ORANGE - SENQU RIVER COMMISSION
BOTSWANA LESOTHO
ORASECOM
NAMIBIA SOUTH AFRICA
Established 2000

IMPROVING GROUNDWATER KNOWLEDGE IN SELECTED TRANSBOUNDARY AQUIFERS

Joint Survey Technical Report

September 2018

Report No. ORASECOM 008/2018

The *Support to* ***the Improving Groundwater Knowledge in Selected Transboundary Aquifers*** Study was commissioned by the Secretariat of the Orange-Senqu River Commission (ORASECOM) with technical and financial support from the German Federal Ministry for Economic Cooperation and Development (BMZ), in delegated cooperation with the UK Department for International Development (DFID), implemented through Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

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IMPROVING GROUNDWATER KNOWLEDGE IN SELECTED TRANSBOUNDARY AQUIFERS

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Document History

Rev.	Date Revised	Editor Details	Note of Changes Conducted
V1.0	September 2018	K. Sami	Initial report distributed to Client

DOCUMENT INDEX

Index Number	ORASECOM Report Number	Report Title
1		**Inception report**
2		Draft final report with updated groundwater recharge estimates in the main recharge areas in the Karroo Sedimentary and the Khakhea/Bray Dolomite Aquifers
3		An agreed list of priority transboundary aquifer features & characteristics, and groundwater quantity & quality parameters and variables of concern, and a list of those areas within the Orange-Senqu River Basin where aquifer characteristics, and groundwater quantity and quality issues are of particular concern
4		A web-based robust framework/programme/system for monitoring and management of important

Index Number	ORASECOM Report Number	Report Title
		transboundary aquifer features/characteristics, and groundwater quantity & quality of all transboundary aquifers in the Ba-sin
5		Report indicating inputs made at the stakeholder's workshop
6		Final Recharge report
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1 INTRODUCTION

1.1 BACKGROUND

One of the objectives of the 'Improving Groundwater Knowledge in Selected Transboundary Aquifers' Project is the undertaking of a ***joint basin survey*** (JBS) by the members of the GWHC to foster closer cooperation by specialists in member states and increase awareness of transboundary issues. ORASECOM intends the joint survey to provide hands-on field observation of key transboundary aquifers, and the issues of concern to members of the GWHC.

The Process Report included a checklist of parameters and features for observation by a joint team of officials responsible for groundwater from the four State Parties. This subsequent Technical report is to be based on the findings and provide justification of features to observe and recommendations on further and similar joint surveys.

The JBS provided hands-on field observation of diverse processes, and the issues of concern, by the members of the GWHC. Experiences from the survey will enable the GWHC members to give technical advice to the Member States regarding transboundary groundwater resources protection, development and management. Moreover, the JBS provided the opportunity for experts from the Member States to exchange ideas. This interaction helped to facilitate and enhance the mandate of ORASECOM, which includes establishing dialogue and assisting with the exchange of data and information among the member States.

To achieve this objective, the methodology employed consisted of a process report, which outlined an itinerary and technical description of each site to be visited by the national representatives to provide a conceptual understanding of the site and its reason for inclusion. Since the prime objective was supposed to be capacity building, a list of questions for the representatives to discuss and debate amongst themselves was provided to stimulate conceptual thinking and dialogue. They were encouraged to produce a report of their joint opinion. The opinions of the team were discussed during a debrief, from which this report was compiled.

1.2 Checklist of Processes to be Observed

The JBS was undertaken from 10-15 September 2018, covering the following areas: -

i. The Maputsoe/Ficksburg Wellfield shared by Lesotho and South Africa, along the sides of the Caledon River, which also forms the border between Lesotho and South Africa. Abstraction from this alluvial aquifer has a transboundary implication and could impact on baseflows in an international river.

ii. The Khubelu Sponges (Wetlands) in the Lesotho Highlands, which forms the source of one of the tributaries of the Senqu River i.e. the Khubelu River. Highland wetlands play a very important role in Interflow and baseflow to transboundary rivers (Wetlands in the Lesotho Highlands)

iii. The Oranjedraai Flow Gauging Station on the Orange River, just after the Senqu flows into South Africa from Lesotho. This gauging station is an integrated location to measure subsurface interactions in Lesotho, hence quantifying baseflow and recharge.

iv. The Tosca/Bray/Verlegee/Khakhea Transboundary Groundwater Aquifer shared by Botswana and South Africa;

v. The Kuruman Dolomitic Groundwater Eye/Spring, which forms the source of the Kuruman River, which is the tributary of the Molopo River, shared by Botswana and South Africa; and

vi. The Rooiputs Waterhole, which is one of the discharge points in the Stampriet Transboundary Aquifer System (STAS), shared by Botswana, Namibia and South Africa, as well as impacts recharge and groundwater use in the upper gradient areas in the Aquifer may have had at the time of the Survey.

