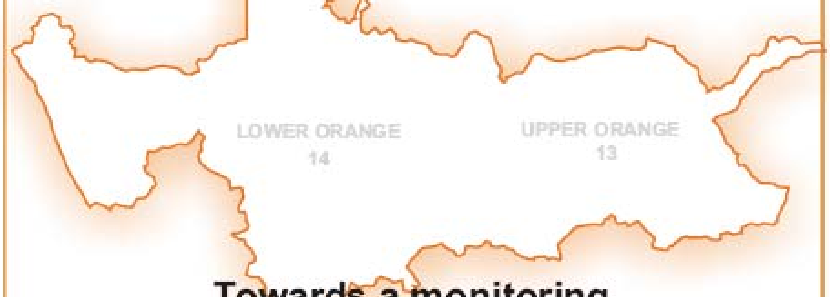
Water Resource Planning Systems

Water Quality Planning

Orange River: Assessment of Water Quality Data Requirements for Water Quality Planning Purposes



Towards a monitoring programme: Upper and Lower Orange Water Management Areas (WMAs 13 and 14)

Report No:. 6
(P RSA D000/00/8009/3)

June 2009

Final

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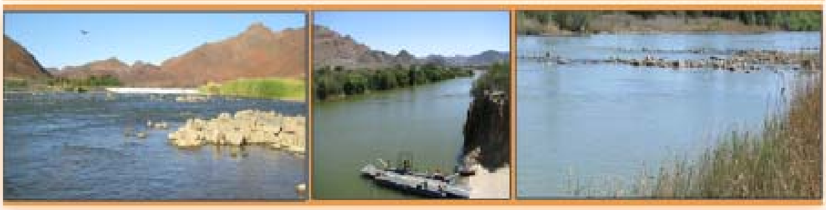

DEPARTMENT OF WATER AFFAIRS AND FORESTRY

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APPROVAL

TITLE:	Orange River: Assessment of water quality data requirements for planning purposes: Resource Water Quality Objectives (RWQOs): Upper and Lower Orange Water Management Areas (WMAs 13 and 14)
DATE:	July 2009
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EXECUTIVE SUMMARY

Monitoring and evaluation are essential components of any water resource management project. In order for water quality managers and regulators on various levels to take management decisions regarding water quality and related issues, they need reliable information on which to base those decisions and actions. Much of the information needed will be generated by water quality monitoring programmes. Ongoing monitoring programmes assist in understanding the changes that occur in the river/dam over time and determine whether the desired management objectives are being met.

Monitoring of system change is crucial, but more importantly the system must be audited against the desired state, *i.e.* Resource Water Quality Objectives (RWQOs), to ensure that the goals of management are met and the system maintains in the desired state – see Report No. 5 for RWQOs of Orange River.

The objective of this task is to propose improvements and recommend changes to the monitoring requirements of the Orange River based on the status quo assessment and to advise on a revised monitoring programme for the Orange River System co-managed by the Directorate Resource Quality Services and the Northern Cape and Free State Regional Offices.

Monitoring Needs Identified:

The status assessment task identified certain gaps in the current monitoring system. Amongst these were the discontinuation of sampling at strategic sites, poor sampling frequency, and important variables that are not measured. A low sampling performance was detected at a number of National Chemical Monitoring Programme sites (NCMP). It is critical that these identified issues be addressed and resolved by the NCMP Programme Manager and Regional Offices as soon as possible.

During this study a clear lack in suspended solids data was identified. See **Tables 9, 10 & 11** for variables currently measured and suggested to be included. It is recommended that:

- Suspended solids and turbidity monitoring be done at all the proposed monitoring sites on the Orange and Caledon River,
- Chl-*a* measurements covered the Orange River fairly well (7 sites), but to make the Chl-*a* data useful, the frequency of measurement should be increased to at least monthly.
- The NMMP be expanded to include the following sites: Marksdrift, Pella and Vioolsdrift; from an ecotourism perspective.
- From a nutrient perspective, if TN is measured, then also determine the total phosphorus (TP) concentrations, thus it is recommended to include TP measurements at Marksdrift, Upington, and in the Kraai River.

The Proposed Strategic Monitoring sites for WMA 13 & 14 are listed in **Tables 5 – 8**.

The following recommendations are made:

Initial proposed monitoring sites that are not recommended as high priority sites are:

- Saamwerk – farm upstream of Gariep Dam,
- Prieska (D7H002),
- Gifkloof (new site) – close to Upington,
- Kanon Island (old D7H004)
- Brand Kaross (old D8H007)
- Caledon at Tienfontein pump station
- Meulspruit
- Leeu River

Reintroduce sampling at the following monitoring site on the Orange River:

- Alexander Bay (D8H012).

Proposed new water quality monitoring sites on the Orange River:

- De Hoek – farm downstream of Orange-Vaal Rivers' confluence (Old site Irene, D7H012)
- Blouputs – Export Farms downstream of Augrabies Falls;
- Sendelingsdrift – downstream of the Fish River confluence.

Proposed new water quality monitoring sites on the Orange River tributaries:

- Sterkspruit – in town of Sterkspruit
- Vaal River at Douglas bridge

Proposed new water quality monitoring sites on the Caledon River:

- Caledon River at the confluence with Little Caledon
- Caledon at Maseru – Lesotho; downstream of city.

Proposed new water quality monitoring sites on the Caledon River tributaries:

- Grootspruit at Fouriesburg
- Moperispruit at Clocolan

It is known that you can not manage what you can not control, and you can not control what you do not measure. Therefore, to manage the water quality in the Orange River system, certain key physical, chemical and biological parameters have to be measured (monitored). Expanding and improving the water quality monitoring programme on the Orange River will contribute to the sustainable utilisation of this important aquatic ecosystem.

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LIST OF ACRONYMS

Chl-*a*	Chlorophyll-a
EC	Electrical Conductivity
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphorus
DMS	Dissolved major salts
DO	Dissolved oxygen
DOC	Dissolved organic carbon
DTEC	Department of Tourism, Environment and Conservation
DWAF	Department of Water Affairs and Forestry
GEMS	Global Environment Monitoring System
GGP	Gross Geographic Product
GPS	Global Positioning System
Kjel N	Kjeldahl Nitrogen
LOR	Lower Orange River
Mm^3	Million cubic metres
NCMP	National Chemical Monitoring Programme
NEMP	National Eutrophication Monitoring Programme
NMMP	National Microbial Monitoring Programme
NTU	Nephelometic turbidity units
NWA	National Water Act, 1998 (Act No 38 of 1998)
PTV	Pollution Tolerant Values – usually expressed as a %
RHP	River Health Programme
RQS	Resource Quality Services
RWQOs	Resource Water Quality Objectives
SA	South Africa
SADC	South African Development Community
SAR	Sodium Adsorption ratio
Si	Silica
SPI	Specific pollution sensitivity index
TAL	Total Alkalinity
TDS	Total dissolved solids
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total suspended solids
TWQR	Target Water Quality Range
WMA	Water Management Area
WQP	Water Quality Planning
WMS	Water Management System

1 INTRODUCTION

Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow and demand more water of high quality for domestic purposes and economic activities. Water abstraction for domestic use, agricultural production, mining, industrial production, power generation, and forestry practices can lead to deterioration in water quality and quantity that impact not only the aquatic ecosystem (*i.e*. the assemblage of organisms living and interacting together within an aquatic environment), but also the availability of safe water for human consumption (UNEP-GEMS, 2006).

Literature worldwide suggests that water demand is ever increasing in the world as changing lifestyles and increasing population puts pressure on the water resources of the world. The pressure is magnified when the water resources are shared between countries. Transboundary water resources management remains a challenge in Africa, which has 60 shared river basins (Wolf *et al*., 1999).

The Orange River catchment is of great importance to South Africa since it drains about 48 percent of the total area of the country and the natural flow represents more than 22 % of the country's surface water resources. South Africa has a high economic dependence on the Orange, with a staggering 100 % of the gross geographic product (GGP) of Gauteng Province being dependent on inter-basin transfers involving the Orange River system (Basson *et al*., 1997).

The Orange River catchment is highly developed, with many dams and transfer schemes harnessing and controlling its flow. Over 50 % of the area of the Orange River Catchment can be classified as hyper-arid to semi-arid with aridity increasing to the west. Water availability is particularly critical for the Orange River Catchment. Climate change and climate variability for the coming years are expected to aggravate the situation by decreasing rainfall, runoff and recharge in large parts of the Orange River Basin (UNEP, 2005).

In future, additional inter- and intra-basin water transfer schemes will be needed to meet the growing demands for water in the Orange-Senqu and neighbouring basins, as well as to meet international and South African Development Community (SADC) obligations to share water equitably. The pressure on the aquatic ecosystem will thus also increase with potential devastating effects. As the water requirements on the Orange River catchment continue to grow, the water in the catchment is becoming more valuable.

It is known that you can not manage what you can not control, and you can not control what you do not measure. Therefore, to manage the water quality in the Orange River system, certain key physical, chemical and biological parameters have to be measured (monitored). Expanding and improving the water quality monitoring programme on the Orange River system will contribute to the sustainable utilisation of this important aquatic ecosystem.

2 STUDY AREA

The Orange River rises in the Drakensberg mountains in Lesotho, flows westward through South Africa to the Atlantic ocean at Alexander Bay. The Orange River is the longest river in South Africa and its catchment covers a large area of about 1 000 000 km^2.

The Orange River catchment is extensive, but the Vaal River system (main tributary to Orange) was excluded from this study because a large study was recently completed for the Vaal River, *i.e.* 'Development of an Integrated Water Quality Management Plan for the Vaal River System' and more detailed studies are currently being undertaken by the Department of Water Affairs and Forestry (DWAF).

The present study area for the project includes the Upper and Lower Orange Water Management areas (WMA 13 and 14) with the main focus on the Orange and Caledon Rivers and their major tributaries (**Figures 1 & 2**). Thirty six (36) monitoring sites were initially identified for this study of which 26 sites are part of the National Chemical Monitoring Programme (NCMP) (See Appendix A and B for minutes of meetings with Regional Offices regarding selection of the sites). Nineteen (19) sites are on the Orange River main stem, 5 sites on the Caledon River, 6 sites on the Orange tributaries (including 1 site on the Vaal River), and 6 sites on the Caledon tributaries – See **Tables 1 – 3** and **Figures 1 and 2**. However, 2 additional sites, *i.e.* the 2 major dams (Gariep and Vanderkloof) were also included during snapshot survey 1, because the water flow reaching the lower reaches of the Orange River is controlled to a large degree by releases from Vanderkloof Dam, supported by water released from Gariep Dam; thus a total 38 sites were included as part of the status quo assessment (See Report No. 3).

Table 1: Upper Orange River (WMA 13): Proposed Monitoring sites Level 1 & 2.

Orange River – main stem – level 1		**Orange River – tributaries – level 2**	
Site code	*Site name (Hydro ID)*	*Site code*	*Site name (Hydro ID)*
OS1	Oranjedraai (D1H009)	OSL2/1	Kornetspruit (D1H006)
OS2	Aliwal North (D1H003)	OSL2/2	Sterkspruit (new site)
OS3	Saamwerk (new site)	OSL2/3	Kraai River (D1H011)
OS4	Roodepoort (D3H013)	OSL2/4	Stormbergspruit (D1H001)
OS5	Dooren Kuilen (D3H012)	OSL2/5	Seekoei River (D3H015)
OS6	Marksdrift (D3H008)	VS 21	Vaal River Douglas

Table 2: Caledon River: Proposed Monitoring sites Level 1 & 2.

Caledon River – main stem – level 1		Caledon River – tributaries – level 2	
Site code	*Site name (Hydro ID)*	*Site code*	*Site name (Hydro ID)*
CS1	Confluence with Little Caledon (New site)	CSL2/1	Little Caledon at Golden Gate (New site)
CS2	Ficksburg (D1H035)	CSL2/2	Little Caledon at The Poplars (D2H012)
CS3	Maseru (D2H011)	CSL2/3	Grootspruit (new site)
CS4	Tienfontein (new site)	CSL2/4	Meulspruit (new site)
CS5	Kommissiesdrift (D2H036)	CSL2/5	Moperi River (new site)
		CSL2/6	Leeu River (new site)

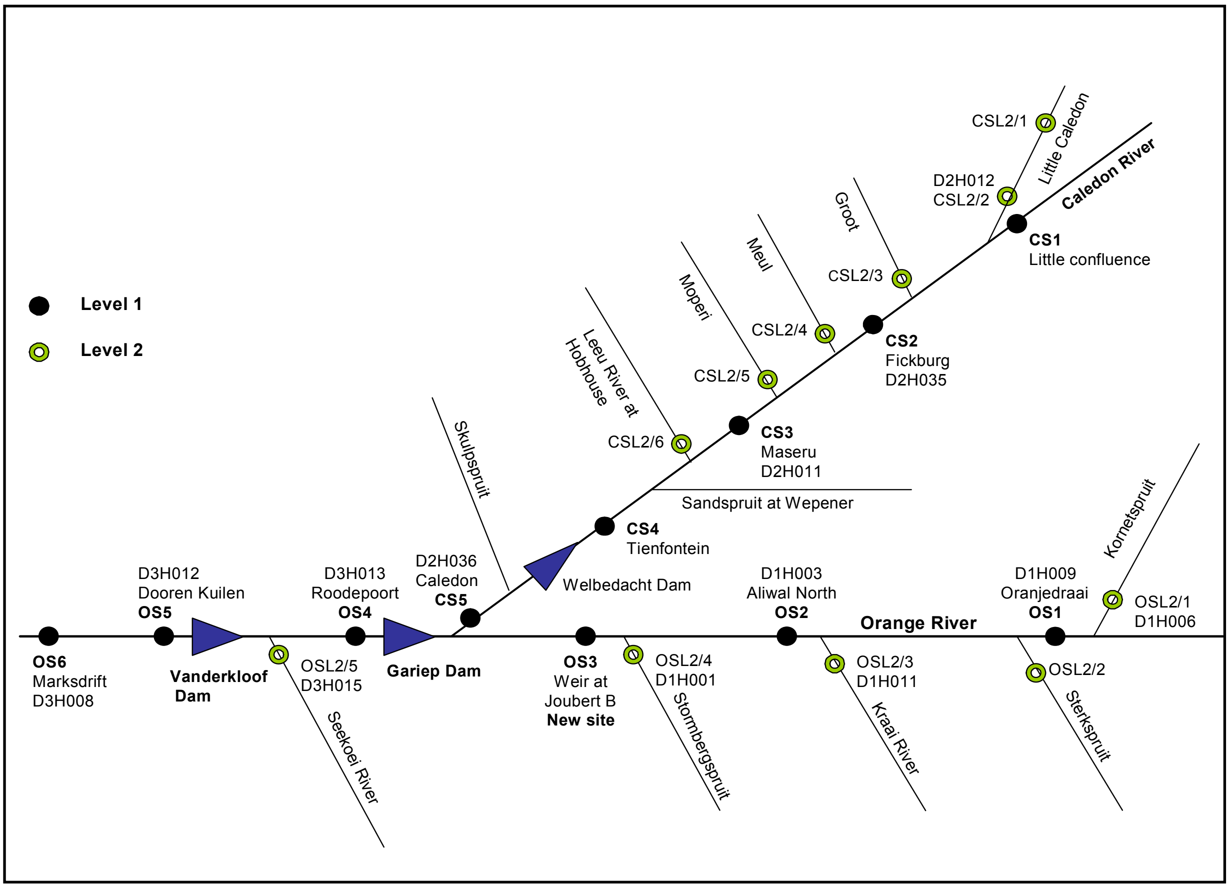

Figure 1: Line diagram of the Upper Orange WMA – monitoring sites – level 1 and 2.

