of the mining companies Alexkor and NAMDEB (jointly owned by De Beers and Namibian Government) located on the South African and Namibian sides of the estuary respectively. This situation has recently changed with the proclamation of the Sperrgebiet National Park in Namibia that includes the Namibian section of the Orange River Mouth and the settlement of a land claim on the South African section, which has now been handed over to the Richtersveld community.

The Orange River has become highly regulated by virtue of more than 20 major dams and numerous weirs or levees within its catchment. As a consequence, river inflows to the Orange River Estuary have been markedly reduced from reference, with only an estimated 44% of natural flows still reaching the system (DWAF, 2003). This causes a significant reduction in the occurrence and magnitude of large floods. Floods in the Orange system normally occur during the summer months. Also the occurrence and magnitude of smaller floods with return periods of 1:1 year to 1:10 years, also during the summer months, has been greatly reduced. This results in a considerable reduction in the occurrence of flooding of the salt marsh near the mouth during the summer months. Such floods would probably have lasted for periods of a few weeks at a time. The upstream structures eliminated the occurrence of periods of very low flow during the winter months, causing mouth closure and back-flooding in the past, to be significantly reduced, because of almost continuous releases from the dams. These releases are undertaken for the generation of electricity and for irrigation purposes. Abstraction and regulation has also resulted in a marked reduction in the variability in river inflows from a pronounced seasonal flow to a nearly even flow distribution throughout the year. Surplus water releases for the generation of hydropower has resulted in the elimination of water deficits in the lower reaches of the river and the mouth now remains open almost permanently. The lack of mouth closure and associated back-flooding is regarded as particularly problematic as it is during such occurrences that flows into the saltmarsh area typically occur (CSIR, 2011).

This situation is likely to be exacerbated in future through increased demand for water by catchment users, and through climate change. With respect to the latter, a recent climate modelling study concluded that:

- the western half of South Africa could experience a 10% decrease in runoff by the year 2015 (including the middle Orange, the Nossob, the Fish and the lower Orange sub-basins);
- The year when a 10% decrease in runoff occurs, moves progressively later (to 2060) as one moves from the western to eastern halves of southern Africa; and

- 12 – 16% decrease in outflow could occur at the Orange River mouth by 2050 (ORASECOM 2008).

The status of the water quality in the lower Orange River is generally assessed to be moderately modified to strongly affected because of fragmentation and flow regulation. Although the general water quality of the lower Orange River is still fairly good, it is deteriorating, but is still regarded as acceptable for agricultural, domestic, recreational, and industrial use. Major water quality related issues and concerns are blackfly outbreaks, increased loads of salts (salinity), and eutrophication (nutrient over-enrichment) (ARTP Joint Management Board, 2009).

In the long-term, increased pressure is expected from population increases and development in the Orange River catchment and will increase the pollution levels, which will probably necessitate additional measures and strategies to maintain acceptable water quality in the river. Management of the Orange River is the responsibility of the two water affairs departments of Namibia and South Africa, whose activities are co-ordinated through the Permanent Water Commission (PWC), and in the larger catchment of the countries involved in ORASECOM.

1.2.2 Holgat- and Kamma Rivers

The Holgat- and the Kamma Rivers, as is the case with other coastal rivers in Namaqualand, comprise relatively small river channels (in places, more than one channel) meandering in wide, shallow, alluvium-filled valleys that have been incised over time into the crystalline bedrock (Heydorn & Grindley, 1981). The episodic nature of the flow in the rivers is confirmed by long term records from Alexkor and its predecessor, Alexander Bay State Alluvial Diggings. No hydrological gauging stations were installed on either river. The catchment areas of both rivers are very small. It is, however, meteorologically improbable that the peak flow rates increased by the ratio of the catchment areas: that is, they were unlikely to have exceeded 100m^3/sec.

The ephemeral nature of the rivers in the project area means that surface water resources are not used at all in the area, either for domestic use or stock watering. Neither river flows sufficiently reliably to be considered as a possible source of water for prospecting operations.

1.2.3 Flooding

1.2.3.1 Orange River

The natural runoff of the Orange River basin is in the order of 11 600 million m^3/a of which approximately 4 000 million m^3/a originates in the Lesotho Highlands and approximately 900 million m^3/a from the contributing catchment downstream of the Orange/Vaal confluence, which includes part of Namibia and a small portion in Botswana feeding the Nossob and Molopo rivers. The remaining 6 700 million m^3/a originates from the areas contributing to the Vaal, Caledon, Kraai and Middle Orange rivers. Highly erratic runoff in the Orange River originates downstream of the Orange-Vaal confluence is.

The actual runoff reaching the Orange River mouth (estimated to be in the order of 5 500 million m^3/annum) is considerably less than the natural value (over 11 000 million m^3/annum). The difference is due mainly to the extensive water utilisation in the Vaal River basin, most of which is for domestic and industrial purposes. Large volumes of water are also used to support the extensive irrigation (estimated to be in the order of 1 800 million m^3/annum) and some mining demands (approximately 40 million m^3/annum) occurring along the Orange River downstream of the Orange/Vaal confluence, as well as some irrigation in the Lower Vaal catchment and Eastern Cape area supplied through the Orange/Fish Canal. In addition to the water demands mentioned above, evaporation losses from the Orange River and the associated riparian vegetation account for between 500 million m^3/a and 1 000 million m^3/a depending upon the flow of water (and consequently the surface area) in the river (McKenzie et al, 1995).