2 OBSERVATIONS AND RECOMMENDATIONS

2.1 Maputsoe Wellfield

The Water and Sewage Authority (WASA) in Lesotho is responsible for water supply and sanitation in the 13 urban areas within Lesotho, all of which are part of the Orange-Senqu River basin. The water supply scheme at Maputsoe northeast of Maseru comprises three sources and associated infrastructure. The Mohokare/Caledon River, two well-point systems and a borehole supplying 300 m³/day.

The well-fields are installed in the sandy river bed. The Quaternary and Recent alluvial aquifers have good hydraulic characteristics although their size is limited. The hydraulic characteristics are variable and often site-specific, making borehole siting difficult. Some of the largest alluvial aquifers in Lesotho are located at Maputsoe (figure 2-1). Under natural conditions, the aquifer discharges baseflow to the aquifer. When such aquifers are subject to abstraction, the nature of interactions may change.

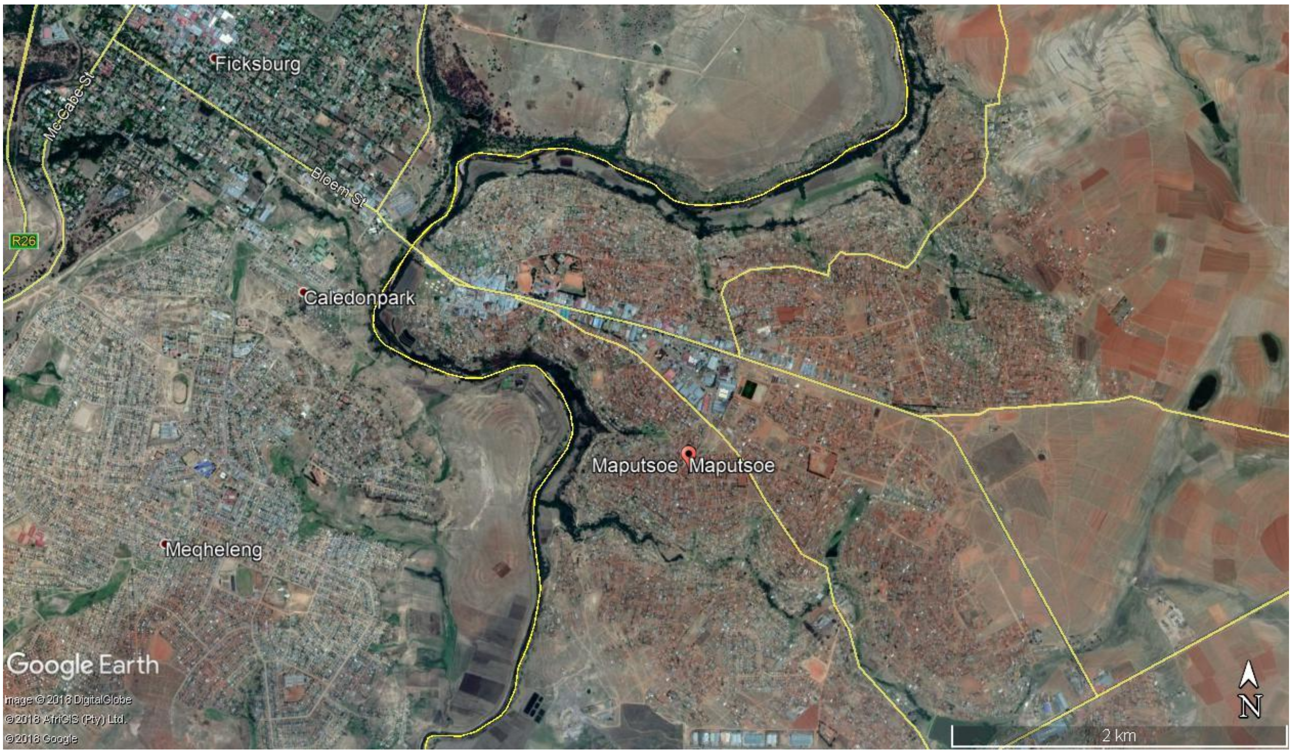

Figure 2-1 Location of Maputsoe

The production boreholes of the Maputsoe Wellfield are situated along the banks of the Caledon River. The boreholes are commissioned for water supply to the surrounding community, which entails, water supply for domestic, industrial and stock watering. It should be mentioned that the only information known about these boreholes is the year they were drilled; other information such as borehole yield, rest water level and borehole total depth is not known at this stage, but efforts to obtain this information is underway. Some production boreholes/abstraction were observed on the Caledon River. No groundwater level and abstraction volume monitoring were carried out on the boreholes.