Table 3: Lower Orange River (WMA 14): Proposed Monitoring sites Level 1.

Site code	Site name (Hydro ID)	Site code	Site name (Hydro ID)
OS7	Irene (D7H012)	OS14	Blouputs (new site)
OS8	Prieska (D7H002)	OS15	Pella (D8H008)
OS9	Boegoeberg Dam (D7H008)	OS16	Vioolsdrift (D8H003)
OS10	Gifkloof (new site)	OS17	Sendelingsdrift (New site)
OS11	Upington (D7H005)	OS18	Brand Kaross (D8H007)
OS12	Kanon Island (D7H004)	OS19	Alexander Bay (D8H012)
OS13	Neusberg weir (D7H016) (North canal)		

The 13 monitoring sites on the lower Orange River, *i.e.* from OS7 at Katlani (De Hoek) to OS19 at Alexander Bay, and 1 site on the Vaal River (VS21) at Douglas (new site) are shown in **Figure 2.**

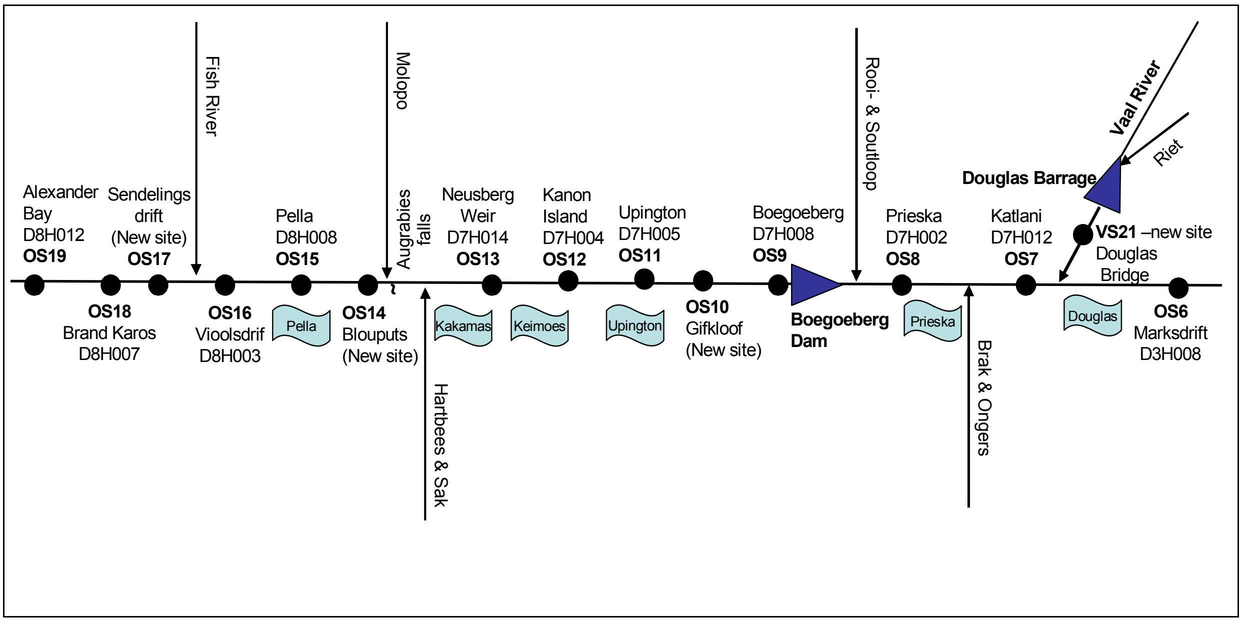

Figure 2: Line diagram of the Lower Orange WMA – monitoring sites (Level 1).

3 STRATEGIES FOR WATER QUALITY ASSESSMENT IN RIVER SYSTEMS

At a given river monitoring station water quality depends on many factors, including: (i) the proportion of surface run-off and groundwater, (ii) reactions within the river system governed by internal processes, (iii) the mixing of water from tributaries of different quality (in the case of heterogeneous river basin), and (iv) inputs of pollutants.

Once polluting substances are introduced into a river, they are transported and transformed by physical, chemical, biological and biochemical processes. It is important to understand these various pathways in order to achieve the best sampling design and to determine the impact of the substance on the water system and the rates at which elimination may occur.

Water quality and quantity are intimately linked although not often measured simultaneously. Water quantity is often measured by means of remote hydrological monitoring stations which record water level, discharge, and velocity. Monitoring of water quantity can be undertaken, to a certain degree, with a minimal amount of human intervention, once a monitoring station has been set up. In contrast, water quality is usually determined by analysing samples of water collected by teams of personnel visiting monitoring stations at regular intervals.

The cost associated with monitoring the many parameters that influence water quality, when compared to those associated with monitoring only a few water quantity variables, usually means that water quality monitoring is not undertaken as frequently as water quantity monitoring. However, the results of water quality monitoring are vital to being able to track both spatial and temporal trends in surface and ground waters.

Sampling and analytical strategies for river assessments and monitoring must be related to the present and future water uses. Two major concepts must be recognised in the design of assessment programmes which address water uses and user requirements (Chapman, 1996):

- Multiple use of river water may occur within any region of the river basin. Each user has different water quality requirements and user conflicts may occur. Ideally, water quality should meet the most stringent user requirement which, in virtually all cases, is the provision of good quality drinking water.

- There is always a responsibility for upstream uses to ensure adequate water quality for the needs of downstream users.

Careful recording and management of data is essential to a monitoring programme, because it leads to both cost-effective and accurate data analysis.

The measurement of discharge is an essential component of most sampling programmes. Without this, only qualitative surveys of the general condition of rivers can be obtained.

The National Chemical Monitoring Programme (NCMP) network currently consists of approximately 800 sampling sites located at flow gauging stations. The current sampling frequency used by the National Chemical Monitoring Network ranges from weekly to quarterly. This is not based on a statistical design but mostly the visiting frequencies of the hydrologists responsible for hydrometric data collection and maintenance at the gauging stations. Water quality samples for the national chemical network are mostly taken by those field hydrologists (Van Niekerk, 2005).

Harris and co-workers (1992), proposed for rivers a sampling frequency of monthly for trend monitoring on a national level. The study confirmed that a monthly sampling frequency would be sufficient to avoid serial correlation in the dataset and also allow for the detection of a change (linear trend) equivalent to two times the standard deviation after two years of monitoring. It would therefore be possible to detect a trend with 24 samples with a significance of 0.10 and a statistical power of 0.90.

The operating plans and procedures that includes, sampling procedures, laboratory analysis procedures, quality control procedures, data storage and retrieval is well developed by DWAF and need no further discussion in this document. Also, types and timing of reporting, reporting formats, distribution of information, and monitoring program evaluation are part of DWAF's information reporting procedures and are not discussed here.

4 THE NEED FOR MONITORING

The design and implementation of effective monitoring networks and repository databases to ensure adequate quantification of the balance between sustainable water use and protection of water resources is pivotal to ensure that the goals of water resource management are being achieved in a catchment. This principle is recognised explicitly in Chapter 14 Section **137** of the NWA (National Water Act, 1998 (Act 38 of 1998)), which requires monitoring of water resource quality to be an integral part of water resources management in South Africa. The NWA mandates the Minister of Water Affairs and Forestry to establish national monitoring systems that monitor, record, assess and disseminate information regarding, amongst many other things, the quality of water resources. The NWA however does not specify exactly, from a systems design perspective, what these national monitoring systems should be, or provide all the other details required to specify, design and implement such monitoring systems (DWAF, 2004).

The main reason for the assessment of the quality of the aquatic environment has been, traditionally, the need to verify whether the observed water quality is suitable for intended users. The use of monitoring has also evolved to help determine trends in the quality of the aquatic environment and how that quality is affected by the release of contaminants, other anthropogenic activities, and/or by waste treatment operations (impact monitoring).

More recently monitoring has been carried out to estimate nutrient or pollutant fluxes discharged by rivers or groundwaters to lakes and oceans, or across international boundaries. Monitoring to determine the background quality of the aquatic environment is also now widely carried out, as it provides a means of comparison with impact monitoring. It is also used simply to check whether any unexpected change is occurring in otherwise pristine conditions, for example, through the long range transport of atmospheric pollutants (Chapman, 1996).

In the Catchment Visioning for the lower Orange (DWAF, 2008), great emphasis is placed on water quality, *i.e.* "to ensure that water supplies are of an acceptable quality to all water users." A major reason for the water quality assessment is to determine the suitability (fitness for use) of the water for intended uses. An abundant supply of clean, usable water is a basic requirement for many of the fundamental uses of water on which humans depend. In the Orange River the major consumptive water user is agriculture (principally irrigation) with on average approximately 88 %.

In general South African water monitoring programmes function on three main levels, namely national level, catchment (regional) level and local level. In establishing the SA GEMS/Water monitoring programme a forth tier will be added, namely international (Van Niekerk, 2005). The main objective of a national monitoring programme is to provide information on the status and trends of water quality in the country as a whole – see Report No. 3 for water quality status and trends in the Orange River and tributaries.

In order for water quality managers and regulators on various levels to take management decisions regarding water quality and related issues, they need reliable information on which to base those decisions and actions. Much of the information needed will be generated by water quality monitoring programmes (Van Niekerk, 2005). Ongoing monitoring or regular monitoring programmes assist in understanding the changes that occur in the river/dam over time and determine whether management objectives are being met and what the effects of not meeting the targets are in terms of management.

Monitoring of system change is crucial, but more importantly the system must be audited against the desired state, to ensure that the goals of management are met and the system is maintained in the desired state – see Report No. 5 for RWQOs of the Orange River.

Monitoring and evaluation are essential components of any aquatic management project. However, we must recognize that our vision of water quality, even with the best documented combinations of observations, will always remain partial due to the discrete nature of most observations at fixed dates and fixed stations; we will never fully capture the temporal-spatial variability of water quality (Meybeck, 2005).

5 AIM OF THE PROJECT

The **aim of this project** is undertake a water quality assessment of the Orange River (Upper and Lower Orange Water Management areas):

To determine the current status,

To undertake a desktop assessment of the water quality of Lesotho

To develop a monitoring programme if necessary

To provide future monitoring requirements and preliminary RWQOs, and

To provide recommendations for future planning and strategy development activities.

The overall objective of the project is to:

Create a clearer picture of the current water quality status and data requirements of the Orange River and in doing so identify the water quality “hot spots” and issues/aspects that have an impact on the overarching planning and management of the system.

The study includes seven tasks, with this report forming the deliverable for task 4 (**Figure 3**).

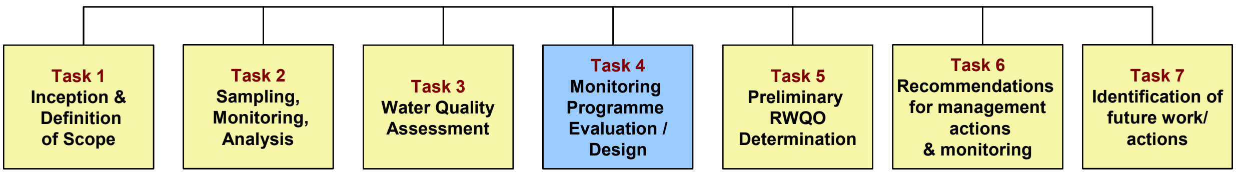

Figure 3: Study tasks

5.1 Aim and objectives of monitoring programme

The objective of this task is to propose improvements and recommend changes to the monitoring requirements of the Orange River that will enable effective resource water quality planning and management. These potential improvements and changes will be based on the status quo assessment and may culminate in the registration of a revised monitoring programme for the Orange River System co-managed by the Directorate Resource Quality Services and the Northern Cape and Free State Regional Offices.

The scope of work for this task will include:

- Using outputs of Task 2 (Sampling, monitoring and analysis) to define strategic monitoring points and their locations (Level 1 and 2);
- Using outputs of Task 2 and further discussions with the relevant DWAF personnel/ Offices/ Directorates on the suite of water quality variables to be monitored;
- Using outputs of Task 3 (Status Quo water quality assessment) to understand the issues at hand, current status, requirements and needs regarding water quality, and what information is needed to support the Regions, the Sub-Directorate Water Quality Planning (WQP) and the other relevant Directorates with regard to management priorities.

Deliverables:

- Locations of strategic monitoring points (Leve1 and 2) – maps, photos and GPS co-ordinates.
- Modification/improvement and expansion of the existing monitoring programme for the Orange WMAs.

6 PROPOSED CHANGES TO EXISTING MONITORING PROGRAMME –

An assessment of the existing DWAF water quality monitoring network, programmes and related information for the Orange River WMAs was undertaken. This was used in defining the current situation and sites. The DWAF RQS database (National programmes) and the Regional Offices' databases were reviewed to obtain existing information on sites. Data were collected during the first half of 2008, therefore, the data available for the present report were limited to the end of 2007.

In the Orange River, flow regulation and diversions, salinisation, sedimentation and occasional algal blooms are considered to be the main threats – see Report No. 3.

Soil erosion, sediment transport and siltation of dams are a major issue in the Orange River (**Figure 4**). The Orange River carries a relatively large suspended load and ranks as the most turbid river in Africa and the fourth most turbid in the World (Bremner *et al.*, 1990).

Much information has been published on the role of particulates in the uptake, release and transport of pollutants, as well as sediment-bound nutrients and contaminant interactions with water and biota, within the aquatic environment (Chapman, 1996). Assessment of the literature on sediments clearly reveals the prominent role that they play in elemental cycling, and this has been used to great effect in environmental monitoring and assessment.

The main indicators are the concentration of total suspended solids (TSS) and turbidity which have changed significantly with time in the Orange River. These indicators are directly linked to the light penetration into the water and thus availability of light to algae. Light availability has been shown as a major driving force for algal growth in the Orange River – see Report No. 3.

However, turbidity is currently measured at 9 and TSS at only 4 of the 19 sites on the Orange River. Therefore, it is strongly recommended that Turbidity and TSS concentrations are measured biweekly or monthly at all the proposed sites on the Orange River. The determination of turbidity is an easy and cheap method.

The Caledon River is characterized by extreme seasonal fluctuations in turbidity (min. 0.5; max. 10 000 NTU) and with a mean value of 400 NTU (at Kommissiedrift) and is probably the most turbid river in South Africa. The Caledon River carries a large load of suspended material but total suspended solids (TSS) is not measured at any monitoring site on the Caledon River. Therefore the inclusion of TSS measurements at all the sites on the Caledon River is recommended.

