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

Southern African Development Community

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Case of the Orange – Senqu River in Botswana

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A Framework for Monitoring Water Resource Quality in the Orange-Senqu River Basin

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Report No. ORASECOM 002/2010

Executive Summary

This report outlines a framework for water resource quality monitoring for ORASECOM that maintains appropriate sovereignty of the Member States, is consistent with the resource constraints in the Member States, and that recognises the commitment to cooperate and share skills and best practices.

In order to establish and maintain a regionally effective water quality management programme ORASECOM may choose to (a) provide support under the auspice of the current Technical Task Team, (b) designate an Implementing Agent, (c) employ consultants through the Secretariat, or (d) instigate the formation of a Task Team with specific responsibilities for monitoring, laboratory analysis, information and data management. The latter is recommended based on experiences in the Danube and Black Sea Commissions.

Taking into account the current financial and human resource constraints in the region, an initial monitoring network is proposed only for transboundary water management, which makes use of current national monitoring locations. Selection criteria for transboundary monitoring resulted in the identification of an initial list of 11 relevant surface monitoring locations, six in the Upper Orange-Senqu catchment with five in the Lower Orange catchment on the Namibian-South African border. Additional monitoring points in the Middle Vaal system may be added as the monitoring network develops.

An initial set of priority monitoring variables has been identified for each of the proposed monitoring stations. Their selection is based on existing data and knowledge, known pollution sources and the sensitivity of specific water users.

Initial Trigger Values (TVs) for each of these variables are proposed for each monitoring location. Exceeding these trigger values would initiate recommendations from ORASECOM proposing more detailed investigations either on a bilateral basis or by one of the Member States. However, the value of the final TV and priority monitoring variables will need to be agreed on a bilateral or multilateral basis for each sampling station based on the current status, historical trend and level of protection required by the Member States. This will be taken further under the gtz (?) support to ORASECOM.

The basis for a transboundary groundwater monitoring programme (as part of the regional monitoring programme) is suggested for the four main transboundary aquifers. A proposal is made for qualitative and quantitative monitoring. A decision is required from the Member States in relation to the location of monitoring boreholes for use in the regional monitoring network.

Without an appropriate QA/QC system in place, any attempt to perform monitoring on a transboundary level may result in a lack of trust between the Member States arising from a lack of traceability of data, and a lack of harmonization of procedures applied by the laboratories (from the sampling to data capture). Therefore, the basis for an effective regional analytical quality control is outlined. This includes the introduction of (i) analytical accuracy targets for monitoring the quality of water, and (ii) a performance-testing scheme, which can be established and implemented as the primary inter-laboratory quality control program in the Orange-Senqu River Basin, with the participation of the laboratories involved in future transboundary water quality monitoring.

National Information Managers (NIMs) are proposed in order to take responsibly for collection of the data from designated Member State laboratories and transmitting these to the Secretariat. NIMs may take responsible for data checking, preparation in an agreed data exchange file format (DEFF) ready for sending to a Central Point. Storage of monitoring data is proposed under the auspice of the South African DWA in their Water Management System Water Quality Database extending the datasets to include data from Botswana (groundwater only), Lesotho and Namibia. It is anticipated that an assessment of the data, highlighting the status of the Orange-Senqu River Basin in respect to water quality, would be presented by ORASECOM to the Member States on an annual basis.

In order to agree the appropriate development of a regional framework for water quality management, a separate questionnaire, which accompanies this report, has been provided to

identify preferences relating to the above issues, namely:

- Options for organisational arrangements
- Options for a Monitoring Network (surface water and groundwaters)
- The selection of monitoring variables for the water quality monitoring network
- Options for the introduction of a QA/QC system
- Options of the use of Trigger Values as a management tool for ORASECOM
- Options for data management

The responses will be collated during early 2010 and incorporated into the final draft of this report. This will represent the framework which will be developed further under gtz (?) support. .

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List of Abbreviations

ANZECC	Australian and New Zealand Environment Conservation Council
AQC	Analytical Quality Control
Chl-*a*	Chlorophyll *a*
DEFF	Data Exchange File Format
DIN	Dissolved Inorganic Nitrogen
DWA - L	Department of Water Affairs, Lesotho
DWA - SA	Department of Water Affairs, South Africa
E-coli	Escherichia coli
EU	European Union
GEF	Global Environment Facility
IA	Implementing Agency
GTZ/gtz	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (German society for technical cooperation)
ICPDR	International Commission for the Protection of the Danube River
IWRM	Integrated Water Resources Management
LOD	Limit of Detection
MAWF	Ministry of Agriculture, Water and Forestry, Namibia
NIMs	National Information Managers
NO3-N	Nitrate Nitrogen
NO2-N	Nitrite Nitrogen
ORASECOM	Orange-Senqu River Basin Commission
PAH	Polyaromatic Hydrocarbons
PCB	Polychlorinated biphenyls
PO4-P	Orthophosphate Phosphorus
POPs	Persistent Organic Pollutants
pTDA	Preliminary Transboundary Diagnostic Analysis
QA/QC	Quality Assurance/Quality Control
RWQOs	Resource Water Quality Objectives
SADC	Southern African Development Community
SOP	Standard Operating Procedure
TDA	Transboundary Diagnostic Analysis
TDS	Total Dissolved Solids
TN	Total Nitrogen
TNMN	Transnational Monitoring Network
TP	Total Phosphorus
TTT	Technical Task Team
UNDP	United Nation Development Programme
UNECE	United Nations Economic Commission for Europe

1. Background

1.1 Brief Description of the Orange-Senqu River Basin

The Orange-Senqu River Basin's areal extent is approximately 1 000 000 km^2, with 60% of the catchment area in South Africa, 25% within Namibia, 11% within Botswana and only 4% in Lesotho. The River originates in the Drakensberg mountain range in Lesotho and stretches over 2 200 km westwards to the South Atlantic Ocean. The main tributaries of the Orange-Senqu River Basin are the Caledon, Kraal, Fish and Vaal Rivers. The Basin also receives water from the Hartbees and Fish Rivers; although these Rivers run dry during several months of the year.

The River Basin is characterised by extremely variable rainfalls, ranging from around 2 000 mm per year in the Lesotho Highlands to 50 mm per year - and thus extremely arid climatic conditions - near its mouth, with an average annual potential evaporation of approx. 1 100 mm in the Lesotho Highlands to over 3 000 mm in lower areas of the Basin. The climatic variability within the Orange-Senqu River Basin causes major differences in the distribution of natural runoff and recharge within the Member States. For example, Botswana does not actually contribute to surface runoff in the River Basin via the Molopo tributary. Meanwhile Lesotho, which consists of only 4% of the Basin area, contributes approximately 45% of runoff. South Africa dominates the Basin in terms of land area and runoff contribution. Namibia contributes about 4% to total surface runoff, and faces a relative scarcity of water resources.

The waters of the Orange-Senqu River Basin serve people for many purposes – drinking water, use for industrial and agricultural activities, power generation and recreation. Irrigation dominates water use with 58%, contrasting with the 9% that goes towards environmental demands and the 4% provided to urban and industrial use. The remaining 27% is accounted for by river losses, while a further 2% is lost in water distribution systems.

The effective management of the Orange-Senqu River Basin is, therefore, particularly complex, but is also vital to the economy of the region. As a result, the riparian States prioritised this Basin for the establishment of a Shared Watercourse Institution under the revised Southern African Development Community (SADC) Protocol for Shared Watercourses. ORASECOM was one of the first of the joint Basin commissions to be established under the revised SADC Shared Watercourses Protocol.

ORASECOM is an advisory body, issuing recommendations to its Member States (The Parties) aimed at optimising the development and management of the water resources of the Orange-Senqu River Basin for the benefit of all the people in the Basin States.

1.2 Transboundary Water Issues

Availability of water, and hence water allocation is commonly regarded as the main transboundary issue in the region. For example, in the northern part of South Africa, both surface and groundwater resources are nearly fully developed and utilised. Growing industrialisation and urbanisation, as well as population growth, will undoubtedly place further demands on water resources. In contrast, Namibia has a high level of water stress due mostly to its arid climate. Plans are currently under discussion for an increase in water supply from the lower Orange River to southern Namibia through a new water reservoir, which would give the country increased assurance of supply for developments in agriculture and industrial uses. Botswana faces a situation of water resources under high levels of stress. The main transboundary issue for Lesotho, though, and one that is also very important for the other riparian countries, relates to the amount of water it sells to its neighbours.