Water level reading before and after the pumping of the boreholes was suggested, by the GWHC, to be carried out as soon as possible to aid with the management of the aquifer in the area. Further human activities were also observed in the area and those included; A landfill, a cemetery and sand mining. Waste dumping and discharge of untreated wastewater was also observed on the river banks, adjacent to the production boreholes. These activities might negatively impact on the quality of the water in the area as well as the flow regime.

To ensure better management practice in the area, the following recommendations were made by the Members: -

i. Two to three groundwater monitoring boreholes be drilled on both Lesotho and South Africa;
ii. Management of the Wellfield based on, among others, an Integrated Water Resources Management approach be implemented;
iii. Harmonization of groundwater monitoring processes, based on among others, Standard Groundwater Monitoring Procedure be undertaken. That would facilitate a joint monitoring exercise by Lesotho and South Africa. Harmonisation, as recommended by the members, needed to include drilling techniques/methods; borehole construction designs; meter readings units; technologies/formats/channels/frequencies for collection, processing, storing and dissemination of data and information among key stakeholder institutions and member States; and
iv. Close cooperation among key Authorities and Institutions in the area such as those responsible for water affairs; water supply; allocation of licences for sand mining, irrigation, etc.; and provision of municipal services (abstraction and wastewater discharge) in both Lesotho and South Africa, be ensured, to optimise water use, monitoring and management of water resources in the area.

2.2 Lesotho Highland Sponges

The river systems in Lesotho contribute approx. 45% of the Orange-Senqu runoff. Most of the water sources originate in the rugged mountainous terrain in the Highlands of Lesotho above 2,000 metres above sea level where the terrain, geology, rainwater and run-off form a myriad of wetlands. High-lying wetlands on slops above the regional valley bottom aquifer are sustained by interflow from perched water tables, which is baseflow occurring before recharge reaches the regional aquifer, hence not available to boreholes. Interflow is the reason why in areas with high recharge, little true groundwater exists for access by boreholes.

These wetlands are valued for their hydrological functions such as their support to river flow as interflow and groundwater baseflow, through the storage and subsequent slow release of rain-water through springs and into streams and rivers. Despite the importance of these wetlands to the people and the economy, the systems continue to be degraded, mainly because of infrastructure development, uncontrolled livestock grazing and trampling.

Deep gullies indicate elevated erosion rates. As some of these wetlands are on steeper slopes, the apparent loss of vegetative cover has rendered them vulnerable to wind and water erosion. The degradation of the wetlands vegetative cover may reduce the ability of the wetlands soil to dissipate the erosive water forces. As such, rills and channels have formed resulting in gullies with extended soil scouring.

The flow had however declined in the recent past due to the human activities such as uncontrolled grazing/trampling and large-scale barrowings caused by increase in the rat/rodent population in the area leading to degradation of the sponges.

As a mitigation measure, a pilot project was being carried out in one of the wetland areas, known as the Khubelu Sponge, in the form of controlled rotational grazing through the use of eco-rangers. Walls/ Levees were also constructed in the downstream to reduce the velocity of water and trap the eroded soils from the Sponge, thus contributing to the re-introduction of the natural eco-system functioning and rehabilitation of the sponges. A subsequent improvement had since been noted in the area and the exercise could be further expanded to other regions. That would increase water retention capacities of the wetlands in the region and provide an increased flow to the downstream rivers.

The following recommendations were made following the site visit: -

i. Collaboration with the shepherds in the control and the continuous up-rooting of the current unwanted alien plant/bush species in the sponges be explored, for the medium to long term protection and management of the sponges;
ii. Awareness among the shepherds regarding the importance of not killing and ensuring co-existence among humans, animals e.g. jackals and birds which preyed on e.g. ice rats, for their population control, in the area needed to be continued; and
iii. Fundraising efforts for the sustainable management of the sponges, including payment of eco-system services by downstream water users needed to be explored.