Figure 4: Satellite image (Google Earth) of erosion on the Lesotho side (south) of the Orange River because of poor land management – note the absence of erosion of land on the South African (north) side. However, erosion management should probably be improved on both sides of the border.

The following section detail the existing water quality monitoring undertaken at each of the selected monitoring sites and briefly describes the findings of the status quo assessment. The recommendations for monitoring at each site are detailed in Section 6.

6.1 Orange River – main stem – level 1

6.1.1 OS1 – Oranjedraai – D1H009 (S30.33772; E27.36277)

Oranjedraai is a very important monitoring site because it is considered to be a fairly natural site with good quality of water from Lesotho. The site is also the first flow gauging station and chemical monitoring site within South Africa's border under DWAF's control. Oranjedraai also serves as a RWQO site representative of the Upper Orange River – see Report No. 5.

The chemical data set at Oranjedraai is good with typically biweekly (fortnightly) measurements from 1975 to 2007 (total number of observations, n ≈ 585). Limited outliers occurred, e.g. a sodium (Na) concentration of 39.8 mg/ℓ (03/07/1989), and a potassium concentration of 12.4 mg/ℓ (06/12/1982) were rejected as outliers.

Very good flow measurements exists, mean monthly data since 1961 to 2007, *i.e*. 47 years (n = 556).

The total suspended solids (TSS) measurements were unfortunately weak with data only during 1963, 1968, 1974, 1985, and 1986 (n = 136). However, weekly/biweekly turbidity readings were taken from 1993 until 2007. Unfortunately no overlap occurred between TSS and turbidity measurements to determine the relationship between these variables.

6.1.2 OS2 – Aliwal North – D1H003 (S30.68612; E26.70600)

The monitoring site at Aliwal North is below the confluence with the Kraai River that brings in fairly large volumes (approximately 652 Mm^3/a) of clear and good quality of water. The disadvantage of this monitoring site is that it is above the town's sewage treatment plant and the effluent enters the river about 4.5 km downstream from this point.

The historical data set is generally good with weekly – biweekly measurements since 1974 – 2007 (n = 98 – 1 219), but unfortunately recently (from 2000) serious gaps, of a month or three, occurred in the basic measurements (**Figure 5**). This inconsistency should be addressed urgently.

TSS measurements were unfortunately only made from 1968 to 1986 (n = 510). It is recommended that TSS measurements be reintroduced.

Total nitrogen (TN) and total phosphorus (TP) measurements were only made between 1982 and 1988 (n = 247), but provide important information in terms of nutrients. It is strongly suggested that TN and TP measurements be reintroduced.

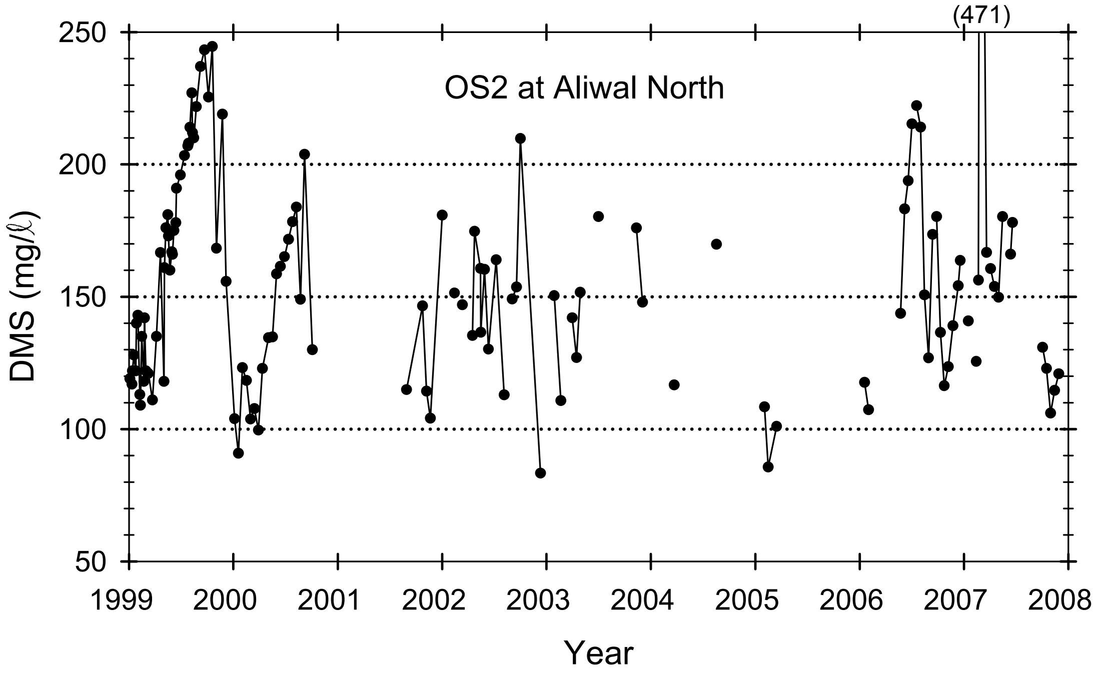

Figure 5: Temporal variation in dissolved major salts concentration (DMS, mg/ℓ) in the Orange River at Aliwal North (OS2) (1999 – 2007).

6.1.3 OS3 – Saamwerk (S30.57622; E26.45638) – new site.

Saamwerk is a proposed new site - upstream Caledon confluence and before the Orange River enters the Gariep Dam, but downstream Stormbergspruit confluence. This spruit discharges poor quality of water from Burgersdorp sewage works into the Orange River. The site is just downstream of a long shallow weir and the accessibility to the site is good.

However, the introduction of this site is not considered to be a high priority because the water quality in the Upper Orange is fairly stable and did not change significantly downstream – see Report 5.

6.1.4 OSD1 – Gariep Dam – D3R002 (S30.60794; E25.50465)

The dam wall is about 200 km downstream of Aliwal North (upstream monitoring site). Processes, like sedimentation, in Gariep Dam change the water quality and characteristic significantly from that of the 2 inflowing rivers (Caledon and Orange) – see Report No. 3.

A fairly good database exists with weekly to biweekly measurements since 1972 (n ≈ 385), but unfortunately with a serious data gap of only a few measurements between 1988 and 1996. Good data (weekly/biweekly) since 2002 until 2007 (n ≈ 120).

The TSS in Gariep Dam has changed dramatically since the dam was built. The mean TSS concentration in Gariep Dam for the period 1972 to 1984 (342 mg/ℓ) was significantly higher than for the period 1999 to 2007 (mean, 28.2 mg/ℓ; difference, 92 %).

Unfortunately, the TSS data set was not continuous and displays a vast gap between 1983 and 1999. Therefore, it's not possible to say if the change in TSS has happened gradually or suddenly for example after a flood. However, the reason for the lower TSS in Gariep Dam during the past 10 years is not clear. There are no indications that TSS transport from upstream has changed significantly during the past 30+ years.

Gariep Dam is the first site in the Orange River with Chl-*a* data since 1999 (n = 120). This is valuable data in terms of eutrophication, but the frequency is poor. The frequency varies from weekly to monthly with serious gaps in the data of 2 or 3 months that will result in an unreliable picture of this highly dynamic parameter. It is strongly suggested that a strict biweekly measurement programme is implemented. The National Eutrophication Monitoring Programme (NEMP) schedules sampling to take place on a two weekly basis (DWAF, 2002).

6.1.5 OS4 – Roodepoort (D3H013) – downstream Gariep Dam (S30.58487; E25.4208)

The Roodepoort gauging station (flow and chemical) is about 11.5 km downstream of Gariep Dam wall, at the N1 road crossing with the Orange River. A very good chemical data set is available with almost weekly measurement since 1976 and is still active (n ≈ 954). - A very good flow data set with mean monthly values since 1974, n = 394 is also available here.

However, the quality of the water released from the dam is generally of poorer quality, and it is proposed that the higher nutrients especially should be carefully monitored (**Figure 6**).

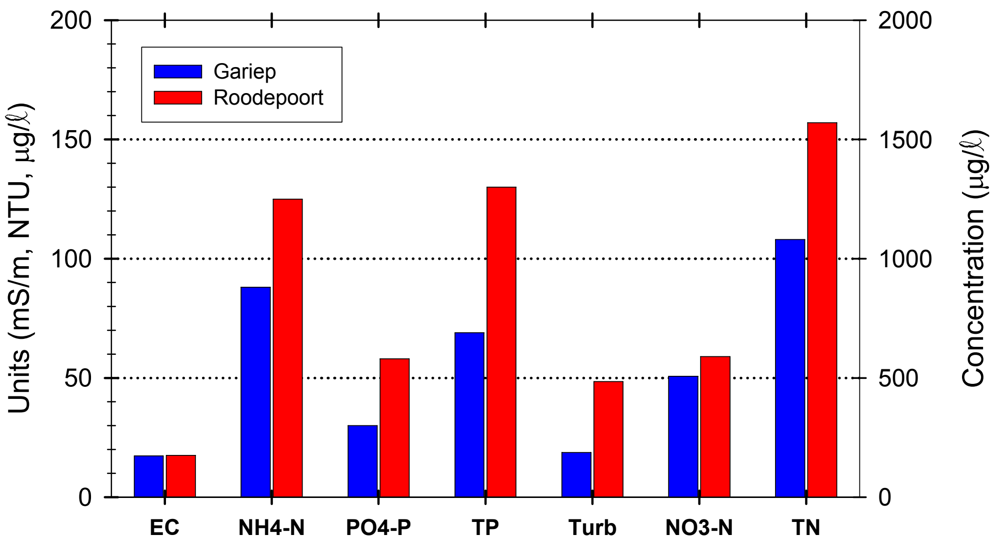

Figure 6: Bar plot of selected parameters (averages) in Gariep Dam compared with water released from the dam at Roodepoort. EC (mS/m), NH_4-N, PO_4-P, Total phosphorus (TP) in µg/ℓ and turbidity (NTU) according to the units on the left hand y-axis scale. NO_3-N and TN concentrations according to right hand y-axis scale.

6.1.6 OSD2 – Vanderkloof Dam – D3R003 (S29.99447; E24.73524)

The water quality database stretches from 1976 to 2007, but was weak before 1992, and thereafter good with biweekly measurement (n ≈ 255). This is the first site with monthly measurements of metal concentrations from 2003 (n = 31). These concentrations are valuable because it can serve as a reference site for downstream sites that experience problems with high metal concentrations – See Report No. 3.

The general chemistry of water in Gariep and Vanderkloof Dam was very much the same with slightly higher salts in Vanderkloof Dam. However, the nutrients were generally lower in Vanderkloof. In fact the TN and TP concentrations in Vanderkloof Dam were the lowest in the whole river, *i.e.* a mean TN of 0.61 mg/ℓ and TP of 0.052 mg/ℓ; compared to the TN and TP at Roodepoort (upstream point) of 1.57 and 0.130 mg/ℓ respectively.

The nitrate concentrations show a different picture – the reason for this contradiction is unclear (**Figure 7**).

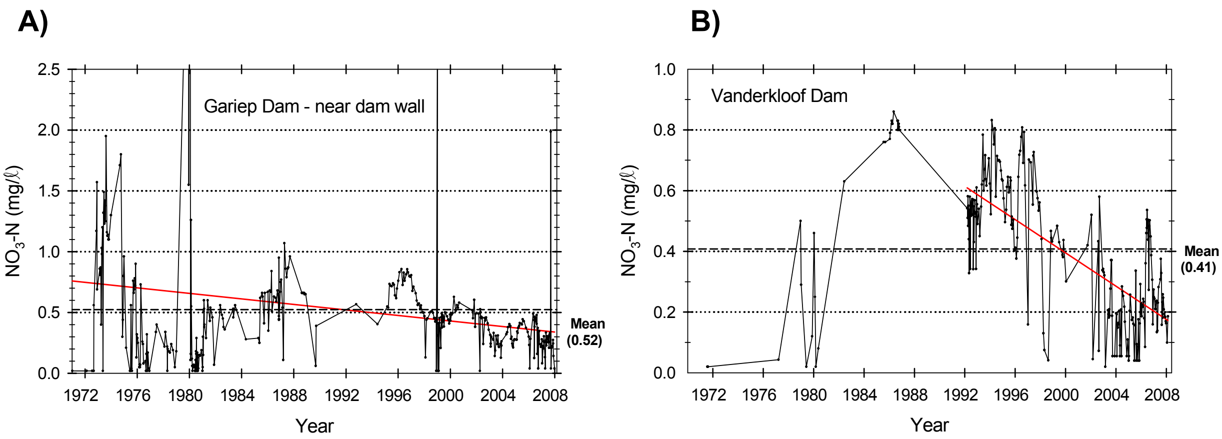

Figure 7: Temporal variation in nitrate concentration (NO_3-N, mg/ℓ) in Gariep Dam (A) and (B) Vanderkloof Dam (1972 – 2007).

6.1.7 OS5 – Dooren Kuilen, downstream Vanderkloof Dam, D3H012 (S29.99141; E24.72414)

This flow gauging station and monitoring site is just downstream of Vanderkloof Dam with a very good chemical data set with weekly to biweekly measurements from 1980 to 2007 (n ≈ 450).

Interesting, the water released from the dam corresponds very much to the quality of the surface water in the dam. The salts concentrations were almost the same and the nutrients slightly higher.

6.1.8 OS6 – Marksdrift – D3H008 (S29.16201; E23.69447)

Marksdrift is the last monitoring site on the Orange River in the Upper Orange water management area and before the confluence with the Vaal River. The water quality data represents a mixture of water from the Caledon, Kraai, Seekoei, and Orange River. Marksdrift was also identified as a RWQO point – See Report No. 5.

The Marksdrift monitoring site is included in the SA-Gems/Water monitoring network to represent runoff from the Orange River catchment upstream of the Vaal River confluence. The historical chemical data set started in 1966, is good with almost weekly measurements (n ≈ 808) and monthly measurements of metal concentrations since 2002 (n ≈ 55). Unfortunately a gap in the data from 1989 to 1992 exists that will disrupt statistical analyses.

The DIN concentrations at Marksdrift were lower than at Dooren Kuilen (upstream point) and ranged between 0.20 and 3.180 mg/ℓ (overall mean 0.469 mg/ℓ). However, the DIN concentration increased significantly from 1977 to 1988, *i.e.* from about 0.2 to 0.8 mg/ℓ (red line in **Figure 8**) and then shows a significant decrease from 1992 to 2007, *i.e.* from 0.7 to 0.3 mg/ℓ (blue line in **Figure 8**). The reason for this phenomenon is unclear.