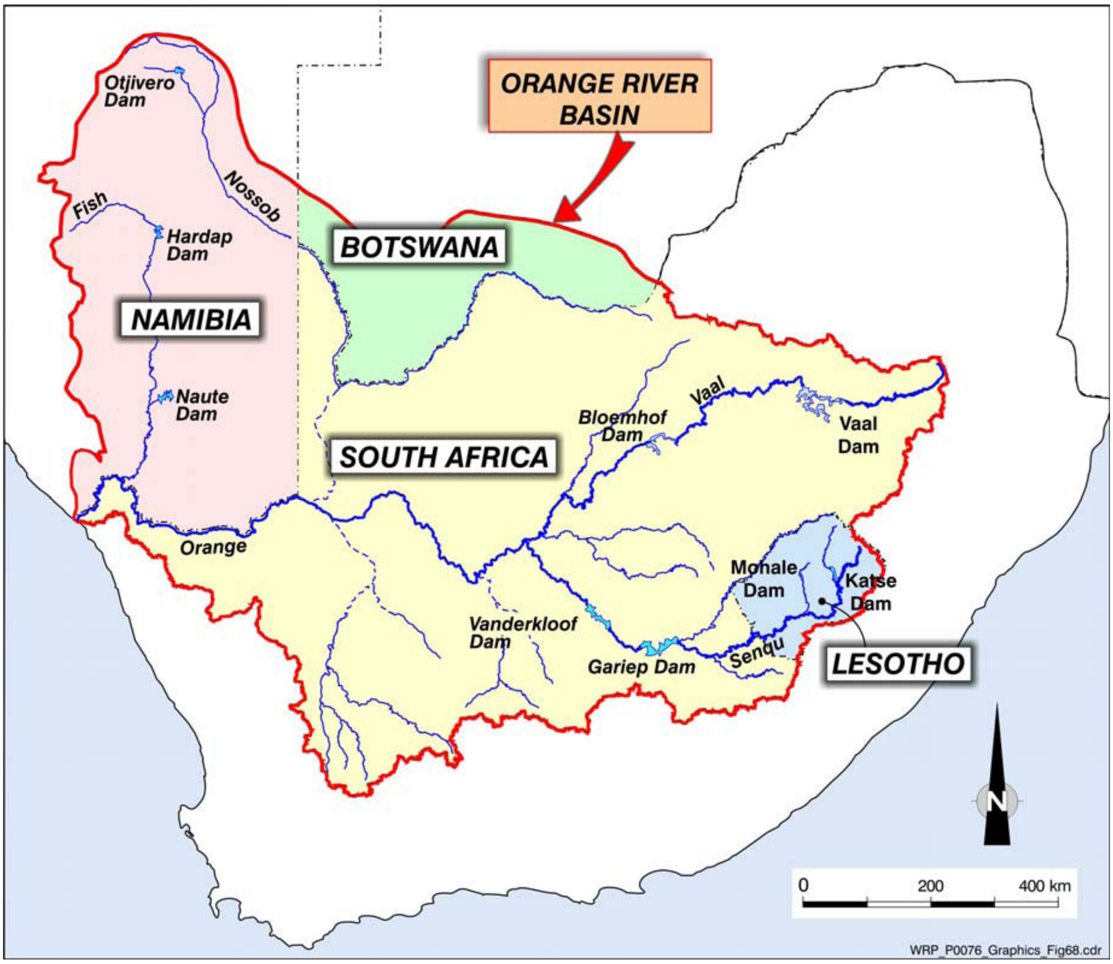


Figure 1.1 Map of the Orange-Senqu River Basin

The Orange-Senqu River Basin is considered to be one of the most developed River systems in Africa; much of this development has been to support growing demands in South Africa. Developments include a series of complex inter-basin transfer schemes, mainly for to thermal power generation and urban use in the Gauteng area. The most well known of these projects is the Lesotho Highlands Water Project, which transfers water within the Orange-Senqu River Basin between Lesotho and South Africa.

Droughts are an important issue for all countries within the Basin. In spite of the relatively high amount of rainfall, droughts and land degradation are also an issue for Lesotho, especially in the southern districts of the country. Botswana and Namibia are, due to their water resources stress, clearly very vulnerable to droughts; Namibia, due to its downstream riparian status, is especially vulnerable.

A recent study (Preliminary Transboundary Diagnostic Analysis - pTDA) concluded that the following water quality issues were of high importance:

- There are concerns along all the Rivers which flow through towns and villages throughout the catchment regarding localized microbiological pollution from untreated and partially treated sewage entering the Rivers;
- The Vaal catchment is highly polluted which has implications for water resource availability and transboundary impacts. The water quality of the Upper and Lower Orange River is said to be good; however there are insufficient data for certain categories of contaminants to make any conclusive statements.
- The increase in Total Dissolved Solids (TDS) in the Vaal and Lower Orange catchments (due to natural and evaporative concentration) and the concomitant increase in constituents such as chloride and sulphate, has had major implications for domestic, industrial and agricultural water use;

- Eutrophication is a severe problem in the Vaal catchment and in isolated pockets in other parts of the Basin.
- The transboundary impacts of POPs, heavy metals and radio-nuclides are unknown due to a lack of monitoring data and detailed studies, but some level of transboundary transfer of these pollutants is suspected;

The pTDA indicated that some of the most significant water quality problems in the Basin might not, as yet, be transboundary in nature. Nevertheless, the TDA has recommended that Resource Water Quality Objectives (RWQOs) be established for the Basin, drawing on the South African experience in this regard. The pTDA also recommended a water quality assessment of the major aquifers in the Basin. In this latter case, there are concerns regarding the quality of groundwater resources and their protection, however there are insufficient data to make any conclusive statements in this regard.

In the transboundary sense, the Member States (each accountable to their own stakeholders) have agreed to jointly and individually manage the resource. International Water Law places an obligation on these States to share information 'where this may lead to transboundary significant harm'. International Water Law also recognises the unity of the environment, and the joint responsibility this imposes on all watercourse States.

Objective setting for transboundary organisations may therefore be limited to objectives assessing transboundary harm, or those that measure progress towards implementing joint management actions, or may assess impacts on the environment as a whole. These may be a sub-set or even supplementary to national objectives each Member State may set with its stakeholders. Transboundary objectives may therefore differ from the national standards.

However, this perspective is somewhat complicated in the ORASECOM setting. The ORASECOM Agreement drops the 'significant harm' out of the provision, which allows Council to make recommendations on the management of pollution, and includes the idea of joint monitoring programmes (which are not required in most International Water Law instruments). So it is somewhat of a moot point as to whether ORASECOM can develop water quality and aquatic environmental objectives (referred to here as Resource Water Quality Objectives or RWQOs) that are aligned with and established in the same way national objectives are, or whether they should be limited to the transboundary issues.

This assignment aims therefore to develop a framework together with ORASECOM within which Council can make recommendations for managing water quality and water environmental issues.

1.3 Objectives of this Study

According to the Terms of Reference, the following specific Results are expected from the Assignment:

- **An assessment of the previous studies**, which must include an analysis of the existing water quality work undertaken by ORASECOM, and in particular the water and environmental components of the TDA and the work done under Phase I of the GTZ support.

- **The development a framework for ORASECOM to provide recommendations to address water resource quality concerns**. This Activity will support ORASECOM to develop approaches to water resources quality management that; maintain appropriate sovereignty of the Member States, are consistent with the resource constraints in the Member States, and that recognise the commitment to cooperate and share skills and best practices. It will aim at producing a vision and supporting framework for how the organisation wishes to address water resource quality management.

- **The development of water resource quality objectives.** This Activity will therefore aim at two issues; firstly, discussing with ORASECOM what are the most appropriate form of management objective for its needs. Secondly, to introduce management objectives for key water resource quality concerns in the Basin based on the experience of South Africa's Department of Water Affairs (DWA).

2. An Assessment of Previous Studies

2.1 International Experience in Transboundary Water Quality Monitoring

As a backdrop to the development of a framework for water quality management in the Orange-Senqu River basin, a comparison is made to the lessons learned for water quality management of European Rivers. Three main questions have been addressed in a comparative study for 10 important transboundary Rivers in Europe on aspects of monitoring and assessment conducted by the International Centre of Water Studies in the Netherlands (of which the short-term expert was a part) on behalf of the Institute for Inland Water Management and Waste Water Treatment (RIZA):

- What are the main problems/issues and what is monitored?
- Which criteria for environmental quality assessment are applied at country level; what are the differences between countries and does this lead to different interpretation of environmental quality of the River?
- What is the environmental quality of the River?

The following 10 Rivers were included in the study during 2001: Rhine, Meuse, Tagus, Elbe, Oder, Danube, Morava, Tisza, Dvina and Bug. The 10 Rivers were selected on the basis of criteria such as: Rivers having an international River Commission Secretariat, major Rivers from the viewpoint of the size of the River, regionally spread over Europe. The following key recommendations arose;

- The broad framework approach of the European Water Framework Directive, in combination with the more detailed recommendations of the UNECE Guidelines on transboundary monitoring and assessment provide a solid basis for international co-operation in water management, with an emphasis on the aspects of water monitoring and assessment. The Water Framework Directive contains one universal list of standards but allows Basin-specific differentiation by choice of desired ecological status. The UNECE Guidelines emphasise that the approach has to be tailor-made to the specific needs of the different River Basin management.
- For all of the 10 international Rivers included in the study, international co-operation exists in the form of an international River Commission and, in, the case of Bug and Daugava, specific international agreements. Throughout, the first activities of such commissions are the establishment of monitoring programmes and early-warning systems.
- The international River Commissions study the different issues per water system (different types of pollution, available water, morphology and ecology), as a basis for the monitoring proposed.
- At the time of the study the economic situation in many of the countries was improving. This economic growth resulted in the introduction of new industrial activities and complexes. Therefore, this was a time to ensure that production methods and processes were developed and implemented with the least danger or impact for the aquatic ecosystems. One important criterion for the effectiveness of such a development was a strict policy on legislation and enforcing of effluent permits. Such developments can be stimulated and facilitated by international co-operation.
- The methods used for the assessment of chemical water quality differed between the 10 River Basins in the use of parameters, the standards and the calculation methods. The differences between the standards used in the River Commissions studied differed in some cases by a factor 10 or more from very strict (Germany, Czech Republic, Slovak Republic) to very loose (Walloon).
- The study clearly demonstrated that an international comparison of water quality data should be carried out with the utmost prudence. Differences in geomorphologic conditions, natural background, location of sampling points, monitoring techniques and assessment methods may easily lead to mistaken conclusions.
- A common problem for all European Rivers is the risk of eutrophication of receiving waters (such as estuaries, enclosed seas, lakes and reservoirs) by high levels of

nitrogen and phosphorous. The problem was evident in all River Basins studied. This problem also has a negative impact on the number of species in the ecosystem.
- Pollution by heavy industry and mining was known to be decreasing (heavy metals, oil, PAH, PCB), which was effected by economic reasons rather than environmental measures. However 'new' toxic substances, such as the polar pesticides and dioxins are known to have high environmental impacts. Due to a lack of information it proved difficult to make an overall assessment of the environmental hazards due to these new pollutants.
- Experience in many of the River Basins studied showed that that hydro-morphological barriers and boundaries have a much greater impact on ecological potencies than water quality issues.
- When assessing the ecological status of River Basins, the impact of invading species had not been fully incorporated. Considering the increasing connection of international waterways this topic will be of growing importance.

2.2 Water Quality Monitoring in the Orange-Senqu River Basin

A summary of the present status of water quality monitoring in the Orange-Senqu River Basin was recently carried out by the UNDP/GEF in their preliminary Transboundary Diagnostic Analysis (pTDA). The findings of this study are summarised below:

Monitoring Networks and Databases:
- Water quality monitoring networks are poorly developed in Lesotho and Namibia. Analyses are confined to basic parameters such as pH, TDS and common anions and cations. Microbiological analysis is carried out in Lesotho;
- South Africa has a sophisticated and extensive monitoring system although there are a number of deficiencies in the data sets available, particularly along the Lower Orange River.

Water Quality in the Vaal Catchment:
- The usage of water in the Vaal River is impacted by high levels of salinity and related macro ions, which has major implications for domestic, industrial and agricultural water use;
- Eutrophication is a key issue in the Vaal River resulting in algal blooms and growth of water hyacinth;
- Microbiological pollution is an emerging concern;
- While the upper part of the Vaal catchment has water of a good quality, the areas of concern include the Vaal Barrage and Lower Vaal River downstream of Harts River confluence;
- Elevated TDS concentrations are a concern for users downstream of the Vaal Barrage.