2.3 Oranjedraai Weir

The farm Oranjedraai 383 is located on the north bank of the Orange River near Zastron. It is the site for gauging flow from Lesotho (30.33611 S, 27.35944 E). The farm is reached from the turn-off on the R26 between Wepener and Zastron onto the R726 to Sterkspruit. The S368 secondary gravel road is then followed past Bergkloof until the sign board to Oranjedraai is reached (figure 2-2).

Figure 2-2 Oranjedraai weir

Oranjedraai is the first flow gauging station and monitoring site within South Africa's border. This site is about 550 km downstream from the origin of the river in the Drakensberg (Lesotho) and represents a fairly un-impacted site with natural characteristics.

The site is downstream of the confluence of the Senqu and Makhaleng Rivers with a catchment area of 24 550 km$_2$, of which 96.8 % is within Lesotho's national territory. The river width at Oranjedraai is approximately 170 m. The stream flow (monthly averages) at Oranjedraai are highly variable and ranged between 1.68 and 934.2 m_3/s (mean, 126.6 m_3/s, i.e. about 3 990 million m_3/a).

Thus, about 60 % of the water resources generally associated with the Upper Orange originate from the Senqu River in Lesotho. The average flow-rates shown a slight decrease ascribed to the inter-basin transfer of 770 Mm_3/a (~24 m_3/s) to the Vaal River system.

The stream flow clearly follows a seasonal pattern with high flows during summer months (November – March) and low flows during winter (May – July). The stream flow usually peaks during February and the lowest flow is usually observed during July.

A significant flow of water was observed at the Weir. That could be wholly attributed to the base-flow as no rainfall had been recorded in the upstream region in months prior to the Survey. Analysis that had been undertaken by the Consultant prior to the Survey showed that groundwater contributed near 20% of the discharge at this site.

The Members were reminded that there was a direct relationship between the status of the sponges/wetlands in the Lesotho Highlands and the amount of flow at the Weir and downstream of the Weir. It was therefore important to ensure proper management of the sponges in the Highlands of Lesotho.

It was further noted that due to increased degradation of the sponges, increased variability of the climatic conditions, increased upstream water demands in Lesotho and South Africa, etc., lower water volumes and baseflows were continuing to be recorded in the area. Future planned water abstractions such as the Lesotho-Botswana water transfer would also reduce the water yield in the area.

The following recommendations were made: -

i. Regulations on abstraction quantities be put in place or improved because of the need for more understanding of the groundwater/surface water interaction; and
ii. Impacts on baseflow be assessed prior to groundwater development projects during the feasibility studies of the planned water abstraction projects to minimis downstream impacts.

2.4 Tosca/Khakea-Bray dolomitic aquifer

In the Khakea/Bray area, two main aquifer types can be identified: porous sedimentary and karstic. The porous aquifer, that stores and transmits water via the interstitial pore space in the sedimentary formations is represented by alluvial and Kalahari Bed aquifers. The karstic fractured aquifer is of carbonate rocks where solution weathering along joints, fractures, and bedding has enhanced the water-bearing capabilities of the rock. The fractured aquifer is transboundary in nature and of significant yield.

The Molopo river is ephemeral and used to flow after heavy rainfall events, however the building of dams (Disaneng dam and recently the Modimola dam) upstream has impeded river flow. There is no groundwater baseflow to rivers in this area. Instead the Molopo river acts as a 'water loss' river, recharging groundwater during runoff events.

The dolomitic compartment extends from Pomfret in south Africa, north east to Tosca and Vergelee, and to the Boshoek police station in South Africa along the Molopo river. The compartment then extends across the river into Botswana (figure 2-3).

The compartment is heavily utilised for irrigation, which can be observed by taking the 3R77 to the Molopo River (Boshoek police station) then driving northwest along the river. Irrigation also occurs across the river in Botswana.