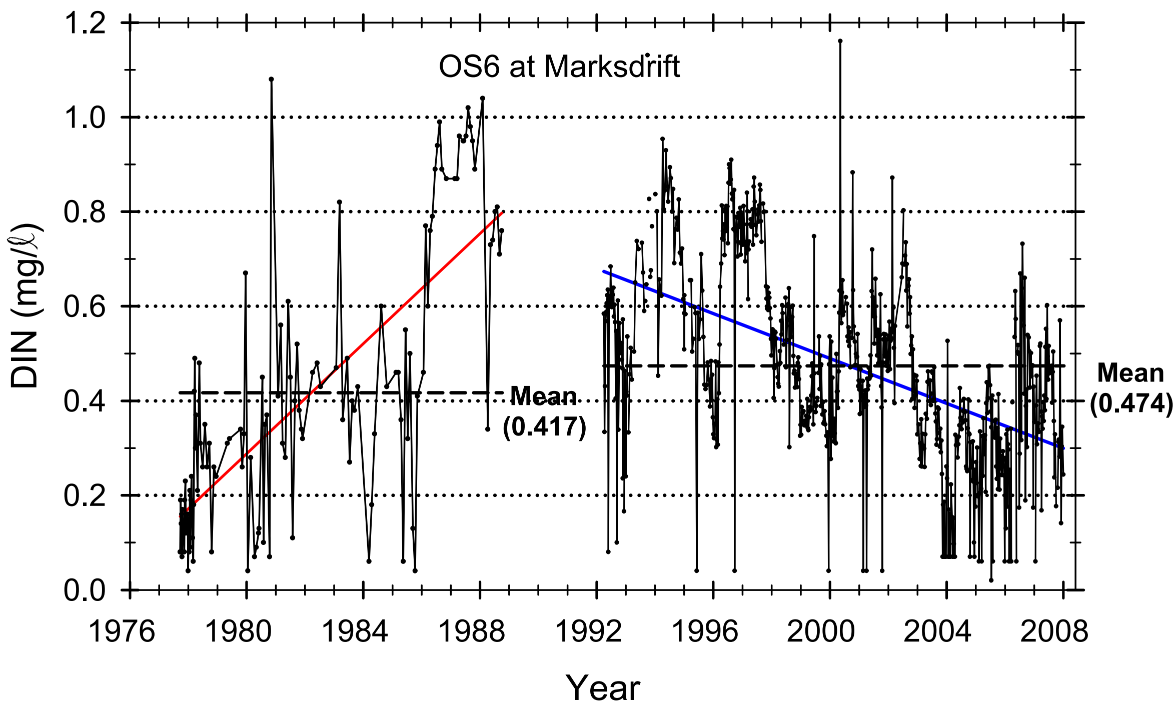

Figure 8: Temporal variation in dissolved inorganic nitrogen (DIN) concentrations (mg/ℓ) in the Orange River at Marksdrift (1977 – 2007).

6.1.9 OS7 – Irene (D7H012)

Irene is a DWAF monitoring site (D7H012), about 15 km downstream of the confluence of the Vaal and Orange River, but currently inactive with historical data only from 1989 to 1997 (n = 21) and thus not useable.

During snapshot 1 survey, Katlani (at a small rural community) was proposed an alternative site, but the accessibility to the river was poor. During snapshot survey 2, the De Hoek farm (approximately 21 km downstream of the Orange-Vaal confluence) was identified as an alternative site. GPS co-ordinates: S29.18512; E23.57332.

Thus, De Hoek is a new site that is considered to be important site because it is the first site after the confluence of the Vaal River that is believed to bring in generally poor quality of water.

6.1.10 OS8 – Prieska – D7H002 (S29.65700; E22.74415)

Prieska is about 166 km downstream from the Orange-Vaal Rivers' confluence. The chemical database of DWAF was very good from 1977 until 1997 (weekly to biweekly measurement, n ≈ 400), but was unfortunately discontinued in 2001 (except for the flow measurements).

According to the minutes of the meeting on Lower Orange River, with the Northern Cape Regional Office (November 2006; Appendix B) "There is a reliable observer for this site", and it is considered to be important because "The impact from the Ongers River (irrigation) will also be included at this site".

However, Prieska is considered to be an important site, but not an essential site.

6.1.11 OS9 – Boegoeberg Dam – D7H008 (S29.02625; E22.18608)

Boegoeberg Dam is a flow gauging weir about 115 km downstream from Prieska. This monitoring site has an initial poor chemical data set from 1976 to 1987 (n ≈ 65), but since 1988 the data frequency has improved noticeably and is good now with almost weekly measurements until today (n ≈ 647). It has a very good flow dataset with mean monthly values from 1933 to 2007 (n = 898).

The site is important because it is the beginning of the intensive irrigation area and the two other monitoring sites, upstream (115 km) and downstream (160 km) are far away. Note that the chlorophyll-a measurements are taken from the weir (close to the dam wall) – site code D7R001. Boegoeberg Dam was also identified as a RWQO site – see Report No. 5.

6.1.12 OS10 – Orange River at Gifkloof – new site

Gifkloof is only about 17 km upstream from Upington and is a proposed new site. The reason for including Gifkloof as a monitoring site is because the weir is suspected to serve as a 'nursing' area for algae that contribute to the algal blooms at Upington.

However, the snapshot data indicated that the water chemical composition at Gifkloof was very much the same as at Upington – close spatial correlation, thus it is not recommended as a priority site.

6.1.13 OS11 – Upington – D7H005 (S28.45259; E21.25994)

Upington is an important monitoring site about 160 km downstream of Boegoeberg Dam. This point was accepted by Regional Office, but it is proposed that it should be moved to the intake at Upington Water Works. This point will include objectives for Upington domestic supply, international obligations (Nakop border post) and Kalahari West pipeline for domestic and stock watering purposes.

Upington has a reasonable good chemical data set with about 360+ measurements from 1975 to 2007. Including almost daily measurements of TSS from 1952 to 1973 (n = 3 505), but unfortunately a TSS data gap occurred between 1975 and 1999 with only limited measurements from 2000 to 2007 (n = 60). A gap in the data set from 1997 to 2000 unfortunately disturbs statistical analyses.

Metal concentrations are determined since 2003 (n = 32). The initial frequency was poor, but from 2005 it is more consistent at monthly intervals. Relatively high lead concentrations were observed occasionally at Upington and it is recommended that this should be monitored carefully.

The chlorophyll-*a* data is also weak with variable frequencies (sometimes weekly, sometimes monthly or longer gaps) that make the interpretation of the data almost impossible. To make the Chl-*a* data useful, the frequency of measurement should be changed to at least biweekly.

Upington is also a monitoring site in the National Microbial Monitoring Programme (NMMP). Thus, the only site on the river with *E. coli* counts. It is recommended that the expansion of the NMMP to other sites should be considered because the nature of the indicator variables used is such that monitoring at the outflow of catchments will not give a representative view of the catchments. However, the occurrence of the organisms is normally much more localized.

6.1.14 OS12 – Kanon Island – D7H004 (S28.63543; E21.09020)

The Kanon Island bridges are only about 30 km downstream of Upington and Neusberg weir is about 42 km downstream of Upington. However, at the meeting with Northern Cape Regional Office it was recommended that "A new site should be added between OS10 and OS11 to monitor impacts of the irrigation on the Islands. Blue-green algae has been observed".

The historical data is weak with measurement from 1971 and 1988 with only 88 samples. However, the site is very close to Upington and Neusberg and the snapshot results do not show any significant different results. Therefore, it is recommended that this site not be considered as a priority site.

6.1.15 OS13 – Neusberg weir (North bank canal) – D7H016 (S28.77392; E20.74297)

Neusberg weir is about 70 km downstream of Upington and an important monitoring weir because it is in the middle of intensive irrigation area (**Figure 10**). The point was accepted as a priority site (used as a RWQO site) and data from the D7H016 monitoring site (canal) was used. Data from the weir itself (D7H014) was poor and ended in 2002. The site includes abstractions for domestic, irrigation and industrial use at Kakamas (wine cellars and raisin companies). Water quality data from the snapshot surveys suggests that the Neusberg wetland probably serves as a biological filter and contributes to the purification of the water (**Figure 9**).

The chemical data set is good with about 375 observations from 1995 to 2007. The discharge data, since 1994, is also good.

Figure 9: Panoramic view of the Wetland upstream of Neusberg weir.

Figure 10: Agriculture irrigation, mainly vineyards, downstream of Neusberg weir close to Kakamas.

6.1.16 OS14 – Blouputs bridge – new site (S28.51409; E20.18518)

Blouputs bridge is a proposed new site about 70 km downstream from Neusberg weir and about 22 km downstream of Augrabies Falls Blouputs Farms is known for exporting grapes.

The Regional (Upington) meeting's minute stated that "The point was accepted as a priority site but it should move closer to the confluence of the Molopo River to include the impacts from the irrigation at Blouputs." – see Appendix A. This is the last site before the Namibian Border. Continuous monitoring was recommended by the PPECB (Perishable Products Export Control Board) and water quality monitoring in terms of their requirements are conducted (See Appendix A).

6.1.17 OS15 – Pella Mission – D8H008 (S28.96443; E19.15276)

Pella is about 150 km downstream from Blouputs. Pella Mission is an important monitoring station with a very good data set with almost weekly measurements since 1995 (n ≈ 600). Chl-*a* concentrations are measured biweekly. Pella was also identified as the RWQO point for this management region.

'This point was accepted as a priority site due to the water supplied for domestic, stock watering and mining purposes by the Pella Drift Water Board.

Water is supplied to Pella, Pofadder, Agenys and mines (Black Mountain mine which mines coal and zinc)' – see minutes, Appendix A.

Metal concentrations are determined since 2005, but the frequency is very low at approximately every 3 months (n = 20). However, the relatively high lead concentration at Pella is a matter of concern and should be monitored more regularly – monthly monitoring is suggested. It is also recommended that turbidity measurements be added at this point.

6.1.18 OS16 – Vioolsdrift – D8H003 (S28.76208; E17.72631)

Vioolsdrift is about 180 km downstream of Pella and the last flow gauging weir in the Orange River. Vioolsdrift is an important monitoring site because it's included in the SA-GEMS/Water monitoring network and is also used as a GEMS/Water site that is used in the Global River Flux monitoring network and Global Water Quality Trends (Van Niekerk, 2005). The hydrometric station at Vioolsdrift receives runoff from 87 % (850 530 km^2) of the Orange River Catchment. The remaining 13 % drains a dry area between Vioolsdrift and the Orange River mouth. The Vioolsdrift gauging station is the closest SADC-HYCOS station to the ocean.

The historical chemical data set is very good with weekly to biweekly measurements from 1977 to 2007 (n ≈ 940). Also a very good flow data since 1940 – 2007, n = 812.

6.1.19 OS17 – Sendelingsdrift – new site (S28.12288; E16.89032)

Sendelingsdrift is a proposed new site about 170 km downstream of Vioolsdrift. The site is very close (approximately 3 km) from the 'old' DWAF site 'Richtersveld Rosh Pinah on Orange' (D8H006); data 1980 – 1982 (105 samples). This site is important because it is the first site below the confluence of the Fish River with the Orange and can indicate water quality changes due to the Fish River. A flow gauging station is also planned for Sendelingsdrift.

6.1.20 OS18 – at Korridor / Brand Kaross – D8H007 (S28.48570; E16.69444)

This site is an existing site with data from 1971 to 2002 (n ≈ 407), but unfortunately it was discontinued during 2002. Good data is available between 1980 to 1988 (almost weekly); after which only 12 readings were made between 1989 and 2002, when it was ended.

However, Brand Kaross is relatively close to Sendelingsdrift (75 km apart) with no obvious significant impacts on water quality in between. The site is also close to Alexander Bay (about 30 km) and the historical chemical data shows a close correlation between these sites. Thus, it is not considered to be a priority site; a good site to have, but not an essential one.

6.1.21 OS19 – Alexander Bay – D8H012 (S28.56689; E16.50728)

The monitoring site is at the bridge (Sir Ernest Oppenheimer, boarder between South Africa and Namibia) close to Alexander Bay. The bridge is about 107 km downstream of Sendelingsdrift and approximately 10 km upstream of the river mouth. Water use includes international use (NAMDEB mining) and domestic water supply to Alexander Bay and Port Nolloth. Borehole abstraction in the river is also used for domestic purposes.

The data capturing at this site was very good (weekly to biweekly) from 1995 until 2002 (n ≈ 263 samples), when the data collection was unfortunately terminated.

This is a very important site for water quality monitoring and represents the last site before the river enters the ocean; it is just above the river mouth and the important Ramsar wetland. Water quality data at this point is crucial for the management of the river mouth Ramsar area.

Reactivation of the monitoring site D8H012 at the Bridge is recommended. Standard parameters (including Turbidity) must be monitored and sampling frequency should be at least monthly.

6.2 Orange River – tributaries – level 2

6.2.1 OSL2/1 – Kornetspruit at Maghaleen, D1H006 (S30.16003; E27.40145)

Kornetspruit, known as the Makhaleng River in Lesotho, is for a short stretch the International boarder between South Africa and Lesotho. The catchment area of the Kornetspruit is mainly in Lesotho.

'A decision was taken to include a level 2 RWQO site on the Kornetspruit as it brings good quality water from Lesotho' – see Appendix B for minutes of the meeting no.1 with Free State Regional Office. Kornetspruit's mean annual discharge is fairly high at about 583 Mm^3 that is almost the same as the Caledon River.

The monitoring station is close to the border post (Makhaleen Bridge) between South Africa and Lesotho. The historical data base is good with almost biweekly measurements that started in 1975 and is still active (n ≈ 612).

It is recommended that monitoring is continued at this site and TSS measurements must be added to the parameters.

6.2.2 OSL2/3 – Kraai River at Roodewal (D1H011) (S30.68612; E26.70600)

The Kraai River drains the Drakensberg D13 catchment (Barkly East area, Eastern Cape) towards the Orange River. There are very little potential for human impact and 30 years of historical flow and water quality data are available.

Because of the good quality of water with little impacts, this site was recommended as a global baseline monitoring site (Van Niekerk, 2005). The GEMS/Water definition for baseline stations is as follows (WHO, 1992): "Baseline stations are typically located in undisturbed upstream river stretches where no direct diffuse or point sources of pollution are likely to be found. They will be used to establish the natural water quality conditions, to provide a basis for comparison with stations having significant direct human impact, to determine through trend analyses the influence of long range transport of contaminants and of climatic conditions."

The Kraai River is an important tributary to the Orange River with a mean annual discharge of 652 Mm^3. A reasonable good historical data set with biweekly to monthly recordings that were started in 1976 until today (n ≈ 505) is available.

Kjeldhal nitrogen concentrations were determined since 2005 with a frequency of almost monthly. From Kjeldhal and nitrate concentrations the total nitrogen (TN) can be calculated. From a nutrient perspective it make sense to determine also the total phosphorus (TP) concentrations, thus it is recommended to include TP measurements in the Kraai River.

6.2.3 OSL2/4 – Stormbergspruit at Burgersdorp, D1H001, (S31.00109; E26.35314)

The Stormbergspruit (also known as Wonderboomspruit) is a relative small spruit close to the town of Burgersdorp. A good historical data set from 1976 – 2007 (n ≈ 729) is available.

In the meeting minutes of 17 January 2008 with the Free State DWAF Regional Office (See Appendix B) it is stated "Only small tanneries and stock farming in the upstream catchment, thus good quality water". However, the chemical data at the monitoring site at Burgersdorp (D1H001) showed that the spruit is highly impacted by sewage effluent from the town – see Reports No. 3 and 5. Thus it is important to rectify this problem and monitor the site for future trends.