Water Quality in the Upper Orange River Catchment:
- Water in the main stem of the Senqu River in Lesotho (called the Orange River in South Africa) is generally of good quality although turbidity is increasing due to agricultural activities;
- Eutrophication and microbial pollution are the primary water quality issues, which have been caused by rapid demographic change to the Lesotho Lowlands coupled with inadequate sewage infrastructure.

Water Quality in the Lower Orange River Catchment:
- Water quality between Boegoeberg and Onseepkans is generally good despite extensive irrigation and settlements in the Upington area;
- Eutrophication is evident in localised areas along the River stretch
- Water quality downstream of Onseepkans remains good although salinity increases are observed towards the mouth of the River due to increasing aridity, evaporation and tidal influences.
- The flushing of salts that are built up in the soils may occur during high flows.

Transboundary Impacts

- The main pollution sources in the Orange-Senqu River Basin lie in the Vaal catchment (salinity, eutrophication, acid mine drainage, heavy metals) which is effectively operated as a closed loop meaning that the potential of pollution from the heartland of South Africa to Namibia would appear, on the surface at least, relatively low. However, the major irrigation areas of the Vaal-Haarts scheme and the Sand-Vet catchment are holding up significant quantities of salts, which may be released downstream in the future as soon as the assimilative capacity of the soils is reached;
- The movement of heavy metals and persistent organic pollutants (POPs) and their potential threat to the water users throughout the River Basin is not known. This issue will be further studied in a future UNDP/GEF programme;
- Localised eutrophication and microbial pollution is known along the Caledon River, along the Orange River downstream of Lesotho and downstream of the Upington irrigation area to Namibia. However, there is insufficient information to determine the transboundary extent of this pollution.

2.3 The Role of ORASECOM in Regional Water Quality Monitoring

One of the first River Basin institutions in the region, and the first to be established with reference to the Revised SADC Protocol on Shared Watercourses, was the Orange-Senqu River Basin Commission (ORASECOM), in the year 2000. The four countries in which the Orange-Senqu River Basin lies are equal members of the Commission.

The Commission is an international organisation with international and national legal personality, empowered to serve as the technical advisor to the Parties on matters relating to the development, utilisation and conservation of the water resources of the Orange-Senqu River Watercourse System. It “shall also perform such other functions pertaining to the development and utilisation of the water resources as the Parties may agree to assign to the Commission”.

The parties have obligations to share data and information under the Revived SADC Protocol while Art. 5.2.5 of the ORASECOM Agreement indicates that ORASECOM could make recommendations on standard forms of data and information collection and dissemination. In the Agreement, the parties commit to regular data exchange and advance notification of any project, programme or activity that would influence the watercourse system and have significant detrimental effects on one or more of the parties. There is also a commitment to the joint protection of the watercourse system. The Commission is seen by the Parties as “an important forum to discuss water matters of mutual interest at a technical level”, and “has a duty to advise the respective Governments accordingly about the perceived best technical solution and to what extent the Commission is in agreement about the way forward“.

The Commission may execute feasibility studies to enable it to recommend technical solutions based on hard facts. No agreement or a possible conflict of national interests places the issue back within the political level for further negotiations or final approval; this ensures the technical solutions proposed will be based on facts and not on political perception or influence. Conflicting situations, which cannot be solved in this manner, are to be taken up by the SADC Tribunal, whose decision on the matter will be recognised as “final and binding”.

The ORASECOM Agreement refers to and recognises the Helsinki Rules, the 1997 UN Convention and the Revised SADC Protocol. It does not replace previous bilateral agreements, nor does it exclude the possibility of further bilateral agreements, but future agreements have to comply with ORASECOM.

The current EU support to ORASECOM is founded on strengthening the organisation’s capacity to develop ‘implementable’ recommendations to Parties. ‘Implementable’ recommendations are those that Member States can and will implement (albeit sometimes with financial support). Many of the pollution problems in the Basin are, nevertheless, already known to the Member States, as are potential solutions to these problems. However, the solutions to some of these problems often remain intractable and expensive. In other cases, particularly with respect to pollution from urban centres, solutions to the problem may involve interaction between different spheres of government, or may be influenced by the balance the State wishes to find between protection and use of the water resource – including the use of the water resource to carry waste.

This raises a number of issues that must underlie a framework for ORASECOM to provide realistic and 'implementable' recommendations on water resource quality issues. Some of the questions that have to be explored in discussions with the Member States include:

Institutional/Organisational Issues:

a. What function/role do you perceive ORASECOM to hold in relation to monitoring and information management concerning water quality issues?
b. What national and regional institutional arrangements would you propose in order to implement an effective system of water management with respect to water quality targets/objectives?

Development of Transboundary RWQOs:

a. What are the key transboundary issues you wish to see addressed by the establishment of water quality objectives? What do you regard as the driving forces of transboundary issues?
b. Would you envisage the development of narrative water quality objectives in the short-term with numeric values in the longer term?
c. Do you wish to see ORASECOM's responsibility extending into the marine receiving/transitional waters with the development of specific water quality objectives?
d. Do you wish to establish short and medium term emission targets in order to meet the proposed water quality objectives in the receiving water?
e. How is water quality assessment of major aquifers carried out? Do you perceive the need for the implementation of groundwater quality objectives?
f. Do you wish to have water quality objectives set for sub-Basin confluence points in addition to border areas? Which key points at border areas would you wish to see sampling/monitoring activities increased?

Monitoring:

a. Do you perceive any relationship between your national monitoring programme and a programme of monitoring which would be designed specifically to address transboundary issues?
b. Are your national laboratories accredited by national or international schemes? How would you respond to the involvement in ORASECOM in issues related to data quality?

Reporting/Data Handling:

a. How do you envisage the process for reporting and management of data for transboundary monitoring of water quality?
b. What would you expect ORASECOM's role would be in data management and reporting on defined and agreed water quality objectives?

Answers by the Member States to the questions above are provided in Annex 1. The information is provided the basis for the development options of a framework for ORASECOM to identify the key issues and, where possible, provide suitable recommendations to address issues related to regional water quality monitoring and the development of quality objectives.

3 The development of a framework for water resource quality monitoring in ORASECOM

3.1 Basic Requirements

The first steps towards joint water quality monitoring in Orange-Senqu River Basin were taken when the governments of the Member States signed the ORASECOM Agreement.

The process of assessing international water quality concerns is an evaluation of the physico-chemical and biological status of waters based on the results collected in the framework (?) of a set time period with the following main assessment objectives:

- Checking of compliance with water quality objective/target values expressed by joint classification agreed by the Member States;
- Identification of water quality changes within the Orange-Senqu River Basin;
- Detection of trends in water quality (loads and concentration);
- Assessment of dangerous/priority substances content in water

For the successful future development of an international water monitoring network in the Orange-Senqu River Basin, it is necessary that the following criteria are satisfied:

- Capable of supporting reliable and consistent trend analysis for concentrations and loads for priority pollutants at key points in the basin;
- Supports the assessment of water quality for water use (surface and ground waters) with respect to the possible impacts of transboundary pollution on the fitness for use;
- Assists in the identification of major pollution sources that may be transboundary in nature;
- Includes quality control.

The implementation of an international monitoring network can be simplified for operation in an initial phase, which is envisaged as a period with:

- The operation of a limited number of stations with defined objectives (mostly) already included in national monitoring networks;
- A determinant list reflecting the major pollution issues;
- An information management system (?) based on a simple data exchange file format between the countries.

When complete data sets from operation of a simplified (initial) water quality monitoring system are processed, these data may be used for an annual evaluation of water quality set against agreed objectives or trigger values. Furthermore, results obtained from such a monitoring network must not been seen (or developed) as a self-standing activity, but should be seen in a broader context to recognise the needs for network improvements. On one hand, when data from initial operations are evaluated, they will provide an identification of possible weak points in the monitoring programme and the suggestions for future improvement. On the other hand the improvement of such a network will have to be strongly connected to continuous implementation of the Basin Wide Plan.

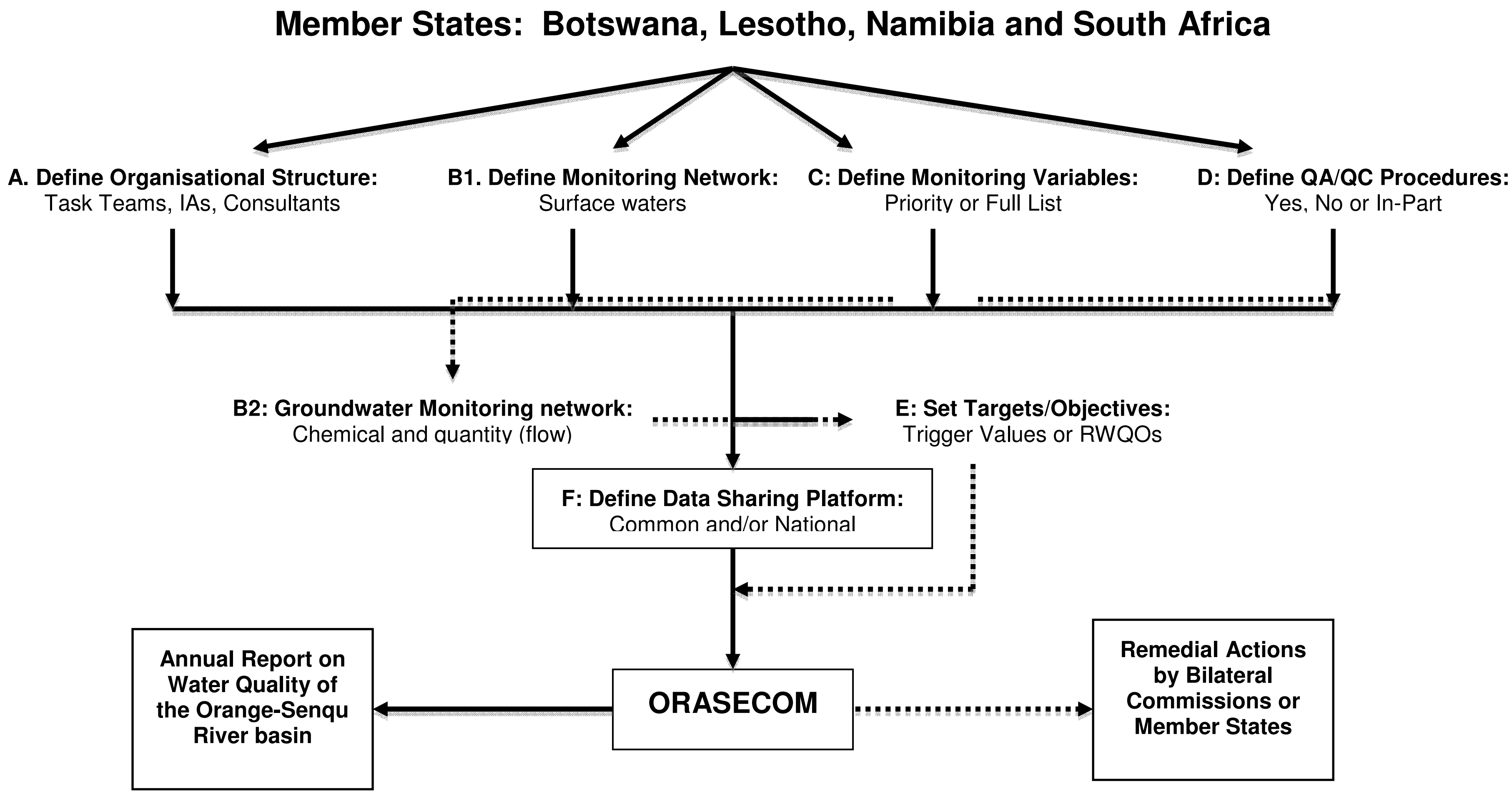
Currently, all of the Member States have operational monitoring programmes, albeit at differing complexities. The most advanced monitoring is carried out by South Africa. All data sets for stations monitored in South African territory are openly available via databases held in the DWA, which may be visualised using Google Earth. All other member States have functioning databases, or are in the process of developing suitable databases for storage of water quality monitoring information.