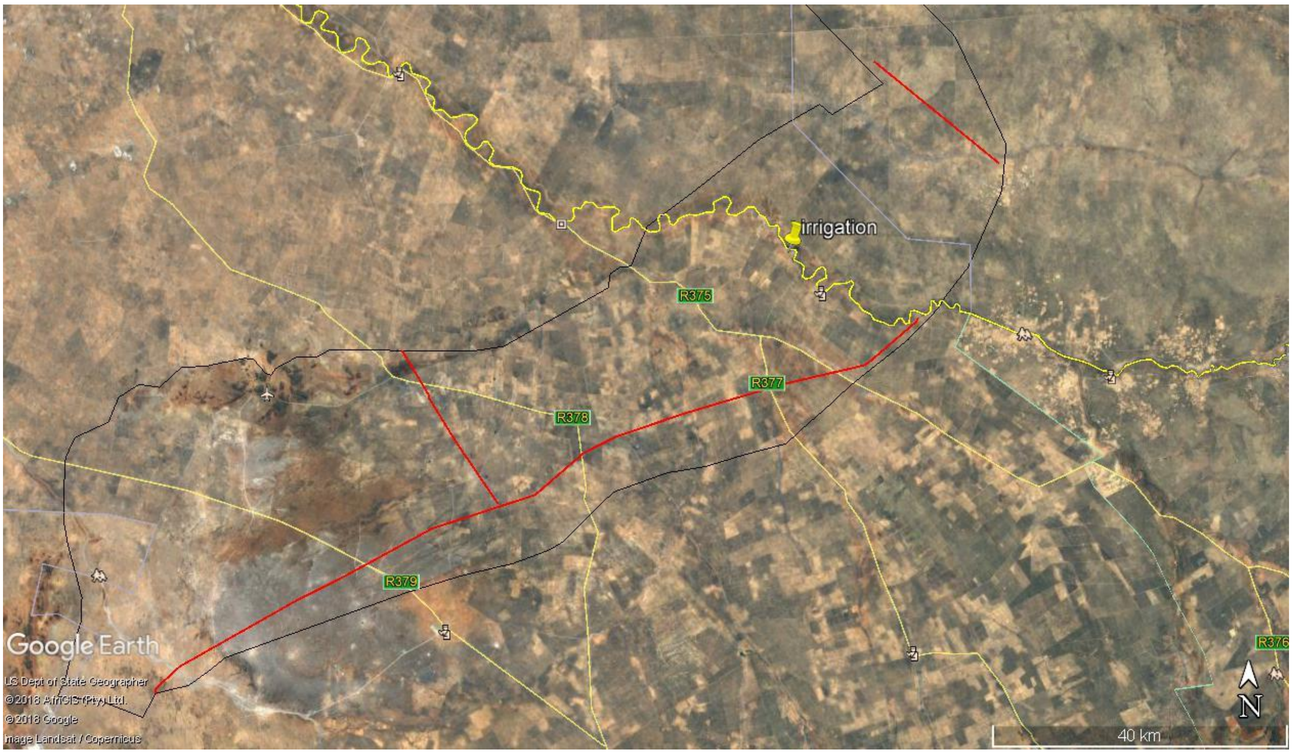

Figure 2-3 Khakea-Bray dolomitic compartment and sub-compartments.

2.4.1 *Tosca Area*

A water quality monitoring borehole (BH1600019) was visited in the Tosca area. Water levels were said to have dropped significantly in the region. The drop in water levels of this dolomite and sedimentary aquifer system was attributed mostly to irrigation by farmers in the area. In an effort to let the aquifer recover, strict measures were put in place to control abstractions in the area, by the South African Department of Water and Sanitation. A local water user association was established for water use and groundwater level monitoring as well as general support of the process. Other additional measures included the banning of further irrigation in the area and compulsory licensing for abstraction for watering of animals. Ongoing illegal irrigation activities was however suspected, as the practice of monitoring for compliance was proving to be a challenge due to the duty being given to a different Directorate, other than the one that was issuing licenses within the DWS. A harmonized working relationship between the two Directorates was therefore of paramount importance. There had not been reports on water quality. However, the said groundwater abstractions might have impacted negatively on the water quality in the area.

The following recommendation was made: -

i. Water level must be included in the parameters being monitored at the current borehole which was at the time measured for water quality only.

2.4.2 *Bray Area*

Three groundwater water level monitoring boreholes close to one another on the South African side of the border were visited. Despite all the pumping in the area, no drop in the water levels ever occurred at the monitoring borehole BHG45666 near the Molopo River, in the Bray Border Town. The frequency of monitoring could not however give enough conclusions as there were insufficient data for any water level trend analysis.