6.2.4 OSL2/5 – Seekoei River at De Eerste Poort (D3H013) (S30.53480; E24.96250)

The Seekoei River drains a relatively unpolluted area in the Karoo. However, the water quality results show relatively high concentrations of almost all the parameters.

The minutes stated "Regular sampling is done" (Appendix B), however, the historical data shows a fairly good sampling from 1981 to 1993 (n ≈ 326), but thereafter (1994 – 2006) very poor data sampling (n ≈ 42) with large gaps in the data (**Figure 11**). This should be addressed urgently to make the monitoring and data of any value for the future. The variables are adequate but the frequency is poor.

The discharge in the Seekoei River has decreased drastically and indicates that the river is over-utilised – see Report no. 3.

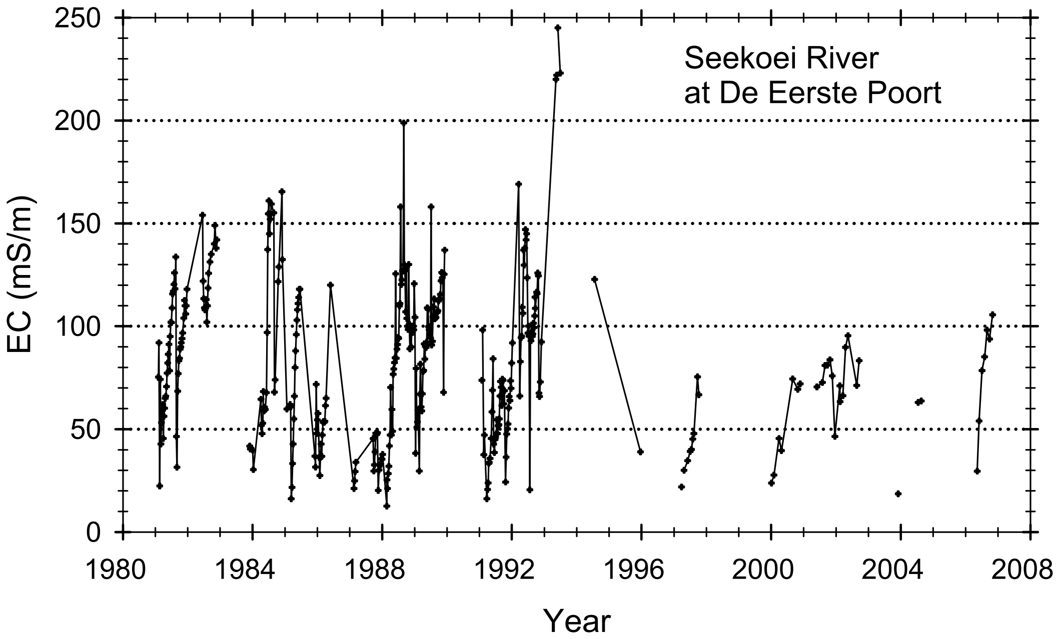

Figure 11: Temporal variation in electrical conductivity (EC) values (mS/m) in Seekoei River at De Eerste poort (1981 – 2007).

6.2.5 VS21 – Vaal River at Douglas (VS21)

The Vaal River is a major and very important tributary of the Orange River and the Vaal at Douglas Bridge is a proposed new site. It is well-known that the salt concentrations are high in the Vaal River that can enhance the salinisation problem in the Orange River and should be monitored. However, the Vaal River is operated to minimise spills into the Orange River and it is therefore mainly during floods that significant volumes of water enter the Orange from the Vaal (DWAF, 2005).

6.3 Caledon River – main stem – level 1

6.3.1 CS1 Caledon River at Caledonpoort, confluence with Little Caledon River (S28.69363; E28.23445)

This is a proposed new site. The minutes of the meeting with the Regional Office motivated the selection of this site as: “This site will provide information as to impacts upstream of the confluence from both Lesotho and SA.”

This site is only some meters away from the monitoring site on the Little Caledon (CSL2/2) which is also at the confluence of the two rivers.

6.3.2 CS2 – Caledon River at Ficksburg Bridge, D2H035

The Caledon River, which is known as the “Mohokare” in Lesotho, is a transboundary river, provides water for *inter alia* the capital city of Lesotho, Maseru, and, as it flows further down to South Africa, it leads to the Welbedacht Dam, which supplies water for the city of Bloemfontein in South Africa. It then flows west before meeting the Orange River at the Gariep Dam near Bethulie in southern Free State.

The historical data set at Ficksburg Bridge (D2H035) started in 1994 and is still active with a monthly monitoring frequency ($n \approx 295$). Good flow measurements since 1992 ($n = 178$) are available.

There is a monitoring site at the Ficksburg Bridge, but it is suggested that DWAF moves the site downstream to monitor the impact of the sewage outflow from the town (formal and informal) on the river. The site is at GPS co-ordinates: S28.69363; E28.23445 and easily accessible.

TN and TP concentrations are not measured at any monitoring sites on the Caledon River. It is suggested that TN and TP measurements being introduced at this site.

6.3.3 CS3 – Caledon River at Maseru (S29.38042; E27.41203)

There is a monitoring site at Maseru, Lesotho (D2H011), but it is not active anymore with data only available from 1981 to 1994 (n ≈ 489). However, it is suggested that DWAF register a new site downstream of Maseru to monitor the impact of the sewage and industrial outflow on the Caledon River. The high pollution levels, particularly salts and heavy metals, are of concern especially to BloemWater, one of the main downstream users (Roos, 2004). The Caledon River downstream of Maseru is a valuable source of drinking water for BloemWater which supplies potable water to the Mangaung Local Municipality and is therefore vulnerable to pollution and degradation of water quality.

This study has preliminary identified a suitable site about 10 km downstream of Maseru. The site is located at S29.38042, E27.41203, but it would be ideal to move the site closer to Maseru. The snapshot results at this site have shown high bacterial contamination but not significantly higher metals concentrations.

6.3.4 CS4 – Caledon River at Tienfontein pump station (S29.78357; E26.90998)

This is a new proposed monitoring site. The minutes of the meeting with DWAF Regional Office indicated that ”General water quality in the dam is good, although sediment is a huge problem, hence move RWQO site above dam to Tienfontein pump station (abstraction point to Knellpoort Dam)”. Accessibility to this site is difficult.

However, Wilgedraai (D2H037; WMS 101817) is a DWAF monitoring site (with good historical data) about 35 km stream up from Tienfontein. It is suggested that this monitoring site is use instead of the proposed new site at Tienfontein.

6.3.5 CS5 – Caledon River at Kommissiedrift, D2H036 (S28.69363; E28.23445)

Kommissiedrift is below Welbedacht Dam and the last monitoring point before the Caledon River enters Gariep Dam. Good historical data set with biweekly recordings from 1993 (n ≈ 212), except for the period 2003 – 2005 with only 5 recordings.

The turbidity values at this site was exceptionally high (mean, 400 NTU), which puts the Caledon River amongst the most turbid rivers in South Africa. Unfortunately, no TSS measurements were available. The 95 percentile for TDS during the past 3 years was high at 437.4 mg/ℓ and the average aluminium concentration during the snapshot monitoring was unacceptable high at 293 µg/ℓ, and should be investigated further. The accessibility to the river at this site is difficult.

It is agreed that this site should be kept as a monitoring site.

6.4 Caledon River – tributaries – level 2

6.4.1 CSL2/1 – Little Caledon River downstream of Golden Gate, (S28.49980; E28.58196)

This is a proposed new site on the Little Caledon River downstream of Golden Gate. The snapshot water quality results show that this is an unmodified natural (pristine) site with clean water stream with low levels of pollution that can serve as a reference site. The Diatom score (SPI = 14) also indicates a good quality and the %PTV (Pollution Tolerant values) of 3.7 indicates low organic impact – see Report No. 3.

6.4.2 CSL2/2 – Little Caledon River at the Poplars – confluence with Caledon River, D2H012 (S28.69363; E28.23445)

The flow gauging and monitoring site is at the confluence with the Caledon River. With a mean annual discharge of about 30.6 Mm^3, the Little Caledon River contributes about 5 % to the Caledon River's flow.

The historical data set is good with weekly to biweekly measurements since 1972 ($n \approx 347$) and is still active. The water quality in the Little Caledon was fairly good, but has relatively high salts (mean, 304 mg/ℓ). The diatom scores during snapshot 1 indicate poor quality and a significant organic impact.

This site was also identified as a RWQO site – see Report No. 5.

6.4.3 CSL2/3 – Grootspruit at R26 road bridge (S28.68026; E28.13996)

Grootspruit, also known as Brandwaterspruit, is a possible new site near Fouriesburg on the R26 road. The RWQO site was included for the snapshot monitoring and it was agreed that if impacts are significant, this will stay as a level 2 RWQO site.

The spruit shows high TDS concentrations (average, 360 mg/ℓ; highest of the tributaries) and high nutrients. The diatom SPI scores ranged between moderate and good quality. The relatively high aluminium and manganese concentration (average, 190 and 79 µg/ℓ respectively) at this site is a matter of concern and should be investigated further.

6.4.4 CSL2/4 – Meulspruit (S28.83528; E27.83340)

This is a proposed new site upstream of Meulspruit Dam, near Ficksburg. The motivation from the Regional Office meeting with DWAF WQP was that: "A number of farm dams for irrigation purposes are in the upstream catchment. Sediment problems exist in the catchment. Meulspruit Dam results in river largely being dry. RWQO site to be situated upstream of the dam, perhaps at the Roosendal road bridge".

The selected site is upstream of the dam at road bridge on the S67 (to Senekal), but close (about 8 km) from Ficksburg. The water quality was good with low bacterial counts, moderate salts (261 mg/ℓ) and SS (45 mg/ℓ), but high DOC (5.95 mg/ℓ). Diatoms results show moderate quality with significant organic impact.

6.4.5 CSL2/5 – Moperispruit at R26 road bridge (S28.96011; E27.56664)

The proposed site on the Moperispruit (also spelled, Mopeli) is close to Clocolan (R26 road bridge). Some irrigation takes place in the catchment. Sediment might be a problem. Snapshot monitoring was done at this site to determine if a RWQO site is really necessary.

The snapshot results show moderate water quality with significant organic impact. Relatively low *E. coli* counts (<100 cfu/100 mℓ); fairly high salts (300 mg/ℓ) especially sulphates, and nutrients, with high SAR (above TWQR for irrigation) and high chlorophyll-*a* (algal) concentration (30 μg/ℓ).

6.4.6 CSL2/6 – Leeu River at Hobhouse (S29.52155; E27.13577)

The Leeu River (or Leeuspruit) was identified as a possible RWQO site, with location at the Hobhouse Road (R26) Bridge. A number of large dams (Armenia, Newbury, Lovedale) for irrigation are situated in the upstream catchment.

The snapshot results showed moderate salts (241 mg/ℓ), nutrients and pH (7.6), but high *E. coli* count (>900 cfu/100 mℓ). However, the high SPI scores (diatoms) indicate good quality but significant organic impact.

Leeu River at Hobhouse is not recommended as a priority monitoring site because the water quality was not bad and because of the high degree of damming that limits the flow significantly to the Caledon River. Further, a DWAF monitoring site already exists on the river, *i.e.* D2H026, Armenia Dam on Leeu River.

7 RECOMMENDATIONS

Water quality assessment should always be seen in the wider context of the management of water resources, encompassing both the quality and quantity aspects.

7.1 Monitoring variables:

Water quality is neither a static condition of a system, nor can it be defined by the measurement of only one parameter. Rather, it is variable in both time and space and requires routine monitoring to detect spatial patterns and changes over time (UNEP-GEMS, 2006).

The best-equipped monitoring stations routinely consider up to 100 descriptors, while financial and technical constraints mean that monitoring stations in the least developed countries, when they exist, can still barely measure a dozen descriptors (Meybeck, 2005). The selection of variables for any water quality assessment programme depends upon the objectives of the programme. Appropriate selection of variables will assist with informed decision-taking, compliance management and cost effective monitoring.

The variables included in the current NCMP cover most of the basic elements (about 20), but not all the variables are determined at all the monitoring sites. **Tables 9, 10 and 11** show the proposed variables that should be monitored for the proposed sites.

It is recommended that suspended solids monitoring be done at all the proposed monitoring sites on the Orange and Caledon River. During this study a clear lack in suspended solids data was identified.

7.2 Sampling Frequency:

Water quality is a highly variable aspect of any water body, although it is more variable in rivers than in lakes, but much less so in aquifers. Variabilities occur not only with regard to their spatial distribution but also over time (temporal).

The current sampling frequency used by the National Chemical Monitoring Network ranges from weekly to quarterly. Most of the existing monitoring programmes on the Orange River make provision for either bi-weekly or monthly monitoring.

The proposed monthly sampling interval for rivers (Harris *et al.,* 1994) is the most appropriate frequency to avoid serial correlation and still be able to detect trends with a high level of confidence. The GEMS/Water (WHO, 1992) recommended sampling frequency for trend detection is also monthly but that TSS at Vioolsdrift be sampled weekly (Van Niekerk, 2005). The most appropriate sampling frequency for SA-GEMS/Water dam sites was determined to be biweekly (every two weeks).

Therefore, a biweekly measurement frequency is recommended for the Orange River system, but at least monthly.

A low sampling performance was detected at a number of NCMP sites. It is critical that this problem be resolved by the NCMP Programme Manager as soon as possible. Continuous monitoring should be considered if problems are experienced with observers.

7.3 Monitoring sites – where to sample

In developed countries, the density of water quality monitoring stations is similar to that of meteorological stations (about one station for 250 km^2 and 25 000 peoples in France), but it is between one and two orders of magnitude lower in the least developed countries (Meybeck, 2005). If one applies this ratio to the Orange River it will mean about 2 400 stations in the Orange Catchment which is unpractical. However, we propose 18 monitoring sites on the Orange River in South Africa's border, *i.e.* about one site per 120 km of river. The Proposed Strategic monitoring sites on the Orange and Caledon Rivers (Level 1 & 2) are listed in **Tables 4, 5, 6, 7 and 8**. The following is proposed:

7.3.1 Re-introduce the following WQ monitoring sites on the Orange River:

- Alexander Bay (D8H012) – discontinued in 2002

7.3.2 Proposed new WQ monitoring sites on the Orange River:

- De Hoek – farm downstream of Vaal River confluence (Old site, Irene, D7H012)
- Blouputs – Export Farms downstream of Augrabies Falls.
- Sendelingsdrift – downstream of the Fish River confluence. A new flow gauging station is planned for this site. Sendelingsdrift is close to the old D8H001 site; Richterveld Rosh Pinah.