The primary questions to be considered in relation to the development of a framework for monitoring and evaluation of regional water quality data (and related data) may include the following:

- Are the current regional institutional structures sufficient to effectively manage a regional water quality monitoring programme?
- Do the Member States wish to share all of their current and future monitoring data or just specific data sets relating to, for instance potential, transboundary problems (cross border)?
- Do the Member States insist on common methodologies being applied to the sampling procedures, analysis of samples and storage of data?
- Do the Member States insist on the provision of QA/QC procedures for the monitoring and assessment procedures, i.e. in order to have trust in one another's data?

Figure 3.1 below provides a schematic representation of the options open to the Member States in relation to the development of a framework for managing water resource quality and developing appropriate objectives to prevent future pollution in the Orange-Senqu River Basin.

Figure 3.1 **Schematic Representation of Options for the Development of a Framework for Managing Water Resource Quality and Developing Appropriate Objectives for the Orange-Senqu River Basin**



3.2 Options for Organisational Arrangements

In order to establish a regionally effective water quality monitoring and quality assurance system, which is capable of supporting regional water management decisions, it is important to define the body that will be responsible for organising and managing water quality monitoring and assessment in the region. The following organisational options exist as shown in Decision Box A below:

Decision Box A: Organisational Options

1) Provide support under the auspice of the current Technical Task Team, i.e. adding experts from the region as required;
2) Using Implementing Agents (IA), e.g. where a University becomes the IA for monitoring and assessment;
3) ORASECOM may employ consultants to carry out all procedures for monitoring and assessment;
4) The formation of a Task Team with specific responsibilities for monitoring, laboratory analysis, information and data management. Such a team may be developed initially as a Project Steering Committee which co-opts specialist as and when required. In the longer term, following the finalisation of projects, this group of regional experts may be formed into a full Task Team.

The current institutional set-up in ORASECOM includes two Working Groups relevant to this current assignment – the Technical Task Team and the Hydrogeological Task Team. It is important to note that the Task Team may include members with appropriate skills as required, which may include knowledge of water quality issues. However, such an approach may place a further unacceptable burden on the Technical Task Team.

The use of IAs to organise a regional programme of water quality monitoring and assessment may place a distinct financial burden on the Member States, although this approach is used within SADC and financial mechanisms could be put in place to carry out such arrangements via the 'Conservation Fund".

The engagement of independent consultants to carry out the monitoring and assessment would undoubtedly be expensive and not provide any learned experience to the Member States in the future. However, this approach may be an interim measure whereby the Member States could take-over as soon as they have the capacity to do so effectively.

If the institutional structure of ORASECOM was widened to include a Monitoring, Laboratory, Information and Data Management Task Team, this also may be regarded as an addition burden on the over-stretched human and financial resources. However, the development of such a Task Team in the region would be of particular importance for the future harmonization of the sampling and analytical methods for use in the proposed monitoring network. The operation of such a Task Team is envisaged to be complimented by the addition of ad-hoc sub-groups (Working Groups) when necessary, which may include those for surface waters, groundwater, chemical monitoring, biological monitoring, sampling, laboratory methodologies, data management and assessment.

The Member States are asked to indicate their preference for arrangements for organising and managing water quality monitoring and assessment in the region, in relation to Decision Box A, for either Points 1, 2, 3 or 4.

3.3 Options for a Monitoring Network

An effective water quality monitoring network for the Orange-Senqu River basin should build on the current national monitoring networks. There are three main options that exist for the development of such a monitoring network, as shown below in Decision Box B:

Decision Box B: Surface Monitoring Network Options

1) Transboundary network, where Member States protect their own rights by establishing monitoring programmes to ensure significant harm does not occur from upstream nations, i.e. selection of monitoring stations (i) just upstream and/or downstream of along a shared international border, and (ii) upstream of confluences between the main River and main tributaries which arise from an upstream country.
2) Joint River basin network, where nations agree to cooperate and share data for the river basin as a whole; i.e. monitoring stations where Member States agree on standard sampling and analysis protocols as well as trigger values,
3) National networks: Data provided from selected country stations from their current national monitoring network, i.e. no change from present situation.

A transboundary monitoring network may, in its simplest state, only require identification of two main criteria for selection of key monitoring points: (Criterion 1) upstream, downstream or along a shared international border and, (Criterion 2) upstream of major confluences which are thought to impact the main river close to a border. Furthermore, the variables, which may be monitored, will likely be focussed on key pollutants (see Section 3.4)

In contrast, a joint river basin monitoring network is in essence the implementation of a monitoring network that is based on standard protocols and agreed responses. It may initially only focus on potential transboundary problems (Criterion 3), but may be expanded to include all known key pollution sources and impact points in the river basin (Criterion 4)..The following is a list of typical monitoring objectives that might be used as the basis for design of a sampling network at the river basin level (as opposed to just undertaking transboundary monitoring). The list below is not intended to be exhaustive, merely to provide some examples:

- Identification of baseline conditions in the water-course system,
- Detection of any signs of deterioration in water quality,
- Identification of any water bodies in the water-course system that do not meet the desired water quality standards,
- Identification of any contaminated or impacted areas,
- Determination of the extent and effects of specific waste discharges,
- Estimation of the pollution load carried by a water-course system or subsystem,

The third option lies where all the data from national monitoring programmes is shared on a common platform, but that there are no attempts to agree standard protocols and/or objectives and responses.

Article 5.2.5 of the ORASECOM Agreement suggests that the Parties intended to develop a joint river basin monitoring network. This need not exclude the sharing of all other data from the basin, nor does it necessarily mean that all monitoring in the shared basin is initially done according to agreed protocols.

As a starting point for the selection of monitoring stations, therefore, Table 3.1 lists the current stations (all within the South African territory of the River Basin) in relation to the both sets of criteria for the development of an initial joint river basin monitoring network for water quality. Selection criteria (1, 2 3 and/or 4 outlined above) resulted in the identification of an initial list of 11 transboundary surface monitoring locations, which are individually described below:

Table 3.1 Potential Joint River Basin Water Quality Monitoring Stations

Monitoring Stations[1]		Transboundary Criteria	River Basin Level Criteria
Upper Orange-Senqu			
New Site	Caledon River at confluence with little Caledon	√ Criteria 1,2	√ Criteria 1,2,3
D2H012	Little Caledon River at the Poplars	√ Criteria 1,2	√ Criteria 1,2
D2H035	Caledon River at Ficksburg	√ Criteria 1,2	√ Criteria 1,2,3
D2H011	Caledon River at Maseru	√ Criteria 1,2	√ Criteria 1,2,3
D2H001	Caledon River at Tienfontein	X	√ Criteria 1,3
D2H036	Caledon River at Kommissiedrift	X	√ Criteria 2
D1H006	Kornetspruit at Maghaleen	√ Criteria 1,2	√ Criteria 1,2
D1H009	Orange River at Oranjedraai	√ Criteria 1,2	√ Criteria 1,2,3
D1H011	Kraai River at Roodewal	X	√ Criteria 2
D1H003	Orange River at Aliwal North	X	√ Criteria 2,3
D1H001	Stormbergspruit at Burgersdorp	X	√ Criteria 2
D3R002	Orange River at Gariep Dam	X	√ Criteria 2
D3H013	Orange River at Roodepoort	X	√ Criteria 2,3
D3H015	Seekoei at De Eerste Poort	X	√ Criteria 2
D3R003	Vanderkloof dam	X	√ Criteria 3
D3H012	Orange River at Dooren Kuilen	X	√ Criteria 3
D3H008	Orange River at Marksdrift	X	√ Criteria 2
Lower Orange			
New Site	Vaal River at Douglas Bridge	√ Criteria 2[2]	√ Criteria 2,3
D7H012	Orange River at Irene	X	√ Criteria 1,3
D7H002	Orange River at Prieska	X	√ Criteria 1,3
D7H008	Orange River at Boegoeberg	X	√ Criteria 1,3
D7H005	Orange River at Upington Water Works	X	√ Criteria 1,3,4
D7H004	Orange River at Kanon Island	X	√ Criteria 1
D7H016	Orange River at Neusberg	X	√ Criteria 1
D8H008	Orange River at Pella Mission	√ Criteria 1	√ Criteria 1
D8H003	Orange River at Vioolsdrift	√ Criteria 1	√ Criteria 1
New Site	Orange River at Sendelingsdrift	√ Criteria 1,2	√ Criteria 1
D8H012	Orange River at Alexander Bay	√ Criteria 1	√ Criteria 1

[1] Monitoring stations according to DWAF's Water Management System coding
[2] Monitoring station included to provide a measure of the influence of the Vaal system on the Lower Orange River

[Most of the above sites are already on the Priority NCMP list as well as GEMS in some cases. The following sites aren't:

Upper Orange:

New Site at Caledon River Confluence – already covered by D2H012 →D2H035 →D2H037 →D2R004 →D2H036.

D2H011 – no samples since early 1994. We use D2H035 which is upstream and D2H037 which is downstream (our international obligation site)

D2H001 – not on our list because it was last sampled thoroughly in 1977 with one single sample in 1984.