The following recommendation was made: -

i. There was a need for drilling of some monitoring boreholes in the Botswana side of the Molopo River to assist in the joint monitoring of the transboundary groundwater, by Botswana and South Africa, in the area;

2.5 Kuruman Eye

The site lies in Quaternary catchment D41L, which is part of the Auob-Nossob and Molopo drainage system. The Kuruman River originates south east of Kuruman, where it is fed by various dolomitic springs, most notably the Great Koning Eye, Little Koning Eye and the Kuruman Eye. The river flows in a north-westerly direction over a distance of approximately 140 km; it then turns west and flows parallel to the Molopo River, until it has its confluence with the Molopo River at Andriesvale, near the Nossob/Molopo confluence. The natural Mean Annual Runoff of the catchment is 10.78 million m^3/a. This discharge is largely attributed to baseflow from the Kuruman springs. This flow no longer contributes to sustaining the perennial flow in the Kuruman River.

The area lies within the Upper Kuruman Groundwater Management Area (GMA), which is 1795 km^2 in size. This GMA is compartmentalised by intrusive dolerite and diabase dykes of low to impervious hydraulic conductivity into several compartments labelled Groundwater Management Units (GMU).

The compartment drained by the eye is compartmentalised by the ENE trending Kuruman dyke to the north, the N-S trending Cubbic dyke to the east, and in the west by banded ironstone of the Kuruman Formation, which form the Kuruman Hills, and to the south by a topographic divide. The compartments are believed to be interconnected, with leakage across sub compartments. The Kuruman dyke is believed to be a relatively impermeable barrier as a water level step of 5 or more metres occurs across the dyke.

The Kuruman eye is a major spring draining the compartment and its flow has been maintained throughout droughts. Discharge from the compartment also occurs at the Kuruman B eye when water levels are high, and the Klein Koning and Groot Koning springs. Stampriet aquifer.

The Eye was discharging into the Kuruman River, which was a tributary of the Molopo River, shared by Botswana and South Africa. The eye made up to 90% of water supply to the Kuruman Ga Segonyana Municipality which includes the town of Kuruman. The original yield of the Eye formerly translated to up to around 20 million litres of water per day and had since dropped by almost half.

Like other resources in the downstream of Orange-Senqu River Basin, the discharge from the Kuruman Eye had been greatly affected by the over abstraction upgradient and that had been observed by the drop in water levels measured in the ground water level monitoring boreholes in the region.

It was also noted that the groundwater monitoring programme was not followed routinely which was attributed to lack of resources and proper structural organization. Monitoring was divided among the DWS national office in Pretoria and the DWS Regional Office, based in Kimberley.

The following recommendations were made: -

i. Roles for monitoring and management of the Eye and the catchment be clarified and requisite resources be provided; A suggestion was also made that involvement of the Ga Segonyana

Municipality in the monitoring and management of the Eye could reduce monitoring costs for the Eye, given their close proximity to the Resource itself;

ii. Sharing of information among relevant Authorities be improved;

iii. Compulsory licensing for water (groundwater control area) be considered as one of the means through which abstraction could be controlled in the area; and

iv. Once flow conditions and yield of the Eye are established, water releases to downstream for vital human needs, environmental flow requirements and international obligations be considered in the long term.

2.6 Stampriet Transboundary Aquifer

The Stampriet Transboundary Aquifer System (STAS, figure 2-4) stretches from Central Namibia into eastern Botswana and South Africa's Northern Cape Province and lies within the Orange River basin. It covers a total area of 86 647km2, of which 73% is in Namibia, 19% in Botswana, and 8% in South Africa.