7.3.3 Proposed new WQ monitoring sites on Orange River tributaries:

- Sterkspruit – in town of Sterkspruit
- Vaal River at Douglas bridge

7.3.4 Proposed new WQ monitoring sites on the Caledon River:

- Caledon River at the confluence with Little Caledon
- Caledon at Maseru – Lesotho; downstream of city's sewage and industrial effluent,

7.3.5 Proposed new WQ monitoring sites on Caledon River tributaries:

- o Little Caledon River at Golden Gate – downstream of Golden Gate
- o Grootspruit at Fouriesburg
- o Moperispruit at Clocolan

7.3.6 Initial proposed monitoring sites that are not recommended as a high priority sites are:

- o Saamwerk – farm upstream of Gariep Dam;
- o Prieska (D7H002),
- o Gifkloof (new site)
- o Kanon Island (old D7H004)
- o Brand Kaross (old D8H007)
- o Caledon at Tienfontein pump station
- o Meulspruit
- o Leeu River

7.4 Microbial Monitoring:

Sewage, agricultural and urban run-off, and domestic wastewater are widely discharged to water bodies, particularly rivers. Monitoring for the presence of pathogenic bacteria is an essential component of any water quality assessment where water use, directly or indirectly, leads to human ingestion. Such uses include drinking, personal hygiene, recreation (e.g. swimming, boating), irrigation of food crops and food washing and processing.

It should also be kept in mind that many persons drink raw water from the Orange River or canal systems. This practice is not recommended and a regular, routine information dissemination system should be maintained in co-operation with the Environmental Health Practitioners on Local, Provincial and National levels of the Department of Health.

The ecotourism and recreational use of the LOR has gained in intensity over the past twenty years. The rafting and canoeing industry in this remote area has developed into an extremely popular experience for tourists (ARTP JMB, 2008), and thus bacteriological status is important.

The National Microbial Monitoring Programme (NMMP) currently focuses only on impacted areas and not on a catchment level (Van Niekerk, 2005). Currently it is only the site at Upington that is included in the NMMP. Therefore, it is proposed that the NMMP be expanded to include the following sites: Aliwal North, Marksdrift, Pella and Vioolsdrift.

7.5 Other concerns:

The increasing cause for concern is skin rashes and other skin and mucous membrane irritations amongst both contact and non-contact recreational users. For example, avian bird flu (swimmers itch) was reported to DWAF by several tourists that did river rafting and swam in the river.

Table 4: Upper Orange River: Proposed (final) Strategic Monitoring sites Level 1 – main stem.

Upper Orange WMA 13

SITE NO	SAMPLE CODE	SA HYDRO SITE ID NO	LOCATION OF SITE – DESCRIPTION	GPS COORDINATES		OTHER INFO
1	**OS1**	D1H009	Orange River (OR) at **Oranjedraai**	S30.33772	E27.36277	Existing site at new flow gauging weir 1st site – close to Lesotho border WMS D12_101793
2	**OS2**	D1H003	OR at **Aliwal North**	S30.68612	E26.70600	Existing site at road bridge Consider downstream site WMS D14_101789
3	**OSD1**	D3R002	**Gariep Dam**	S30.60794	E25.50465	Exciting site near dam wall First site with Chl-*a* concentrations WMS D34_101834
4	**OS4**	D3H013	OR at **Roodepoort**	S30.58487	E25.42084	Existing site, d/s Gariep Dam Flow gauging WMS D34_101828
5	**OSD2**	D3R003	**Vanderkloof Dam**	S29.99447	E24.73524	Existing site – near dam wall First site with metal concentrations WMS D31_101837
6	**OS5**	D3H012	OR at **Dooren Kuilen**	S29.99141	E24.72414	Existing site; just downstream of dam Flow gauging WMS D33_101827
7	**OS6**	D3H008	OR **at Marksdrift**	S29.16201	E23.69447	Existing site, at weir WMS D33_101824, GEMS/SA site.

Table 5: Lower Orange River: Proposed Strategic monitoring sites level 1 – main stem.

Lower Orange River, WMA 14

SITE NO	SAMPLE CODE	SA HYDRO SITE ID NO	LOCATION OF SITE – DESCRIPTION	GPS COORDINATES	OTHER INFO
1	**OS7**	New site	Orange River at **De Hoek** Old site, Irene (D7H012)	S29.18512; E23.57332	At De Hoek farm (H J Cillie). Downstream Vaal confluence
2	**OS9**	D7H008	OR at **Boegoeberg** weir	S29.02625; E22.18608	Existing site – below weir Beginning of intensive irrigation
3	**OS11**	D7H005	OR at **Upington Water Works**	S28.45259; E21.25994	Existing site Also part of NMMP
4	**OS13**	D7H016	OR at **Neusberg** weir	S28.77481; E20.74558	Existing site at weir - discontinued Intensive irrigation
5	**OS14**	New site	OR at **Blouputs**	S28.51409; E20.18518	New site at new road bridge Below Augrabies water fall
6	**OS15**	D8H008	OR at **Pella** Mission	S28.96443; E19.15276	Existing site at intake tower; good data set – high metals; Mining activity
7	**OS16**	D8H003	OR at **Vioolsdrift**	S28.76208; E17.72631	Existing site at weir – priority site GEMS site; CA 850 530 km^2
8	**OS17**	New site	OR at **Sendelingsdrift**	S28.12288; E16.89032	New site – close to old site (D8H006), Richtersveld Rosh Pinah
9	**OS19**	D8H012	OR at **Alexander Bay**	S28.56689; E16.50728	Existing site at Oppenheimer Bridge – discontinued; close to river mouth

Table 6: Orange River: Proposed Strategic Monitoring sites level 2 – tributaries

Upper Orange WMA 13 & 14

SITE NO	SAMPLE CODE	SA HYDRO SITE ID NO	LOCATION OF SITE – DESCRIPTION	GPS COORDINATES	OTHER INFO
1	**OSL2/1**	D1H006	**Kornetspruit** at Maghaleen	S30.16003; E27.40145	Existing site at flow gauging weir; Important tributary – good quality WMS D15_101792
2	**OSL2/2**	New site	**Sterkspruit** (at R382 crossing)	S30.52694; E27.37484	In town at road (R392) bridge Sewage and urban run-off Discharge unknown; D12
3	**OSL2/3**	D1H011	**Kraai River** at Roodewal	S30.73707; E26.78440	Existing site at bridge Important tributary – good quality WMS D13_101795
4	**OSL2/4**	D1H001	**Stormbergspruit** at Burgersdorp (Wonderboomspruit at diepkloof)	S31.00109; E26.35314	Existing site at weir Serious sewage pollution WMS D14_101788
5	**OSL2/5**	D3H015	**Seekoei River** at De Eerste Poort	S30.53480; E24.96250	Existing site at flow gauging weir Reduced flow WMS D32_101829
6	**VS21**	New site	**Vaal River** at Douglas bridge	S29.04885; E23.76822	At bridge in town High salts en nutrients

Table 7: Caledon River: Strategic monitoring sites level 1 – main stem

Upper Orange WMA – Caledon River

SITE NO	SAMPLE CODE	SA HYDRO SITE ID NO	LOCATION OF SITE – DESCRIPTION	GPS COORDINATES	OTHER INFO
1	**CS1**	New site	**Caledon River** at **confluence** (with Little Caledon)	S28.69363; E28.23445	At RSA-Lesotho border post (Caledonpoort bridge)
2	**CS2**	New site (Old D2H035)	**Caledon River** at **Ficksburg**	S28.90409; E27.83084	Downstream of town. WMS D22_101815
3	**CS3**	New site (Old D2H011)	**Caledon** at **Maseru (**Lesotho)	S29.38042; E27.41203	Downstream of city Monitor sewage & industrial outflow WMS D22_101807
4	**CS5**	D2H036	Caledon River at **Kommissiedrift** at N6 crossing	S30.27994; E26.65427	Existing site at N6 road crossing WMS D24_101816 Difficult access

Table 8: Caledon River: Proposed strategic monitoring sites level 2 – tributaries

Upper Orange WMA – Caledon River tributaries

SITE NO	SAMPLE CODE	SA HYDRO SITE ID NO	LOCATION OF SITE – DESCRIPTION	GPS COORDINATES	OTHER INFO
1	**CSL2/1**	New site	**Little Caledon River** at Golden Gate	S28.49980; E28.58196	Downstream of Golden Gate; On Road R712 crossing Unmodified Natural
2	**CSL2/2**	D2H012	**Little Caledon River** at The Poplars	S28.69477; E28.23486	Existing site – at RSA-Lesotho border (Caledonpoort bridge) WMS D21_101808; gauging station
3	**CSL2/3**	New site	**Grootspruit** at R26 road bridge (also called Brandwaterspruit)	S28.68026; E28.13996	At R26 road bridge Close to Fouriesburg High salts – high Mn and Al
4	**CSL2/4**	New site	**Moperispruit** at road bridge (also called Mopeli)	S28.96011; E27.56664	At road bridge close to Clocolan Relative small High salts – high chlorides

Table 9: Water quality variables at different site – Upper Orange WMA - Orange River – level 1 & 2.

Hydro code	Sample site	Ca	Cl	Corr	Chl-a	DMS	EC	*E. coli*	Flow	F	Hard-T	K	Kjel N	Langl	Metals	Mg	Na	NH_3	NH_4-N	NO_3-N	pH	PO_4-P	SAR	Si	SO_4	TAL	TP	TSS	Turb
OS1	Oranjedraai	•	•	•	X	•	•	X	•	•	•	•	√	•	√	•	•	•	•	•	•	•	•	•	•	•	√	√	•
OS2	Aliwal North	•	•	•	X	•	•	√	•	•	•	•	√	•	X	•	•	•	•	•	•	•	•	•	•	•	√	√	√
OS3	Saamwerk*	√	√	√	X	√	√	X	X	√	√	√	X	√	X	√	√	√	√	√	√	√	√	√	√	√	X	√	√
OS4	Gariep Dam	•	•	•	•	•	•	X	X	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•
OS5	Roodepoort	•	•	•	X	•	•	X	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	•	√	•
OS6	Vanderkloof	•	•	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
OS7	Dooren Kuilen	•	•	•	X	•	•	X	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	√	√	•
OS8	Marksdrift	•	•	•	X	•	•	√	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	√	√	•
Level 2 – Tributaries																													
OSL2/1	Kornetspruit	•	•	•	X	•	•	X	•	•	•	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•	X	√	•
OSL2/2	Sterkspruit*	√	√	√	X	√	√	√	X	√	√	√	X	•	X	√	√	√	√	√	√	√	√	√	√	√	X	X	√
OSL2/3	Kraai River	•	•	•	X	•	•	X	•	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	√	•	•
OSL2/4	Stormberg	•	•	•	X	•	•		•	•	•	•	√	•	X	•	•	•	•	•	•	•	•	•	•	•	√	√	√
OSL2/5	Seekoei River	•	•	•	X	•	•	X	•	•	•	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•	X	√	√

• = Variable currently measured X = no measurement √ = Suggested being included * = New site

Table 10: Water quality variables at different site – Upper Orange WMA – Caledon River – level 1 & 2.

Hydro code	Sample site	Ca	Cl	Corr	Chl-a	DMS	EC	*E. coli*	Flow	F	Hard-T	K	Kjel N	Langl	Metals	Mg	Na	NH_3	NH_4-N	NO_3-N	pH	PO_4-P	SAR	Si	SO_4	TAL	TP	TSS	Turb
CS1	Caledon-confl.	√	√	√	X	√	√	X	X	√	√	√	√	√	X	√	√	√	√	√	√	√	√	√	√	√	√	√	√
CS2	Ficksburg	•	•	•	•	•	•	•	•	•	•	•	X	•	X	•	•	•	•	•	•	•	•	•	•	•	X	√	√
CS3	Maseru*	•	•	•	X	•	•	√	X	•	•	•	•	•	√	•	•	•	•	•	•	•	•	•	•	•	X	√	√
CS4	Tienfontein#	√	√	√	X	√	√	X	X	√	√	√	X	√	X	√	√	√	√	√	√	√	√	√	√	√	X	√	√
CS5	Kommissiedrift	•	•	•	X	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	√	√
Level 2 – tributaries																													
OSL2/1	Little Cal –G#	√	√	√	X	√	√	X	X	√	√	√	X	√	√	√	√	√	√	√	√	√	√	√	√	√	X	√	√
OSL2/2	Little Cal -Pop	•	•	•	X	•	•	√	•	•	•	•	√	•	X	•	•	•	•	•	•	•	•	•	•	•	√	√	√
OSL2/3	Grootspruit#	√	√	√	X	√	√	X	X	√	√	√	X	√	√	√	√	√	√	√	√	√	√	√	√	√	X	√	√
OSL2/4	Meulspruit#	√	√	√	X	√	√	X	X	√	√	√	X	√	X	√	√	√	√	√	√	√	√	√	√	√	X	√	√
OSL2/5	Moperi River#	√	√	√	X	√	√	X	X	√	√	√	X	√	X	√	√	√	√	√	√	√	√	√	√	√	X	√	√
OSL2/6	Leeu River#	√	√	√	X	√	√	X	X	√	√	√	X	√	X	√	√	√	√	√	√	√	√	√	√	√	X	√	√

• = Variable currently measured   X = no analyses   √ = Suggested being included   * = currently inactive   # = New site

Table 11: Water quality variables at different site – Lower Orange WMA 14 - Orange River – level 1 & 2.