D3R003 not on our list because focussed predominantly on rivers with dams only occasionally.

Lower Orange:

New Site on Vaal River at Douglas Bridge – we use C9H024 Vaal River at Schmidsdrift which is also a GEMS site.

D7H004 – last sampled briefly in 1988. On our list it is covered by D7H005 and D7H014 downstream.

New Site at Sendelingsdrift not on our list.

.

These monitoring stations have been limited to those deemed important in relation to transboundary problems in the basin,, and are a starting point in the development of a more comprehensive water quality monitoring network . The choice of the above 11 transboundary monitoring stations for inclusion in a transboundary network is further justified in Table 3.2.

Table 3.2 Justifications for Proposed Transboundary Water Quality Monitoring Stations

Station No.	Location	Justification for Inclusion in the Network
1	Caledon River at confluence with little Caledon (Lesotho – South Africa)	This is a proposed new site, which will provide information as to impacts upstream of the confluence from both Lesotho and SA.
2	Little Caledon River at the Poplars (Lesotho – South Africa)	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. Diatom scores indicate poor quality and a significant organic impact.
3	Caledon River at Ficksburg (Lesotho – South Africa)	This site will monitor Lesotho's impacts to the Caledon from industrialactivities The historical data set at Ficksburg Bridge started in 1994 and is still active with a monthly monitoring frequency. Good flow measurements since 1992 are available.
4	Caledon River at Maseru (Lesotho – South Africa)	There is a monitoring site at Maseru, Lesotho but it is not active anymore with data only available from 1981 to 1994. However, it is suggested that a new site downstream of Maseru is included to monitor the impact of the sewage and industrial outflow on the Caledon River. 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.
5	Kornetspruit at Maghaleen (Lesotho – South Africa)	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. 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

Station No.	Location	Justification for Inclusion in the Network
6	Orange River at Oranjedraai (Lesotho – South Africa)	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. The chemical data set at Oranjedraai is good with typically biweekly (fortnightly) measurements from 1975 to 2007. Very good flow measurements also exist since 1961 to 2007.
7	Vaal River at Douglas (South Africa)	The Vaal is a major and very important tributary of the Orange River and the Vaal at Douglas Bridge is a new proposed DWAF site. It is well know that the salt concentrations are high in the Vaal River, which can enhance salinisation problems in the orange River.
8	Orange River at Pella Mission (South Africa – Namibian border)	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. 'This point is also important 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.
9	Orange River at Violsdrift (South Africa – Namibian border)	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.
10	Orange River at Sendelingsdrift (South Africa – Namibian border)	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.
11	Orange River at Alexander Bay (South Africa – Namibian border)	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.

Based on Points 1, 2 or 3 in Decision Box B, the Member States are asked to provide a potential list of monitoring stations that they wish to have included on the regional monitoring network

3.4 Selection of Monitoring Variables for Water Quality Monitoring

3.4.1 Definition of basic data set for surface water quality assessment

As with all freshwater systems, river quality data must be interpreted within the context of a basic understanding of the fluvial and river basin processes, which control the underlying characteristics of the river system. Similarly, for the design of a regional monitoring network, selection of sampling methods and variables to be measured must be based on an understanding of fluvial processes as well as the requirements for water use.

For most purposes, water quality can be adequately described by fewer than 20 physical, chemical, and biological characteristics. The selection of variables will depend on the program objectives and on both existing and anticipated uses of the water and will also be influenced by the ability of an organisation to provide the facilities, and suitably trained operators, to enable the selected measurements to be made accurately. Full selection of variables must be made in relation to assessment objectives and specific knowledge of each individual situation. A further very important question relates to the frequency of data required to get specific knowledge about the variability of a process. This is important since only few variables are measurable with a high frequency and without great cost.

More complex programs may analyze up to 100 variables, including a range of metals and organic micro-pollutants. Moreover, analysis of biota (plankton, benthic animals, fish and other organisms[1]) and of particulate matter (suspended particulates and sediments) can add valuable information. Determining the hydrological regime of a water body (velocity, discharge, water level, suspended matter dynamics) is also an important aspect of a water quality assessment. Discharge measurements, for example, are necessary for mass flow or mass balance calculations and as inputs for water quality models.

A generally accepted data set for basic water quality monitoring is outlined below:

- Temperature
- pH
- Electrical conductivity and/or TDS
- Ammonia
- Chloride
- Chlorophyll [Not practical given field effort required, filtering etc.? Doubtful that Hydro staff would be willing to do this during routine visits due to time constraints.]

An optional data set may include: nitrogen and phosphorus compounds, major ions (sodium, potassium, calcium, magnesium, carbonates and bicarbonates, chloride, sulphate), metals and faecal coliforms.

For each water use (e.g. agriculture, domestic, industrial etc.) the parameters need to be chosen to identify particular water quality characteristics or 'indicators' that are used to assess whether the condition of the water supports that use. For example, the presence of faecal coliforms is used as an indicator for recreational and drinking water quality, because this directly puts those uses at risk, but it is not an indicator for the protection of aquatic ecosystems.

The following decisions for the choice of monitoring variables by the Member States for selected stations are shown in the box below:

Decision Box C: Monitoring Variable Options

1) Agree the use of a priority set of variables focused at the known pollution problems, i.e. minimum set, which may include basic physico-chemical parameters, microbiological parameters and nutrients,
2) Agree the use of a full (or extensive) parameter set which includes basic and optional variables covering all aspects of water quality
3) Provide data for monitoring variables from selected country stations from the national monitoring network, i.e. no change from present situation.

[1] An Aquatic Ecosystem Health Monitoring Programme for ORASECOM has already been described in a separate report,

In order to determine the variables for use in a water quality monitoring network, one option (Point 1 of decision Box C) is to agree the use of variables that are targeted at known pollution issues. In order to achieve this, it is essential to determine the historical trend and current status of the waters in relation to water use (termed 'fitness-for-use') at the selected sampling stations proposed as a starting point for construction of the network.

The multiple use of river water may occur within any region of the River Basin. Each user sector will have different water quality requirements and user conflicts may occur. The desired water user's category can be described in terms of quantitative and descriptive information goals, and the information provided in the form of water user category specifications, i.e. domestic, recreational, industrial, irrigation, livestock watering, aquaculture and aquatic ecosystems. Ideally, water quality should meet the most stringent use requirement. There is always a responsibility for upstream uses to ensure adequate water quality for the needs of downstream users.

The fitness for use or level of protection may be categorised as follows:

1) Ideal
2) Acceptable
3) Tolerable
4) Unacceptable

Based on the current water quality status of the selected monitoring stations, Table 3.3 below provides an overview of the priority variables proposed for initial measurement in the network, which is in accordance with Point 1 of decision Box C. Table 3.3 also shows the water use that each of the variables is targeted at.

Table 3.4 below further provides an overview of the targets for protection for each water use for each of the proposed 11 transboundary monitoring stations. The information, based on recent DWA studies, shows the number of variables, which are designated as either ideal, acceptable or tolerable (or worse) for each of the water uses.

The Member States are asked to provide a potential list of monitoring variables for surface waters in relation to Decision Box C for either Points 1, 2 or 3.

Table 3.3 Priority Variables for the Proposed Transboundary Water Quality Monitoring Network

	Proposed Monitoring Stations										
	Upper Orange-Senqu						Lower Orange				
Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Hardness									B		
pH (95th)	A	A	A	A	A	A		A	A	A	A
Alkalinity					B	B					
NH4-N	B										
Chloride							A	A	A	A	A
Manganese		A									
Aluminium									B		
Cadmium								A			
Copper										A	A
Molybden.									C		
Lead								C	C		
SAR									A	A	A
Sodium							A	A	A	A	A
TDS		A	A	A	A	A	A	A	A	A	A
PO4-P											
TP											
NO3-N											
DIN											
TN											
Chl-a											
Diatoms											
E-coli											

Key to Protection for Water Use:

	Agricultural Use (**A** - Irrigation, **B** –Aquaculture; **C** - Livestock Watering)
	Domestic Use
	Aquatic Ecosystem Protection
	Industrial Use
	Recreational Use
	Not regarded as a priority for protection of surface waters by ORASECOM

Table 3.4 The Level of Protection for Different Water Uses at the Proposed Transboundary Monitoring Locations (based on the number of variables analysed by South Africa's DWA – for further details of all parameters for each monitoring station, refer to Annex 4)

Monitoring Stations	Agriculture									Domestic			Ecosystem			Industrial			Recreational		
	Aquaculture			Irrigation			Livestock														
	I	A	T	I	A	T	I	A	T	I	A	T	I	A	T	I	A	T	I	A	T
Upper Orange-Senqu																					
Caledon R at Little Caledon	2	1	1[1]	6			-	-	-	7	1		1	3	1[5]	3	1				1[10]
Little Caledon R at Poplars	-	-	-	6	3		2			8	2		1	4	1[5]	5	1		1		
Caledon R at Ficksburg	-	-	-	4	2		-	-	-	8	1		3	3		4	1				1[10]
Caledon R at Maseru	-	-	-	4	2		-	-	-	8	1			3	3[5,6]	4	1				1[10]
Kornetspruit at Maghaleen	2		1[1]	6			-	-	-	7	1		5		1[5]	3	1		1	1	
Orange R at Oranjedraai	1	1	1[1]	6			-	-	-	7	1		3	2	1[5]	3	1		1	1	
Lower Orange																					
Vaal at Douglas	-	-	-	4	2	2	2			3	5		2		4[5,6,9]	3	3			2	
Orange R at Pella Mission	-	-	-	6	7		2		1[3,8]	5	4	1[4]	3	4	2[7]	5	2		1		
Orange R at Violsdrift	1		2[2]	6	7				1[3]	6	4		4	3	2[7,8]	4	2		1		
Orange R at Sendelingsdrift	-	-	-	6	4		2			6	4		1	3	2[1,9]	4	2		1		
Orange R at Alexander Bay	-	-	-	6	4		2			5	5		2	3	1[9]	4	2		1		1[9]

I – Ideal; A - Acceptable; T - Tolerable; - Not applicable; according to DWAF Water Quality Guidelines (see Annex 2)

[1]Alkalinity levels at upper limit of tolerable quality; [2]Aluminium levels below tolerable quality; [3]Molybdenum levels close to or below tolerable quality [4]Cadmium levels at upper limit of tolerable quality; [5]Phosphate levels between acceptable and tolerable level; [6]Nitrate+nitrite levels between acceptable and tolerable level; [7]Copper levels below tolerable quality; [8]Lead levels below tolerable quality; [9]Chlorophyl a levels at upper limit of tolerable quality [10]E.coli levels at upper limit or below tolerable quality;

3.4.2 Groundwater monitoring

In recent years much progress has been made by SADC on moving towards more effective groundwater management. However, a greater consideration of groundwater is still required in order to put into practice the concept of Integrated Water Resources Management at River Basin and regional level. Discussion with the Member States highlighted the need for a move towards enforcement of agreed procedures, guidelines and standards to be further enhanced to develop joint management of shared aquifers, along with the harmonisation of concepts concerning the sustainable use of groundwater, encompassing technical, legal, regulatory, social and financial aspects.