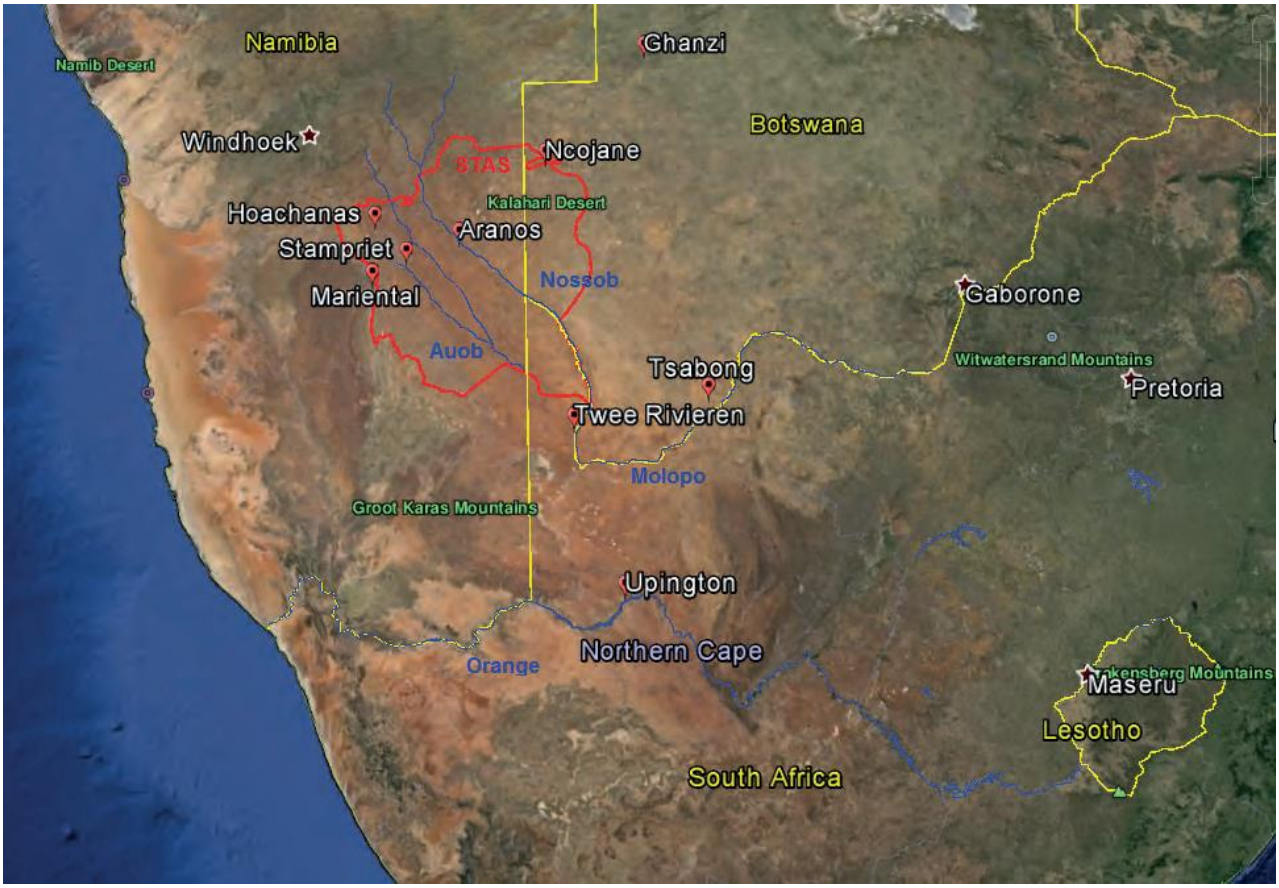

Figure 2-4 Stampriet aquifer

The STAS is delineated based on the occurrence of geological formations belonging to the Ecca Group within the Auob and Nossob River basins. The Auob and Nossob Rivers are the only major streams within the study area and these originate in Namibia and flow in a south-easterly direction towards the Molopo River between South Africa and Botswana. The Auob and Nossob Rivers are ephemeral and only flow for short periods during heavy rainfall events.

The aquifer is a huge sedimentary basin of mainly sandstones, shales, mudstones, siltstones and limestone. They are covered by a blanket of sediments of the Kalahari Group, of Tertiary-Quaternary age.

The STAS is formed by the confined artesian Auob and Nossob aquifers, and the overlying phreatic Kalahari aquifers.

Average rainfall in the STAS area is of 150 to 310 mm/yr. Recharge to the Kalahari aquifer during years with average rainfall is estimated at 0.5% of rainfall. Recharge to the Auob and Nossob aquifers in normal rainfall years is negligible but considerable recharge occurs during extreme rainfall events. The general groundwater flow in the STAS is from northwest to southeast. Groundwater quality generally decreases towards south-western Botswana and the north-western Cape in South Africa for all the three aquifers.

In the South-Eastern quadrant of the area, groundwater massively seeps upward from the confined aquifers and discharges into the Kalahari Formations, from where it evaporates from pans and water holes. Groundwater salinity in this zone – known under the name Salt Block – therefore is rather high. It is estimated that it takes more than approximately 30 000 years for groundwater to travel from the Auob and Nossob recharge zones to the discharge zones.

Over 20 million m³/year are abstracted rom the Stampriet aquifer, most of which occurs in Namibia (over 95%). The largest consumer of water is irrigation (~46%) followed by stock watering (~38%) and domestic use (~16%).

In South Africa, the aquifer has only limited potential for further development because, apart from the poor water quality (figure 3-13), the permeability and storativity are low.