Hydro code	Sample site	Ca	Cl	Corr	Chl-a	DMS	EC	*E. coli*	Flow	F	Hard-T	K	Kjel N	Metals	Mg	Na	NH_3	NH_4-N	NO_3-N	pH	PO_4-P	SAR	Si	SO_4	TAL	TP	TSS	Turb
OS9	De Hoek#	√	√	√	X	√	√	X	X	√	√	√	X	X	√	√	√	√	√	√	√	√	√	√	√	X	√	√
OS10	Prieska*	•	•	•	X	•	•	X	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	X	√	•
OS11	Boegoeberg	•	•	•	√	•	•	X	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	•	√	•
OS12	Upington	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	√	√	√
OS13	Kanon Island*	•	•	•	X	•	•	X	•	•	•	•	X	X	•	•	•	•	•	•	•	•	•	•	•	X	√	√
OS14	Neusberg*	•	•	•	√	•	•	X	•	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	√	√	•
OS15	Blouputs#	√	√	√	X	√	√	√	X	√	√	√	X	X	√	√	√	√	√	√	√	√	√	√	√	X	√	√
OS16	Pella	•	•	•	•	•	•	√	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	√	√
OS17	Vioolsdrift	•	•	•	√	•	•	√	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	√	√
OS18	Sendelingsdrift#	√	√	√	√	√	√	X	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
OS19	Alex Bay*	•	•	•	X	•	•	X	X	•	•	•	•	X	•	•	•	•	•	•	•	•	•	•	•	√	√	√
VS21	Vaal River	√	√	√	√	√	√	√	X	√	√	√	X	X	√	√	√	√	√	√	√	√	√	√	√	X	√	√

• = Variable currently measured X = no analyses √ = Suggested being included * = currently inactive # = proposed new site

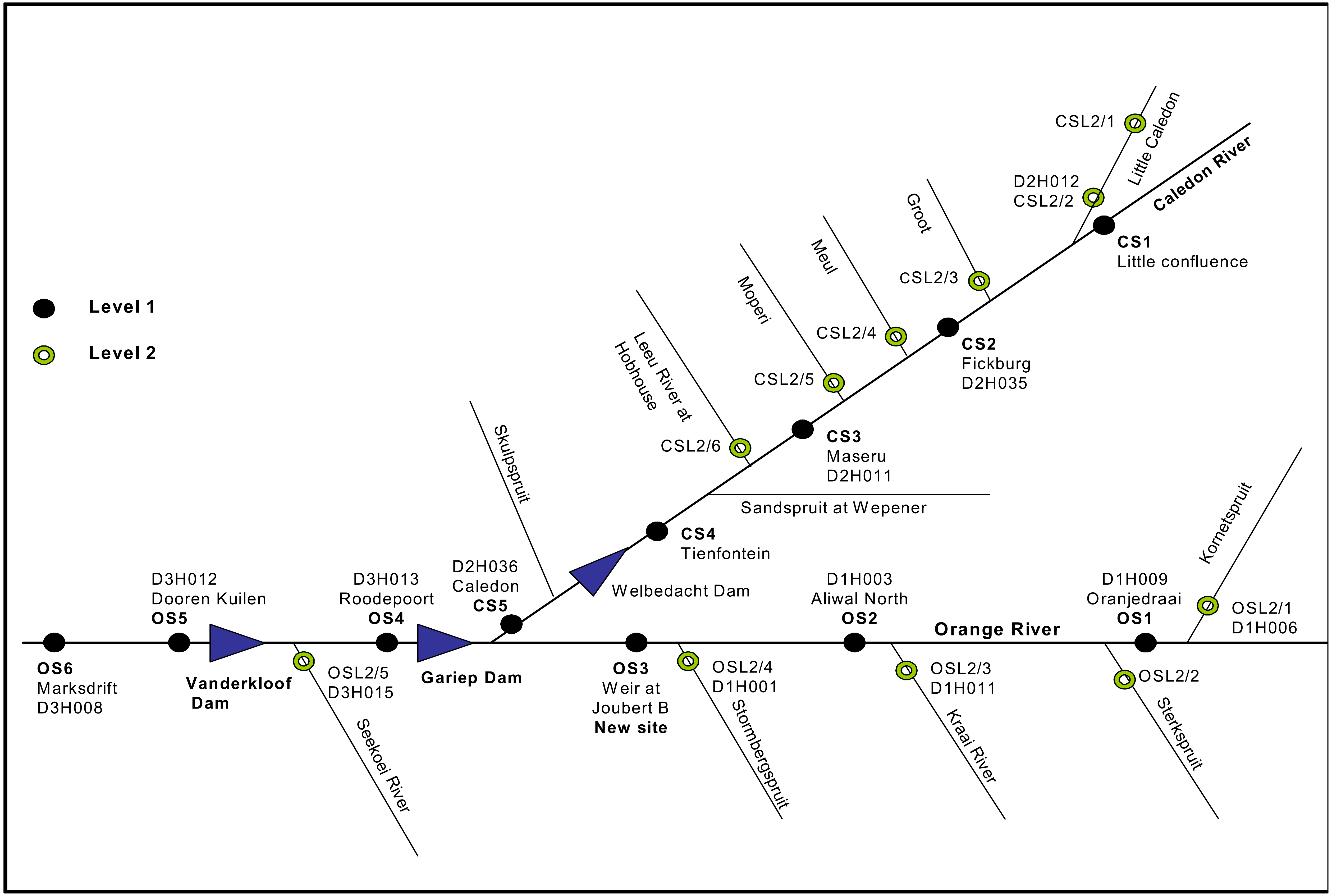

Figure 12: Line diagram of the Upper Orange WMA (13) monitoring sites – level 1 and 2.

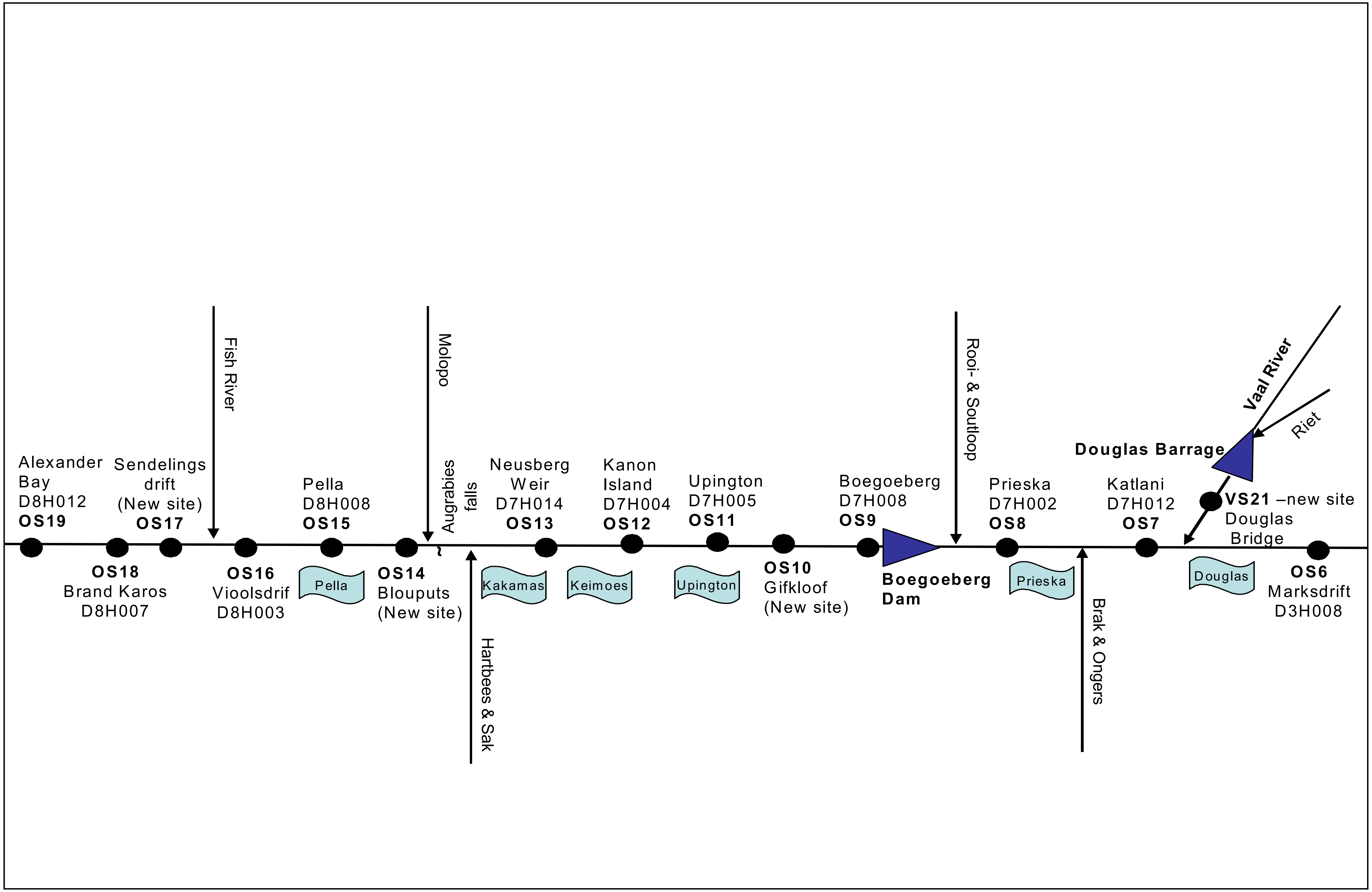

Figure 13: Line diagram of the Lower Orange WMA (14) monitoring sites – level 1 and 2.

8 CONCLUSIONS

It must be recognised that the appropriate use and reporting of monitoring data is a vital part of the overall monitoring and assessment programme. Without clear reporting of understandable and relevant results to programme managers and eventually to the water resource managers, little will be achieved. That requirement can only be met if it is fully taken into account at the very earliest stages of the overall programme objective definition and subsequent design finalisation. It is also essential to understand that at every stage of the monitoring process, the data needs of the analysis and reporting stages are recognised. Without good data, no useful information may be reportable, no matter how good the underlying analysis may have been.

Thus, it is essential that the water quality monitoring programme for the Orange River ultimately supports the information needs of the users. In terms of the monitoring programme for the Orange River it is envisaged that the proposals and recommendations made will support the water quality data needs in terms of the current management objectives of the river.

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APPENDIX A

Lower Orange River – Resource Water Quality Objectives

Minutes of meeting No. 1 with the Northern Cape Regional Office

DWAF Offices, Upington, 20 November 2006

LOWER ORANGE RIVER

RESOURCE WATER QUALITY OBJECTIVES

MINUTES OF MEETING NO.1 WITH REGIONAL OFFICE

VENUE: DWAF OFFICES, UPINGTON
DATE: 20 NOVEMBER 2006

1. Welcome

H Abbott welcomed everyone and introduced the attendees.

2. Purpose of the meeting

J van Wyk introduced the purpose of the meeting as three components:

- RWQOs (this covers discussions on the proposed RWQOs, preliminary RWQOs and also variables of concern),
- Visioning, and
- Monitoring.

3. Attendance

See the attached list.

4. Approval of the agenda

The agenda was accepted without any additions or corrections.

5. Background

J van Wyk provided the background for the proposed meeting and stressed the importance of visioning for the catchment, especially with the impacts from the Vaal and Upper Orange that causes the deterioration of the water quality.

6. RWQOs

6.1 Proposed RWQOs sites

The first comment from H Abbott was that he is pleased by the initiative but concerned about the number of monitoring points due to the lack of officials to undertake the monitoring. R Stassen indicated that most of the proposed RWQOs sites are linked to existing monitoring sites with data available from the Water Management System (WMS).

The proposed sites OS1-OS5 on the map falls within the Upper Orange and will not be discussed during the meeting.

The proposed RWQO sites for the Lower Orange were discussed by the members of the meeting.

6.2 Level 1 RWQO sites

OS6 – Marksdrift. This is an important and suitable point because it is located just before the confluence of the Vaal and Upper Orange Rivers. Use existing D3H008Q01 monitoring station.

OS7 – Irene. B Conradie mentioned that there are currently no observers and that the site is used as a flood section only. She suggested that the site be moved closer to the confluence of the Vaal and Upper Orange Rivers and that farmers (W Bruwer) nearby be requested to take the samples.

OS8 – Prieska. There is a reliable observer for this site. There is currently no data at this site (D7H002Q01). The impact from the Ongers River (irrigation) will also be included at this site.

0S9 – Boegoeberg. The point was accepted, but it was suggested that it should be moved to Boegoeberg Dam (D7H008). This will include the impacts of the irrigation upstream of the dam.

New site: Gifkloof. B Conradie suggested a site between OS9 and OS10 because of the impacts from irrigation (algae).

OS10 – Upington. This point was accepted, but should be moved to the intake at Upington Water Works. This point will include objectives for Upington domestic supply, international obligations (Nakop border post) and Kalahari West pipeline for domestic and stock watering purposes.

New site: Islands. A new site should be added between OS10 and OS11 to monitor the impacts of the irrigation on the Islands. Blue-green algae have been observed.

OS11 – Neusberg. The point was accepted, data from D7H014Q01 monitoring site will be used. The site includes abstractions for domestic, irrigation and industrial use at Kakamas (wine cellars and raisin companies).

OS12 – This point was taken out due to little impact from the Hartbees River (irregular flow).

OS13 – Blouputs. The point was accepted but it should move closer to the confluence of the Molopo River to include the impacts from irrigation at Blouputs. This is the last site before the Namibian Border. Continuous monitoring was recommended by the PPECB (Perishable Products Export Control Board) and water quality monitoring in terms of their requirements are conducted. Data to be obtained from them. D8H004Q01 can be used to set the RWQOs, but should be revised with the new data.

OS14 – Pella. This point was accepted due to the water supplied for domestic, stock watering and mining purposes by the Pella Drift Water Board. Water is supplied to Pella, Pofadder, Agenys and mines (Black Mountain mine which mines coal and sink). Data from D8H008Q01 to be used for the determination of RWQOs.

OS15 – Vioolsdrift. The point was accepted, data from D8H003Q01 to be used to determine RWQOs. Abstractions at Henkries for water supply to Springbok and Kleinzee. All impacts from Pella to Vioolsdrift, including Goodhouse are taken into consideration. International obligations (Namibia) and recreational use in the downstream Ai/Ai-Richtersveld Transfrontier Park should be included in the RWQOs. The point is also located downstream of the proposed dam.

OS16 – Sendelingsdrift. The point was accepted as it is downstream of the Ai/Ai-Richtersveld Transfrontier Park and upstream of the Fish River (Namibia) confluence. A new monitoring point is needed and officials from the Park can be requested to be the observers.

New site: Rosh Pinah. There was a proposal for another RWQO site between OS16 and OS17, downstream of the Fish River confluence. This will cater for the impacts from the Fish River (irrigation) and Rosh Pinah (mining). The data from the existing monitoring site D8H007Q01 should be used for the RWQOs. Continuous monitoring should be considered if problems are experienced with observers.

OS17 – Alexander Bay. This point was accepted because it is located just upstream of the estuary (RAMSAR site). Use D8H012Q01 to determine RWQOs. Water use includes international use (NAMDEB mining) and domestic water supply to Alexander Bay and Port Nolloth. Borehole abstraction in the river is also used for domestic purposes.

6.3 Level 2 RWQO sites

L2OS/10 – Ongers. Point not essential. Smarrt Sindicate WUA can assist as observers. Impacts mainly irrigation. OS8 can be used for impacts.

Rest of proposed level 2 sites is on episodic rivers and is not viable as RWQO sites.

For the level 2 sites on the. The same numbers as for the Vaal River Reconciliation study should be used for the Vaal and Modder/Riet Rivers.

6.4 Reserve determination resource units

The proposed RQO sites are adequate for the initially identified resource units.

6.5 Water uses/impacts per proposed RWQOs site

Included in the notes on the proposed level 1 RWQO sites.

6.6 Preliminary RWQOs from model

This was not discussed in detail due to time constraints and changes to the location, monitoring points and variables of concern for the proposed RWQO sites. A follow-up meeting will be scheduled to discuss the RWQOs.

6.7 Variables of concern

pH is the main variable of concern, with Cla-a and E-coli.Other variables that could be considered are PO_4-P, NO_3+NO_2+N, KJEL-N, P-tot COD and Cd.

7. Vision for Lower Orange WMA

More than one vision should be considered for the Lower Orange WMA. This can be per area (river and inland), homogeneous sector (irrigation, mining, etc) or type of resource (mainstem Orange, episodic tributaries, groundwater).

The vision for the Lower Orange WMA is to:

- Create awareness,
- Introduce an early warning system (water quality), and
- Improve the water quality of the mainstem (eutrophication and bacteriological).