Figure 3.2 provides a representation of the four major transboundary aquifers situation in the Orange-Senqu River Basin.

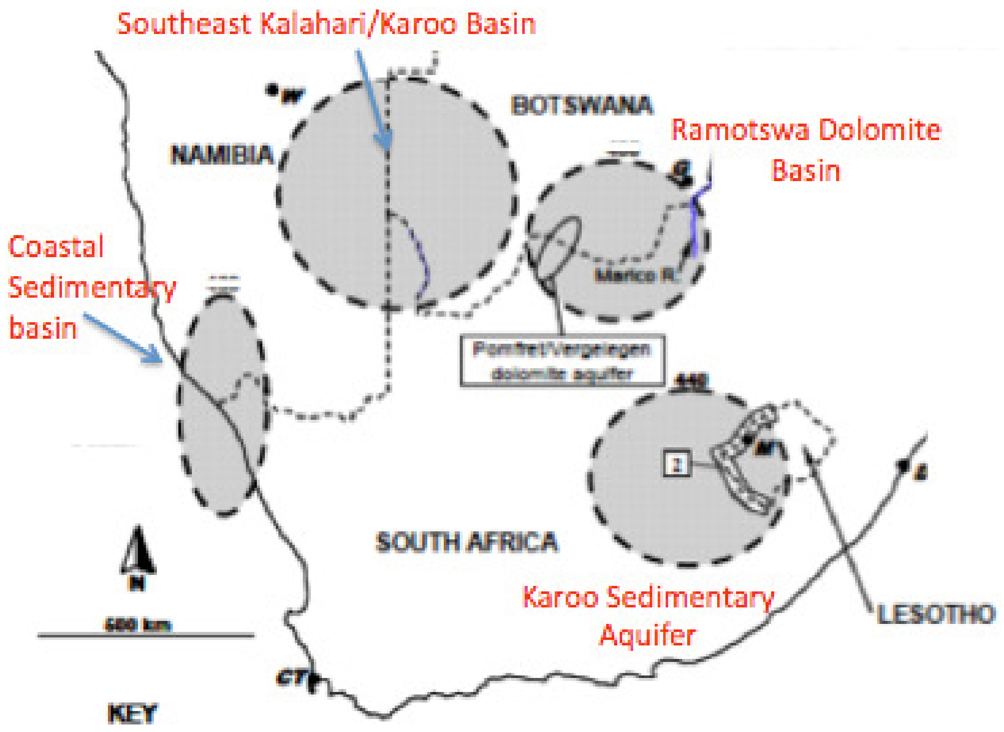


Figure 3.2 Transboundary Aquifers in the Orange-Senqu River Basin

Transboundary monitoring information from groundwater is required for:

- Provision of a reliable assessment of quantitative status of all transboundary groundwater bodies or groups of bodies;
- Estimating the direction and rate of flow in groundwater bodies that cross Member States boundaries;
- Supplementing and validating impact assessment procedures;
- Use in the assessment of long term trends both as a result of changes in natural conditions and through anthropogenic activity;
- Establishing the chemical status of all transboundary groundwater bodies or groups of bodies determined to be at risk;
- Establishing the presence of significant and sustained upwards trends in the concentrations of pollutants;
- Assessing the reversal of such trends in the concentration of pollutants in groundwater.

The assessment, planning and management of transboundary groundwater resources are seen as important functions within the overall scope of IWRM. Of equal importance is the interaction between surface and groundwater and the contribution of groundwater to base-flow. Although a significant amount of information is available on the assessment, planning and management functions as it pertains to groundwater resources in South Africa (DWAF guidelines), this has not as yet been coordinated on a full River Basin level.

With respect to groundwater, a transboundary monitoring will require information on the chemical and quantitative status. For ORASECOM, this concerns the 4 transboundary aquifers of Basin-wide importance. With the view of establishing a Basin wide coherent monitoring approach, bilateral agreements should be reached on monitoring strategies (i.e. sampling procedures, network design etc.) and principles, which require coordination of conceptual, model development, the exchange of data and QA and QC aspects.

For groundwater bodies within which groundwater flows across a Member State boundary, it has to be assured that sufficient monitoring points are provided to estimate the direction and rate of groundwater flow across the Member State boundary. Sufficient frequency of measurement to estimate the direction and rate of groundwater flow across the Member State boundary must also be ensured.

Transboundary water bodies must be monitored for those parameters, which are relevant for the protection of all of the uses supported by the groundwater flow. The quantitative monitoring network must be designed so as to provide a reliable assessment of the quantitative status of all groundwater bodies or groups of bodies of Basin-wide importance including assessment of the available groundwater resource. Member States shall also be required to provide a map or maps showing the groundwater monitoring network in the future IWRM plan.

3.4.2.1 Proposal for Chemical Monitoring

The following core set of determinants is proposed for groundwater monitoring:

- pH-value,
- Electrical conductivity,
- Nitrate,
- Ammonium,
- Temperature and
- A set of major (trace) ions.

In addition it is recommended to monitor the water level at all chemical monitoring points in order to describe (and interpret) the 'physical status of the site' and to help interpreting (seasonal) variations or trends in chemical composition of groundwater.

The selection of appropriate monitoring frequency should generally be based on the characteristics of the aquifer and its susceptibility to pollution pressures. Sampling must be continued until the groundwater body is determined, with adequate confidence, to be no longer at poor status or at risk of being at poor status and there is adequate data to demonstrate a reversal of trends.

Sampling frequency and sample timing at each monitoring location should furthermore consider:

- Requirements for trend assessment;
- Whether the location is up-gradient, directly below, or down-gradient of the pressure.
- Locations directly below a pressure may require more frequent monitoring;
- Short-term fluctuations in pollutant concentrations, e.g. seasonal effects. Where seasonal and other short-term effects are likely, sampling frequencies and timings should be increased and sampling must take place at the same time(s) each year, or under the same conditions; and
- Land use management patterns, e.g. the period of pesticides or nitrate application. This is especially important for rapid flow system like karstic aquifers and/or shallow groundwater bodies.

A groundwater body will be at good chemical quality if the following criteria are satisfied:

- *General water quality:* The concentrations of pollutants should not exceed the quality standards applicable under the national legislation of the Member States;
- *Impacts on ecosystems:* The concentration of pollutants should not be such as would result in failure to achieve the quality objectives for associated surface waters nor any significant diminution of the ecological or chemical quality of such bodies nor in any significant damage to terrestrial ecosystems which depend directly on the groundwater body;
- *Saline intrusion:* The concentrations of pollutants should not exhibit the effects of saline or other intrusions as measured by changes in conductivity.

3.4.2.2 Quantity monitoring

Recommended parameters for the purposes of quantitative assessment of groundwater include:

- Groundwater levels in boreholes or wells
- Flow characteristics and/or stage levels of surface water courses during drought periods (i.e. base flow)
- water abstraction

Frequency of monitoring predominantly depends of the characteristics of the water body and the monitoring site respectively. Sites with significant annual variability should be monitored more frequently than sites with only minor variability. In general monthly monitoring will be sufficient for quantity monitoring where variability is low but daily monitoring would be preferred (particularly when measuring flows). The frequency should be revised as knowledge of the aquifer response and behaviour improves and in relation to the significance of any changes in pressures on the groundwater body. This will ensure that a cost-effective programme is maintained.

The parameters and frequency for the proposed monitoring (transboundary groundwater) programme are shown below in Table 3.5.

The Member States are asked to provide a potential list of boreholes for inclusion in the regional network (with reference to Decision Box B, Section 3.3), and variables for groundwater monitoring in relation to Decision Box C (Section 3.4.1)

Table 3.5 Parameters and Frequency for the Proposed Monitoring (transboundary groundwater) Programme

	Botswana/Namibia	Botswana/South Africa	Lesotho/South Africa	Namibia/South Africa
Transboundary Aquifer	**Southeast Kalahari/Karoo Basin**	**Ramotswa Dolomite Basin**	**Karoo Sedimentary Aquifer**	**Coastal Sedimentary Basin**
		Chemical (with estimation of frequency)		
pH	>1/annum	>1/annum	>1/annum	>1/annum
EC	>1/annum	>1/annum	>1/annum	>1/annum
NO3-N	>1/annum	>1/annum	>1/annum	>1/annum
NH4-N	>1/annum	>1/annum	>1/annum	>1/annum
Temperature	>1/annum	>1/annum	>1/annum	>1/annum
Major ions	1/annum	1/annum	1/annum	1/annum
		Quantity		
Groundwater levels/head pressure	√[1]	√	√	√
Flow characteristics	√	√	√	√
Extraction	√	√	√	√
Reinjection	If applicable	If applicable	If applicable	If applicable

[1]Parameter is measured

3.5 Quality Systems

Water quality monitoring in the Orange-Senqu River Basin is currently carried out independently by the Member States, or as part of bilateral agreements. The gaps in existing knowledge and the problems of the comparability of the monitoring results have been recognized. One of the major tasks of the Member States is to establish the water monitoring network using accepted methodologies and appropriate quality control.

The most difficult issue in the monitoring of international Rivers is to obtain reliable information, comparable data on the different pollutants in a manner that is trusted by all the riparian States. Therefore, implementation of monitoring programmes in international River Basins requires harmonization and coordination. Harmonization should be first of all during the design period when target determinants for monitoring are identified, sampling locations and frequencies, sampling and analytical methodologies, the quality control measures particularly for the analytical quality control are selected and agreed.