Monitoring by the DWS was started in 1997 as part of its National Groundwater Quality Monitoring Programme. Results from the Programme showed that even if the borehole's water level stayed the normal, the water quality was deteriorating in the area. It was therefore decided by the DWS that to start a chemical profiling programme in the Kalahari area. High nitrates concentrations were recorded, with sources not known yet.

During the visit a number of boreholes were noted. A number of water holes for the watering of the wild animals in the Kgalagadi Transfrontier were noted including the Rooiputs itself. The area activity being the wildlife conservation, the waterholes were observed from inside the vehicle. There was no outright information that there was monitoring taking place at the water holes.

Most of the water holes were located along and inside both the Nossob and the Auob Rivers. It was also observed that vegetation in the Auob River catchment was thicker than the one seen in the Nossob catchment area, suggesting upwelling groundwater, or losses from episodic surface runoff.

The following recommendations were made: -

i. As part of sustainability and good water resources management practices there was a need for a periodical monitoring to observe the trends of abstraction on water level and chemistry of the area;
ii. Transboundary groundwater level in the different vertically layered aquifers, and quality monitoring be undertaken in order to ensure sharing of data and information among all the three countries sharing the STAS; and
iii. Use of isotope chemistry be used to investigate the age of the water in the area.

3 CONSULTANT'S EVALUATION AND RECOMMENDATIONS

3.1 General

During the debrief it was obvious that the group realised the need to increase and improve monitoring in order to understand and evaluate the processes and impacts they observed. They also noted that their needs to be an overall joint monitoring strategy as activities in one country can impact another.

Overall, the impression was one of enthusiasm, appreciation of common problems, gratitude for the experience and awareness of how fruitful the survey was to learn what is happening on both sides on the border and how they can work together. One by-product of this awareness and enthusiasm is that data and information was much more readily forthcoming after the survey than before. This likely stems from an increased awareness of the importance of transboundary projects and how cooperation is necessary to address the problems they face in their own spheres.

There was a clear indication that they learnt how to observe a new situation, try and understand processes and come up with a strategy to monitor.

There was an understanding that groundwater contributes to surface water and changes to groundwater can impact on surface water downstream. They stated a need to elevate the importance of baseflow awareness in groundwater evaluations and the importance of protecting baseflow. Except for South Africa, no data on groundwater contributions to baseflow exist, so the impact of groundwater abstraction on flows is not considered, and environmental impacts cannot be assessed, however an awareness of the problem was developed

One topic that was identified as needing further attention was the need to involve communities in the monitoring process

They also identified the problem that allocations are made based on abstraction only on one side of the border, and cumulative impacts due to abstractions on both sides are not considered. In addition, verification monitoring is inadequate, so that after licences are issued little compliance monitoring occurs.

It was markedly evident that the survey fostered a a friendly team atmosphere amongst the participants from 4 nations.

3.2 Way Forward

Overall, the format of a technical starter document of processes to observe and questions to answer to foster debate amongst the participants seems to have been a successful one, as opposed to a passive travel guide approach of one-way information from a specialist. Tilting responsibility to participants encouraged active participation, confidence, mutual respect, discussion, thought and the sharing of ideas. This led to a strong cooperative team spirit which will reap rewards in future due to shared experience, trust and personal relations. The importance of such shared developing awareness and joint problem solving is a very important aspect in future relationships and attitudes to transboundary problems. In future, the joint survey process reports should not only focus on logistics, but also prepare participants for their responsibility to make inputs. Not only passing of information should be emphasised, but the development of team cooperative spirit to addressing problems.

Due to budget constraints, it must be considered whether more can be achieved by spending more time at fewer sites, to include things like practical data collection, and participants collecting data and comparing it to a historical time series to personally and jointly assess impacts and draw conclusions. This would involve more hands-on participation at the expense of observing fewer sites and less processes. There would therefore have to be a theme to the survey, such as abstraction and impacts on baseflow, abstraction and impacts on water levels, social issues affecting groundwater monitoring etc. The advantages of such a more specialised approach would be: lower cost due to less travel, more hands one experience and analytical experience, the use of data to draw conclusions and responses, more time spent on an issue and less on travel, and a more comprehensive understanding of specific problems. The disadvantages would be: less exposure to varied processes over a wide area, less relevance of a specific problem in another country, less awareness of problems from source to sink, and a narrower microscopic view of an issue rather than a global view of a range of issues.