It is only during infrequent and extreme rainfall events that the lower Orange catchment (excluding the Fish) makes a noticeable contribution to the Orange River. Such events may occur at intervals of many years or even decades and during such periods it is likely that the Orange River will already have above average or flood flows. The average natural inflow of ~420 million m^3/a is therefore of limited use since it occurs sporadically in large volumes when it is least required and cannot be stored since there are no storage reservoirs downstream of the Orange/Vaal confluence. The losses on the other hand occur each year assuming that there is flow in the river (which is generally the case) and therefore have a very significant and detrimental influence on overall water resources. When describing the water resources of the Orange River it should be noted that the sum of the individual natural run-offs does not necessarily give the total run-off for the whole basin. In reality, the natural run-off at the Orange/Vaal confluence is estimated to be in the order of 10 850 million m^3/a. The natural resources to the river mouth, however, should rather be quoted as approximately 11 000 million m^3/a and not 11 750 million m^3/a, since the evaporation losses downstream of the Orange/Vaal confluence tend to exceed the combined natural inflows from other areas.

Flood discharge in the Orange River is highly controlled through a system of levees. Early records in the Department of Water Affairs archives report on damage to flood levees after a flood event in 1957. However, it was only after a particularly large flood in 1974 that there was a concerted effort by the Department of Water Affairs and various local municipalities to develop a network of flood levees.

1.2.3.2 Holgat- and Kamma Rivers

Although there is no visible flow in the Holgat- and Kamma rivers for most of the time, they do experience rare flooding events. During such events, extreme out-of-channel inundation might occur. The two recorded flash flood events during the years of 1928 and again in 1996 did result in spectacular flood occurrences. These were also the only episodes when noticeable discharge was recorded in these two rivers.

In the absence of published flood flow data for these two river systems, the flooding regimes were estimated using the DWAF publication TR 137 – Regional Maximum Flood Peaks in Southern Africa (DWAF 1988), as recommended in the Best Practice Guidelines for Water Resource Protection in the South African Mining Industry (DWAF 2006). The process followed to estimate the extent of flooding resulting from high-flow events with long return periods was as follows:

(i) Estimate the catchment areas at points on each river where flooding my impact on prospecting activities.

(ii) Identify the regional category of the catchment using the categorisation in TR 137.

(iii) Estimate the peak flow magnitude (Q), in cubic metres per second (m^3/sec), of the Regional Maximum Flood (RMF) using the relationships presented in TR 137.

(iv) Estimate the peak flow magnitude for floods with return periods of 50, 100 and 200 years using the relationship between such floods and the RMF in TR137.

Note: TR137 presents relationships between the RMF and floods of other return periods for South Africa.

The results of the flood peak magnitude estimates are shown in Table 1.

Table 1.1: Estimated peak flood magnitudes at selected points in the project site

River	Location	Catchment Area (km^2)	QRMF m^3/s	Q50	Q100	Q200
Holgat	At R385	88	159,7	39.84	57.24	80.84
Kamma	At R385	242	155,3	45.75	62.95	85.25

http://www.dwaf.gov.za/Hydrology/ - Data, Dams and Flow Information

Given the uncertainties in the data used to determine the flood profiles, the results must be regarded as indicative only. The analyses do, however, indicate that the extent of flooding during the 100- and 200-year floods is not expected to exceed the limits of the well-defined riverbed / floodplain areas of any of the rivers, even for the higher peak magnitudes.

1.3. Groundwater

1.3.1 Introduction

The geological conditions on site comprise an uncomplicated arrangement of aquifers and hydrostratigraphic units. The aquifers on site can be divided into two main units as follows:

Unconsolidated primary aquifer:

This aquifer consists of the surface aeolian sands, marine sands and basal grits and conglomerates overlying the quartzitic and schist bedrock. The presence of damp sands and minor mud at the base of a number of exploration boreholes, most notably in areas corresponding to topographic lows in the surface of the bedrock, are indicative of a minor concentration of groundwater in the Muisvlak and Seemansrus areas. Although minor kaolinisation and cementation from the weathering of the feldspars in the underlying schist and gneisses exists, the unit is generally unconsolidated and relatively permeable. The unit has a relatively high clay content constituting some 20% of the overall volume on average with local values up to 35%. The undulating nature of the bedrock contact means that only local perched aquifers with limited aerial extent may form, separated by palaeo-highs in the bedrock contact.