The current gaps in QA/QC identified in the Orange-Senqu River Basin are as follows:

- There is no harmonization of sampling and analytical methods and development of related QA/QC procedures for all types of waters (surface water and groundwater);
- There is no harmonized or standardized sampling validation schemes and procedures for reasonable estimation of sampling uncertainty;
- There are no Basin wide QA/QC procedures for sample transport, storage and sample pre-treatment on analytical results
- No proficiency testing for sampling and analysis exists between the Member States;

The application of quality systems to the design of the regional monitoring network must be seen as an opportunity to fill in the observed gaps, resulting in essential improvements in the region i.e. to find out which laboratories require addition capacity, training etc. In terms of QA/QC a series of options exist for the Member States:

Decision Box D: QA/QC Options

1) Agree the use of national accredited laboratories in each of the Member States, i.e. data produced by each Member State is deemed acceptable;
2) Joint monitoring is carried out on a bilateral basis, where Member States sample the same site, separate the sample, analyse and compare data, i.e. incorporating laboratory procedures for accuracy testing;
3) ORASECOM designates accredited laboratories in each of the Member States, i.e. following an official tender process;
4) Spiked samples are used to determine the effective performance of the designated laboratories, i.e. incorporating inter-laboratory performance testing
5) Data is provided by Member States without application of QA/QC.

It is important to point out that evaluation of the quality of the River system and the realistic description of the concentrations and trends of pollution requires that the analytical results should be of the same high quality, irrespective of the laboratory that provided the results. As can be seen from decision Box D, there are a variety of options open to the Member States to achieve this. Also, it must be borne in mind that the operation of a reliable monitoring network can only be ensured by the adoption of harmonised sampling and analytical methodologies, the establishment of quality targets and the implementation of an appropriate quality assurance scheme.

If a quality assurance program is implemented in the Orange-Senqu River Basin laboratories, an implementation plan for the future monitoring must be prepared and agreed, which must include: (a) Standard Operating Protocols (SOPs), (b) recommendations for similar laboratory facilities, (b) provision of necessary analytical instrumentation in the laboratories, (c) implementation of integrated training programs, and (d) proficiency testing carried out in inter-laboratory comparison studies.

As far as the laboratory work is concerned, harmonization of the related activities must include:

- Selection of determinants for the monitoring network in the Orange-Senqu River Basin (see Section 3.4);
- Selection of appropriate sampling and sample handling procedures for water and biota;
- Selection of reference and optional analytical methods for determination of the identified physical, chemical, biological and microbiological determinants;
- Establishment of a QA/QC performance testing system (see Section 3.5.2 below);
- Regular revision of the methodologies;
- Identification of training needs and implementation; and
- Regional co-ordination of the laboratory work.

Monitoring on a transboundary level, without appropriate QA/QC systems in place, may result in poor data quality data due to:

- Lack of traceability of data: where data are not sufficiently documented and not containing reliable references;
- Lack of harmonization of procedures applied by the laboratories: from the sampling step on the field to data given back (concentration measurements accompanied with their uncertainty);
- Lack of representativeness (data not reflecting the reality);
- Too high level of uncertainty for several parameters (when expressed, sometimes it is

too high to take a decision);
- A lack of metadata (useful information provided with the data), necessary for the interpretation and comparison of data: from the sampling step (what, how, when measurements were made) to the data given, resulting in a lack of traceability of data along the analytical chain.

A positive example of an effective QA/QC programme can be taken from the Danube River Basin involving actively 13 European countries. To ensure the quality of the monitoring data, a Basin-wide analytical quality control system is regularly organized by the International Commission for the Protection of the Danube River (ICPDR). The reports on the analytical quality are published annually and indicate the precision and accuracy of the results produced within the transnational monitoring network (TNMN). The analytical methodologies for the determinants applied are based on a list containing reference and optional analytical methods. In this system, National Reference Laboratories (NRLs) have been provided with a set of ISO standards (reference methods) reflecting the measurement lists, but taking into account the current practice in environmental analytical methodology in the EU.

The ICPDR decided not to require each laboratory to use the same method, providing the laboratory would be able to demonstrate that the method in use (optional method) meets the required performance criteria. Therefore, the minimum concentrations expected and the tolerance required of actual measurements were defined for each variable, in order to enable laboratories to determine whether the analytical methods currently in use are acceptable. It was found as a good practice that defines the standard of the accuracy, which was necessary for the task in hand. Therefore, two key concentration levels - the minimum level of interest and the principal level of interest – were defined for each measurement. These levels helped define the aims of the monitoring programme and were used to establish the performance needed from analytical systems used in the laboratories involved in the TNMN.

3.5.1 The Application of quality and accuracy targets

The measurement cycle for the implementation of the monitoring starts with the collection of samples and closes with reporting the analytical results and the reliability of the results depends on the effectiveness of the quality assurance as shown in Fig. 3.3 below.

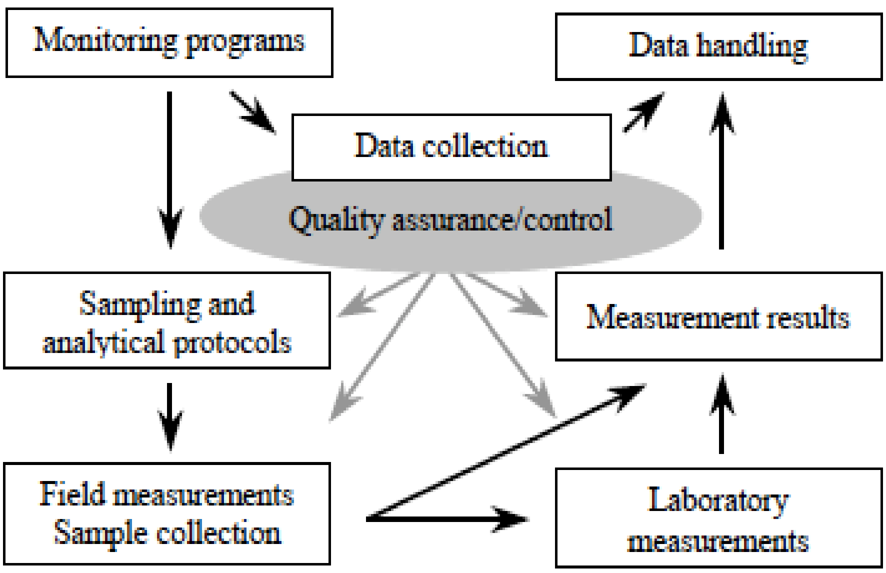


Fig. 3.3 Quality assurance/control in the data collection/measurement cycle

Water quality targets, objectives and standards are set to evaluate the quality of the water resources, both surface and groundwater bodies, to characterise chemical and ecological status (for surface waters) and to establish satisfactory condition for intended uses of the water body. The laboratory data define whether that condition is being met, and whether the water is of acceptable quality to fit for the purpose. If the laboratory results indicate a violation of the standard, action would be required by ORASECOM. The analyst must be aware that their professional competence, the procedures used, and the reported values are reliable and may be used with confidence.

The proposed approach to determine the analytical accuracy targets for monitoring the quality of water (Table 3.6) in the Orange-Senqu River Basin is summarized as follows:

- Two key concentration levels must be defined for each determinant. These are: (i) the lowest level likely to be encountered in the waters of interest (the minimum level of interest); and (ii) the concentration which represents the likely level at which most monitoring (for example, for the assessment of trends or compliance with water quality standards) will be carried out (the principal level of interest). These levels define the aims of the program; they can be used to establish the performance (or detection limits) needed from analytical systems used in the laboratories.
- It is assumed that the aims of the monitoring program will be satisfied provided: (i) that relatively few results are reported as “less than” the minimum level and (ii) that the accuracy achieved at the principal level is not worse than ± 20% of the principal level. Experience suggests that it is usually appropriate to set a required limit of detection that is at least one tenth of the principal level of interest. A subsidiary aim is that the limit of detection should be at least one third of the minimum level of interest.
- Any practical approach to monitoring must take into account the current capabilities of analytical science. This means that if some targets are recognized as very difficult to achieve, it may be necessary to set more relaxed, interim targets and to review performance and data use in the course of the monitoring program.

The analytical methodologies must be based on a list containing reference and optional analytical methods. The laboratories that are selected to take part in the monitoring programme must be provided with a set of ISO standards (reference methods) reflecting the determinant lists. However, it is not necessary for each laboratory to use the same method, providing the laboratory is able to demonstrate that the method in use (optional method) meets the required performance criteria. Therefore, the minimum concentrations expected and the tolerance required of actual measurements must be defined for each determinant (Table 3.6), in order to enable laboratories to determine whether the analytical methods are acceptable.

Table 3.6 Proposed Accuracy targets of water quality variables proposed for monitoring.

Determinants in Water	Units	Interest Levels for Monitoring		Accuracy Levels Required	
		Minimum[1]	Normal[1]	LOD[2]	Tolerance[3]
Hardness	mg/l	10	100	1	5 or 20%
EC	mS/m	30	300	5	5 or 10%
pH (95th)	unit	-	7.5	-	0.1
Alkalinity	mg/l	10	500	1	5%
NH4-N	mg/l	0.01	0.1	0.005	0.01 or 20%
Calcium	mg/l	2	20	0.2	0.1 or 10%
Chloride	mg/l	5	50	1	1 or 10%
Fluoride	mg/l	0.1	1	0.05	0.05 or 10%
Magnesium	mg/l	1	10	0.5	0.2 or 10%
Potassium	mg/l	0.5	20	0.25	0.5 or10%
Sodium	mg/l	10	100	5	5 or 10%
Sulphate	mg/l	5	50	1	5 or 20%
TDS	mg/l	50	150	10	5 or 10%
PO4-P	mg/l	0.02	0.2	0.005	0.005 or 20%
TP	mg/l	0.05	0.5	0.01	0.01 or 20%

Determinants in Water	Units	Interest Levels for Monitoring		Accuracy Levels Required	
		Minimum[1]	Normal[1]	LOD[2]	Tolerance[3]
NO3-N	mg/l	0.1	1	0.1	0.1 or 20%
DIN	mg/l	0.2	1	0.1	0.1 or 20%
TN	mg/l	0.2	2	0.5	0.1 or 20%
Si	mg/l	10	100	5	5 or 10%
Chl-a	µg/l	0.5	10	0.25	0.25 or 20%
Diatoms	SPI	17	13	5	-
E-coli	/100ml	20	100	1	5 or 10%

[Note: TDS vs EC look very much too low in the Table above. In the Drinking Watre Quality Guidelines (1998) an EC of 70 mS/m is approximately equivalent to a TDS of 450 mg/l. The "normal" level of E. coli may be a little high.]