There was a proposal to sub divide the vision into areas of concern. These areas are:

- Douglas to Boegoeberg (Use WUA, W Bruwer)
- Boegoeberg to Augrabies/Kakamas (Irrigation Boards)
- Kakamas to the Mouth, including Springbok and Namaqualand
- Episodic rivers (Hartbees, Ongers, etc)
- Groundwater driven areas around the Molopo and Kalahari areas

H Abbott to ensure officials from the groundwater section at the RO is included. WQP to assist the RO with the desktop visions before taking it to the LORRF.
8. Monitoring M Daswa to contact Joleen for data that is available at the Regional Office that needs to be captured onto WMS. The other entities that need to be contacted for data are Orange-Vaal WUA, Pella Drift Water Board, Namaqua Water Board and Henkries Water Board. B Conradie provided data for the episodic rivers and the Kenhardt area. Data on algae is also available from previous studies. A snap-shop monitoring study (once-off during high and low flow periods) will be undertaken by WQP at all the proposed RWQO sites. This will assist with the refinement of the proposed objectives.
9. General No discussions.
10. Way forward It was agreed by the Regional Office and Head Office (WRPS: WQP) that there is a need to undertake the snap-shot monitoring and that WQP will assist with the desktop visions.
11. Closure J van Wyk closed the meeting.

APPENDIX B

Upper Orange River

Visioning, Resource Water Quality Objectives and Monitoring.

Minutes of meeting No. 1 with the Free State Regional Office

DWAF Offices, Bloemfontein, 17 January 2008

UPPER ORANGE RIVER

VISIONING, RESOURCE WATER QUALITY OBJECTIVES AND MONITORING

MINUTES OF MEETING NO.1 WITH REGIONAL OFFICE

VENUE: DWAF OFFICES, BLOEMFONTEIN

DATE: 17 JANUARY 2008

1. Welcome JV welcomed everybody attending the meeting at 09h20.
2. Attendance Willem Grobler (WG) Gerda Venter (GV) Mariette Swart (MS) Jackie van Bosch – (JB) Jurgo Van Wyk (JvW) Retha Stassen (RS) Johan van Van der Merwe (JV) Samantha Boshoff (SB) The attendance register is attached as Annexure A.
3. Additions to agenda The following points were added to the agenda: 8.1 Samantha to share on her work on the Lower Orange River 8.2. Share on work in Lesotho 8.3 Waste Discharge Charge System 8.4 Monitoring standards and methods
4. Purpose of the meeting (JvW) An exploratory, informal meeting with the following goal: • Two main WMAs, hence, need integration across areas as well as with the Vaal River System • Identification of any past initiatives e.g. catchment assessment studies, objectives and what data is available • Explain the linkages/interaction between WQP and the other directorates within the Integrated Water Resources Planning chief directorate, Regional Offices and Resource Quality Services • Discuss the importance of water quality monitoring and the use by WQP for scenario planning , foresight and reconciliation • Provide background to the snap-shot monitoring project for the Orange River System
5. Resource Water Quality Objectives (RWQOs) (JvW) A number of considerations were discussed, namely: • DWAF is legally obliged to set Resource Quality Objectives • WQP is considering the planning level, mainly the main stem and major tributaries, while Regional Offices need to consider objectives at a more detail level, i.e. at the sub-catchment level • Level 1 objectives are set for the main stem and major tributaries, e.g. Caledon River and Level 2 for smaller tributaries

- There is a need to formulate rules to differentiate between Level 1 and 2 for rivers. (JB) suggested that catchment area can be a consideration. WG suggested impacts as a criterion, the more impacted tributaries should be Level 1, e.g. discharges of sewage treatment works to a tributary
- The parameters for each RWQO site should be considered separately
- RWQO sites should be coupled with existing monitoring sites where possible. However, RWQO sites can guide strategic monitoring where specific gaps are identified in national monitoring.
- Both the users upstream and the water uses downstream of the RWQO site should be considered when determining the objectives
- JvW explained the difference between RWQO, Reserve and RQOs

5.1 Proposed RWQO sites (RS)

The proposed Level 1 and 2 RWQO sites were discussed using a schematic diagramme of the Upper Orange River System. The following RWQO sites were proposed:

- ***OS1*** Orange River just before confluence with Kornetspruit
  Good quality water from Lesotho
- ***OSL2/1*** Kornetspruit
  Decision was made to include a level 2 RWQO site on the Kornetspruit as it brings good quality water from Lesotho
- ***OSL2/2*** Sterkspruit
  Decision taken to include as a level 2 RWQO site due to farming, communities and sewage impacts in the catchment
- ***OS20*** Orange River between Sterkspruit and Kraai confluences
  Impacts of Sterkspruit and good quality water from Kornetspruit
- ***OSL2/3*** Kraai River
  Good quality water with little impacts
  One level 2 site just before confluence with Orange River
  A second level 2 RWQO site in the vicinity of Barkley East might be considered in the future
- ***OS2*** Orange at Aliwal North
  Aliwal North sewage works discharges into river and the location of this RWQO site should be below the STW
- ***OSL2/4*** Stormberge
  Relatively drier than the other upstream tributaries
  Only small tanneries and stock farming in the upstream catchment, thus good quality water
- ***OS3*** Orange River upstream Caledon confluence
  This RWQO site should be close to Gariep Dam
- ***OS4*** Orange River downstream of Gariep Dam
  Agreed to keep this site
- ***OSL2/5*** Seekoei River
  Quite dry but a rather large catchment
  Regular sampling is done
  The Seekoei River confluence with the Orange River is close to Vanderkloof Dam
- ***OS5*** Orange River downstream Vanderkloof Dam
  Agreed to keep this site
- ***OS6*** Orange River at Marksdrift

Some irrigation between OS5 and OS6
Agreed to keep this site, but responsibility of Kimberley Office

It was agreed to change the Caledon River main stem to level 1 and the major tributaries of the Caledon River to level 2. The following RWQO sites were identified:

- ***CSL2/1*** Little Calendon River at Golden Gate
  Site to be situated just downstream of Golden Gate
- ***CSL2/2*** Little Caledon at Oorlogspoort
  Move site further upstream due to possible backwater from main Caledon River
- ***CS1*** Caledon River at Little Caledon confluence
  This site will provide information as to impacts upstream of the confluens from both Lesotho and SA
- ***CSL2/3*** Groot River
  RWQO site to be included for the snap shot monitoring
  If impacts are significant, this will stay as a level 2 RWQO site
- ***CS2*** Caledon at Ficksburg
  RWQO site should be situated after the sewage treatment works
  Lesotho's industrial impacts to Calendon River (material dying)
- ***CSL2/4*** Meulspruit
  A number of farm dams for irrigation purposes in the upstream catchment
  Sediment problems in the catchment
  Meulspruit Dam results in river largely being dry
  RWQO site to be situated upstream of the dam, perhaps at the Roosendal road bridge
- ***CSL2/5*** Moperi River
  Some irrigation in the catchment
  Sediment might be a problem
  Snap shot monitoring to determine if a RWQO site is really necessary
- ***CS3*** Caledon River at Maseru
  This RWQO site should be situated after Maseru to monitor the impacts
  A RWQO site should also be considered at Ladybrand
  Snap shot monitoring to determine if a second RWQO site is needed
- ***CSL2/6*** Leeuspruit at Hobhouse
  A number of large dams (Armenia, Newberry, Lovedale) for irrigation are situated in the upstream catchment
  Possible location of RWQO site is at the Hophouse Road bridge
- ***CS4*** Caledon River at Welbedacht Dam
  General water quality dam is good, although sediment a huge problem, hence move RWQO site above dam to Tienfontein pump station (abstraction point to Knellpoort Dam).
- ***CS5*** Caledon upstream of Gariep Dam
  Agreed to keep this RWQO site

Other relevant points discussed:

- Gariep Dam has three small rivers (Slykspruit, Suurbergspruit and Brakspruit) flowing directly into the dam. It was agreed that there's no need to have RWQO sites on them

- Vanderkloof Dam has two small rivers (Hondeblafrivier and Bergrivier) flowing directly into the dam. It was agreed that there's no need to have RWQO sites on them
- Sedimentation is a concern for the catchment, especially the Caledon River catchment (land use), ground formation and slope contributes to this problem (JB)
- The inclusion of additional RWQO sites can be considered to clearly establish what impacts are coming from Lesotho (JvW)
- Currently, no RWQO site is considered for the Sandspruit at Wepener as it's mostly dry. However, the point of discharge from Wepener STW should be established before a final decision is made.
- No RWQO site is currently considered for the Skulpspruit, tributary of the Caledon River that flows past Smithfield.
- Smaller tributaries should be included on the schematic diagramme even if no RWQO sites are situated on them

A table summarizing the RWQO site description, river name and number is attached as Annexure B. Annexure C presents the updated schematic diagramme indicating the RWQO sites.

5.2 Existing monitoring sites (MS)

- National monitoring point's data will be on WMS
- Regional Office monitoring points – data may exist but mostly not on WMS as it is with the Regional Office. RQS can assist with the updating if requested through the Director of RQS. A Diefenbach is currently acting director
- Regional Office (Danie Wagenaar, Cell 082 8048 051) has a template that can be used to enter data to be send to RQS for capturing. WQP to contact him to see what his concerns are (JB)
- Most of the regional points are for compliance monitoring, e.g. discharge of sewage treatment works (WG)
- MS generated a map showing the surface water points for the Upper Orange River system. This map includes all the monitoring sites for national and regional monitoring programmes that are registered. These monitoring points should be checked for data availability
- Other possible contacts for monitoring data are Dr Potgieter by (Department of Health, CSIRor CEM for Welbedacht Dam)
- The Regional Office is in the process to appoint an official to manage their WMS and data entry. Korien de Kock is currently responsible (JB)
- The frequency of the monitoring is important as the distances between the monitoring points in the catchment can have an influence, especially in the upper reaches of the catchment (JB)
- A committee is responsible for overseeing the water quality monitoring in Lesotho. JB has a contact name

5.3 Existing objectives

No previous objectives have been set for the Upper Orange River System (WG and GV).

5.4 Water uses/impacts

The main impacts are:

- Mainly irrigation impacts throughout the catchments
- Erosion (sedimentation) and suspended solids. Results are available from work conducted on the Modder and Riet Rivers
- Sewage treatment works discharges to the rivers have localized impacts. Most of these works are oxidation pond systems
- Impacts from industries in Lesotho, mainly from Maseru. The main impact is from the dying industries that discharge the waste water to the rivers
- Sedimentation in the Caledon River and upper reaches of the Orange River

5.5 Variables of concern

The main variables are:

- Nitrates and phosphates, especially the Gariep Dam area due to agricultural activities
- TDS, DSS throughout the catchment
- E coli, especially around Maseru and Ficksburg. Maybe also protozoan at some points

6. Snap-shot monitoring (JvW)

- WQP is in the process to appoint consultants and the study includes both the Upper and Lower Orange and a desktop study on the water quality of Lesotho
- Two sampling trips are planned, one high flow and one low flow sampling survey
- Chemical and algal sampling will be conducted. SASS (macro-invertebrate) would be an additional survey that might be included. This need to be discussed with the consultants when they are appointed.
- WG request his inclusion in the sampling surveys as he would like to do fish surveys (FAII) at selected sites
- The study will only provides an overview, without any high level of detail
- The outcomes of the study will be a proposed sampling programme, confirmation of variables of concern, future work, and what water quality data is available in Lesotho
- The study will be done in close liaison with the Regional Offices
- The first meeting to be in Bloemfontein and then to alternate between Bloemfontein and Kimberley

7. Visioning

The visioning process is important as this is translated into objectives for planning and management purposes.

It forms the basis of the CMS and also links to the National Water Resource Classification System (NWRCS).

No visions are available for the Upper Orange River System. The following should be considered when planning to undertake visioning:

- Possible future dam in the Kraai River catchment
- The number of visions (how many areas?). The management units as identified in the ISP documents can be used as a guide
- No existing forums. The current focus of the Regional Office is on the Vaal River System due to it having larger impacts. Catchment management committees are being used and not catchment forums. The Regional Office plan to initiate the institutional establishment of the CMA in 2009 (GV)
- Key role players are Bloemwater, district municipalities, water user associations, and irrigation boards. The Eastern Cape Regional Office in Cradock could also assist with the transfer Gariep Dam to Eastern Cape. Theo Geldenhuys as the contact person.
- Maps should be drawn up showing the visioning areas

The proposed areas for visioning are:

- Caledon River
- Upstream Gariep Dam, including the Kraai and Stormberge catchments
- Downstream Gariep Dam to Marksdrift

8. General

8.1 Samantha to share on her work on the Lower Orange River
SB is following a similar process in the Lower Orange and will document existing information.

8.2 Share on work in Lesotho
JvW to speak to Prof Roos to get water quality data from Lesotho. JB will provide contact person for Lesotho. Contact should be made with the committee responsible for the water quality monitoring in Lesotho. Peter Pyke might be the responsible official in DWAF.

8.3 Waste Discharge Charge System
Discuss at point 9 – way forward.

8.4 Monitoring standards and methods

- JB questioned the quality standards between laboratories as all should have the same standards (accredited). Standard procedures for collecting samples exist (MS)
- MS is investigating an efficient scheme for internal DWAF as RQS is overloaded
- The responsibility for the analysis of the samples taken during the snap shot monitoring should be discussed with the consultants to be appointed.
- RS to register a monitoring project with RQS if required
- The D: RQS requirements as being used in WMS should be used for numbering and naming of new monitoring points

9. Way Forward

The following should be addressed:

- The current internal DWAF initiative will identify stressed and priority areas
- The snap shot project will provide additional information for the identification of the priority areas

• Scenario analysis will be done as part of a larger study that may include economic modeling • The implications of the Waste Discharge Charge System requirements will be addressed as part of a larger study • The purpose of the above is to develop an integrated water quality management plan for the Orange River System
10. Next Meeting No meeting was scheduled as the meetings for the water quality assessment project (snap shot) will cater for this.
11. Closure Meeting JvW closed the meeting at 12h00

Annexure B

Summary table of proposed RWQO sites, Rivers and level

Summary of proposed RWQOs for Upper Orange River System

Code	River	Description
Orange River		
OS1	Orange	Upstream confluence with Kornetspruit
OS20	Orange	Downstream Sterkspruit confluence
OS2	Orange	Downstream Kraai confluence
OS3	Orange	Upstream Caledon confluence
OS4	Orange	Downstream Gariep Dam
OS5	Orange	Downstream Vanderkloof Dam
OS6	Orange	Marksdrift
OSL2/1	Kornetspruit	Kornetspruit
OSL2/2	Sterkspruit	Sterkspruit
OSL2/3	Kraai River	Kraai
OSL2/4	Stormberge River	Stormberge
OSL2/5	Seekoei River	Seekoei
Caledon River		
CS1	Caledon	Upstream Little Caledon confluence
CS2	Caledon	Caledon at Ficksburg
CS3	Caledon	Caledon at Maseru
CS4	Caledon	Caledon upstream Welbedaght Dam
CS5	Caledon	Caledon upstream Gariep Dam
CSL2/1	Little Caledon	Little Caledon at Golden Gate
CSL2/2	Little Caledon	Little Caledon at Oorlogspoort
CSL2/3	Grootspruit	Groot River at R26 road bridge
CSL2/4	Meulspruit	Above Meulspruit Dam
CSL2/5	Moperi River	At R26 road bridge
CSL2/6	Leeuspruit	At R26 road bridge at Hobhouse