Fractured secondary aquifer:

This aquifer underlies the primary aquifer and comprises predominantly fractured bedrock within quartzite, gneiss and schist, which underlie the site. The bedrock geology consists of high-grade metamorphic rocks of the Namaqua-Natal Mobile Belt, which are generally massive and highly deformed. The topography of the bedrock contact with the overlying weathered material has been shown to correspond with structures in the bedrock such as faults and fractures, which are generally oriented north-north-west – south-south-east, northeast - south-west and west-north-west - east-south-east. Although significant groundwater flow may be encountered in faults and fracture zones, overall storativity is likely to be very limited with a resultant decrease in long-term sustainability of abstraction, particularly at the relatively high rates that would be required for production. Based on the apparent depths of drilling, it is clear that all the boreholes in the area are drilled into fracture or fault zones in the bedrock

1.3.2 Precipitation, Evapo-transpiration and Runoff

The mean annual evaporation values for the site are given at approximately 2,524mm per year. This is significantly higher than the mean annual rainfall of approximately 50mm per year. However, rainfall on site occurs in discrete events, which tend to be of high intensity and short duration. As a result, it is possible that some runoff into the local rivers can occur without major evaporation losses. Although monthly evaporation values for the area are not available, WR2005 lists the average annual runoff for the area as 1mm per year. This is considered realistic based on observations on site corroborated by evidence from local landowners who indicate that flow in the area occurs as minor flash floods immediately during and after intense rainfall events.

1.3.3 Flow Directions

Groundwater levels on site vary from 1.6m below surface in the Kamma River bed to the south of the site, and 87.5m below surface up gradient topographically towards the eastern border. On a regional scale, groundwater flow is from east to west, flowing towards the Atlantic Ocean. On a local scale, groundwater flows from the centre of the site towards the Holgat River in the central area, and the Kamma River in the south.

1.3.4 Groundwater Recharge and Discharge

Groundwater recharge in the area is approximately 2% of mean annual precipitation. It is expected that actual recharge may be less than this figure owing to the relatively high levels of evaporation in the area. However, for the purposes of determining contribution of recharge to the aquifers, the value is not considered unrealistic. The relatively high clay content of the unconsolidated aquifer serves to retard vertical flow and may result in a significant reduction in recharge. It is thought that the recharge to the fractured rock aquifer is more regionally sourced than locally, due to the retarded vertical flow of infiltrating rainwater. The retardation is a result of both the high evaporation in the area, and the aquitard effect of the weathered, kaolinite-rich bedrock layer. This recharge occurs in the topographically higher areas to the east of the site with the resultant high head causing flow to the west. Lateral recharge of groundwater from the east follows the overall topographic gradient towards the Atlantic Ocean. The ephemeral rivers probably act as losing streams as is common in arid zones, but more detailed data from groundwater elevations around the riverbeds is required to determine this.

1.3.5 Aquifer characterisation

Due to the availability of water from the Orange River and the low potential of appreciable ground water yield in the area, ground water has been ruled out as a source of water at present. The last borehole abstraction of ground water at Alexkor and at the neighbouring properties was terminated in the late 1980's. Groundwater daylights at two localities only on the entire Alexkor property, namely at Seemansrust in the south and at Rietfontein in the central part of the area. Both these occurrences are primary aquifer related with the Seemansrust occurrence probably related to seepage from the Kamma River, and the Rietfontein springs probably fed by the secondary aquifer, but accommodated by the primary aquifer.

Historic exploration and mining indicated the presence of a thick layer of weathered bedrock material with elevated proportions of kaolinite clay between the upper aeonian sands aquifer and the lower fractured bedrock aquifer. This relatively impermeable layer probably may act as an aquitard, which restricts water flow between the two aquifers and, importantly, influences the volume and rate of seepage from backfilling operations to the water table.

Geologically there are no distinct structural or lithological boundaries within the site, and as a result it is assumed that the Holgat River to the north and the Kamma River to the south act as boundaries to flow in these directions. High ground to the east acts as a watershed for surface water, and is assumed to coincide with the boundary between groundwater units, while the Atlantic Ocean to the west acts as a natural boundary. The proximity of the site to the coastline, and the surface elevation of the bedrock and groundwater levels, does pose a risk of seawater intrusion as a result of groundwater abstraction.

1.4 Assessment of impacts

1.4.1 Impacts on groundwater

Impacts relating to groundwater are assessed for the exploration period only.

1.4.2 Impacts on surface water

Impacts relating to surface water are assessed for the exploration period only.

1.4.3 Cause and comment

No ground- or surface water will be used during prospecting. No impacts are anticipated.

1.5 Conclusions

This ground and surface water assessment cover the prospecting phase of the Vast Mineral Sands (Pty) Ltd project in terms of baseline ground and surface water data for the area. The area has been mined extensively during the past 80 years. This allowed for the establishment of a very good survey record of conditions relating to the ground and surface water situation at the site.

It is proposed that a 125m buffer zone is established between the Ramsar area and the prospecting area in order to avoid any disturbance that might cause interference with the natural flow of ground water or to generate dust that might impact the water body at the Orange River mouth. No prospecting will take place in the Holgat- and Kamma Rivers and the riparian zones should be excluded from prospecting. This will eliminate any possible impacts on both surface and ground water in these areas. Exploration over the entire area will be limited to the unconsolidated primary aquifer where drilling will be done to an average depth of 15m below surface.

1.6 References

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