Note 1 –The minimum likely level of interest is the lowest concentration considered likely to be encountered or important in the monitoring program. This assumption is based on previous data available for the proposed monitoring stations, as provided by DWAF in South Africa. The principal level of interest is the concentration at which it is anticipated that most monitoring will be carried out.
Note 2 - The required limit of detection (LOD) which laboratories will be required to achieve. This is intended to ensure that the best possible precision is achieved at the principal level of interest and that relatively few less than results will be reported for samples at or near the lowest level of interest.
Note 3 - The tolerance indicates the largest allowable analytical error, which is consistent with the correct interpretation of the data and with current analytical practice. The target is expressed as "x concentration units or P%". The larger of the two values applies for any given concentration. For example, if the target is 5 mg/l or 20% - at a concentration of 20 mg/l the maximum tolerable error is 5 mg/l (20% is 4 mg/l); at a concentration of 100 mg/l, the tolerable error is 20 mg/l (i.e. 20%) because this value exceeds the fixed target of 5 mg/l.

3.5.2 The application of performance-testing in the Member States laboratories

As part of the QA/QC, a performance-testing scheme is proposed as the primary inter-laboratory quality control program in the Orange-Senqu River Basin, with the participation of the laboratories involved in the transboundary water quality monitoring.

One of the most important parts of the sustainable QA/QC is the design of an organisational structure for performance testing that can ensure continuity of analytical quality control in the proposed monitoring programme and the following points had to be considered: (a) the determinants of interest, (b) the level of concentration of determinants, (c) sample preparation, (d) analysis and reporting, and (e) evaluation of the results.

The requirements for a performance-testing scheme will be as follows:

- The sample should be considered to be adequately representative of a real test material. Determinants will depend on parameters and sample type analysed routinely by the laboratories of Orange-Senqu River Basin.
- Concentration level of determinants will depend on parameters and sample type analysed routinely by the laboratories in the Orange-Senqu River Basin. In the case of real surface water or biota, the concentration range is limited.
- The number of samples should be sufficient to distribute sample-pairs according to the Youden-technique, to each of the future implementing laboratories.
  Note: *Youden plots are a graphical technique for analyzing interlab data when each lab has made two runs on the same product or one run on two different products.* An example of such can be visualised at:
  http://www.itl.nist.gov/div898/handbook/eda/section3/youdplot.htm
- Performance testing and related sampling should ideally be at a frequency of four-times per year according to the distribution schedule. Samples should be accompanied with clear instructions on the procedures for the analysis and the reporting procedure.

- The results reported back from the analytical laboratories should be evaluated and fed back to the laboratories within a relatively short time period, i.e. two weeks. Laboratories must be identified only by code numbers.

- The sample preparation, distribution and evaluation schemes of the performance testing are demonstrated in Fig. 3.4. The reported analytical results can be compared with the assigned reference values.
- The test materials to be distributed in the scheme must be similar to the materials that are routinely analysed (in respect of the concentration range or quality of the determinant) including the type of samples as follows:
  - ✓ synthetic water samples as concentrate-pairs (according to the Youden-technique),
  - ✓ real-world water samples and their spikes ensuring sample-pairs again according to the Youden-technique,
  - ✓ reference materials

The organisation of an interlaboratory comparison in the Member States must be the responsibility of a single institute. It is suggested as the first distribution, only samples for the analysis of a minimum amount of determinants are carried out: e.g. TDS, alkalinity and chloride. In following distributions, depending on the laboratory capacity, four more distributions could be made for the analysis of the following determinants: e.g. nutrients and different metals.

Interlaboratory studies, organized regularly, will help to improve analytical performances because the participants can review their own performance concerning the accuracy of the analytical results and where necessary, investigate the sources of error and take corrective actions.

It is expected that performance of laboratories analysing samples in the frame of the proposed monitoring programme will further improve and the comparability of the water quality monitoring results in the River Basin and related regions will be ensured. To achieve this goal regular performance testing and the continuation of the interlaboratory comparison studies are of paramount importance.

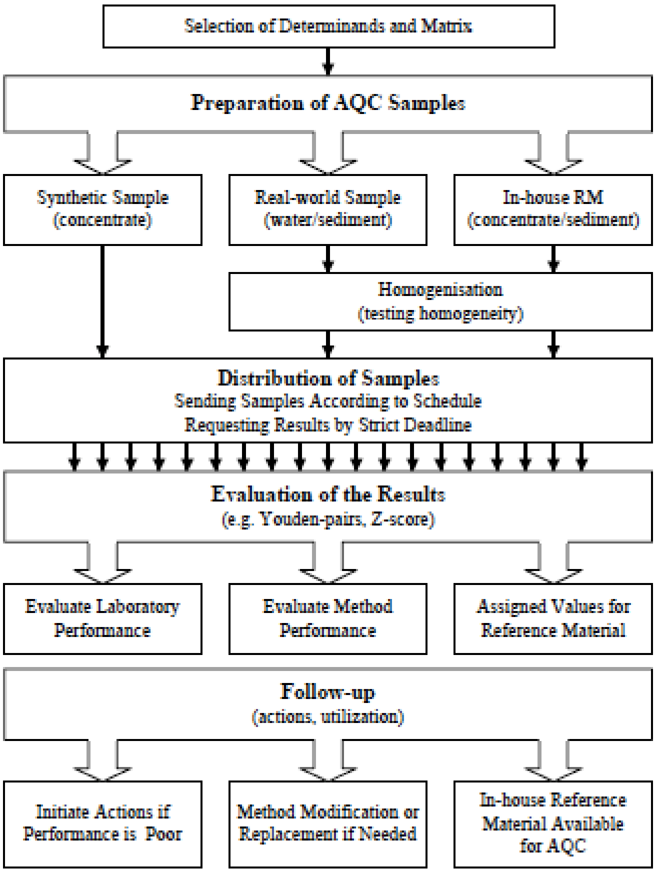


Figure 3.4 A Scheme for Performance Testing in the Orange-Senqu River Basin

3.5.3 The role of a nominated supporting body in the development of QA/QC Procedures

There are a number of points that need to be highlighted in relation to the designation of either a Task Team, an Implementing Agency or Consultants (as described in Section 3.2; herein termed the "institution') in the development and implementation of quality systems in regional water quality monitoring:

- It is essential to ensure that the involvement and specific role of the chosen institution is well defined and integrated into the overall programme of data assessment and interpretation and that it has the power to influence the use of data;
- The institution requires its own clear terms of reference. They will also need to be coordinated or provided with co-operating guidelines, in order that the Member States operate to similar principles.
- An important role of the selected institution would be to act as a focus for initiatives intended to provide awareness of QA/QC in the reporting chain from laboratory to the Member States and beyond to ORASECOM;

The role of the chosen institution can be seen as being divided into activities prior to monitoring and after data collection. Before monitoring commences the institution should be involved in the following activities:

- Facilitation of communication between data producers and data users about the basic requirements for QA/QC for physico-chemical monitoring;
- Definition of monitoring specifications, including performance targets and QA/QC guidance. These definitions should include a specification of required performance for each parameter, for each substance. The resulting performance criteria should be proposed by the chosen institution to the competent monitoring authorities as a means of identifying suitable contracting laboratories;

- Determination of issues relating to analysis and monitoring of technically feasibility and disproportionate cost;
- Provision of guidance on topics including:
    - ✓ Sampling scheme design;
    - ✓ Procedures for sampling, sample handling and preservation and sample processing;
    - ✓ Suitable analytical techniques and appropriate specific methods;
    - ✓ Collection of QA/QC and metadata.

After data collection is performed, QC information should be collected in summary form and then reviewed with respect to the planned data use by a designated institution. The institution must be responsible to the ultimate data user (i.e. ORASECOM) for assessing fitness for purpose of the data, for identifying areas where improvement is needed and for confirming the aspects of data interpretation (e.g. trend detection) that are directly related to quality issues. The institution would also be responsible for provision (based on the assessment of QC information) of advice to the competent monitoring authorities in each Member State regarding:

- The compliance of the data with respect to the defined performance criteria;
- Measures required for improvement in performance (from gaps that are identified as part of the continuing QC programme).

3.5.4 Issues for QA/QC in groundwater monitoring

Due to the technical difficulties in accessing groundwater and the rapid changes in chemistry that can take place once the water has been removed from its point of origin, sampling for groundwater monitoring requires careful planning and the selection of the most suitable equipment and methods.

Standard methods for sampling are generally less precise than analytical methods, in part because of the varying field conditions at different sites and the varying purposes of sampling, and in part because the process of standardising sampling is presently less advanced than that for chemical analysis. Therefore, even with national and international standards there is a need of harmonisation of approaches and methods to ensure the comparability and representativeness of sampling. Sampling methods for groundwater monitoring must take into account:

- The hydrogeological conditions (layered aquifer, porous/fissure/fracture etc.),
- Physico-chemical properties (volatility of substances, adsorption properties, reactivity etc) of determinants sampled for;
- The type of parameters being measured (chemical, biological, physical);
- The characteristics of the sampling point (e.g. well diameter, screen length, depth of sampling, static/flowing).

Unstable parameters such as pH, temperature and conductivity must be measured in the field, as quickly as possible. For this, special calibrated equipment with clear operating instructions and procedures is required. Similarly, sample treatment such as preservation or filtration of water samples must be done in the field without aeration and as rapidly as possible in order to avoid changes in the distribution between dissolved and particulate phases within the sample.

The Member States are asked to provide their preference for implementation of QA/QC for the proposed regional monitoring programme in relation to Decision Box D for either Points 1, 2, 3, 4 or 5

3.6 Trigger Values

For each issue or pressure in the Orange-Senqu River Basin, it is important to set key parameters, (which may be regarded as indicators of water quality) together with resource quality objectives to measure whether the desired environmental values are at risk. As an example, for the environmental value 'protecting aquatic ecosystems', resource water quality objectives will need to be set for biological, physical and chemical parameters.

In South Africa, the DWA have recently proposed resource water quality objectives (RWQOs) for the Orange River (Upper and Lower) for a wide range of monitoring parameters, while Namibia is in the process of establishing similar national guidelines. In the DWA approach, the specific water users in the catchment were identified for the applicable reach in the Orange River, and realistic or achievable objectives set recognising the economic impacts The water uses selected included: domestic, agriculture (stock watering, irrigation, and aquaculture), aquatic ecosystem, industrial, and recreational (see Annex 4 for further details of RWQOs proposed for all of the monitoring stations outlined in Section 3.3)

Choosing the right parameters (indicators) for monitoring is critical and should be based on the key issues in the local waterway and the main pollutants that might be generated by the activity(ies) under consideration. As an example, the Australian and New Zealand Environment Conservation Council (ANZECC) provide 'Trigger Values' for a wide range of parameters (indicators), but stress that only those relevant to the issue being faced need to be considered. For example, an assessment might focus on those indicators relevant to stresses in the catchment, or on those that are known risks from the activity or development under investigation.

The Trigger Values for different parameters (indicators) of water quality may be given as a threshold value or as a range of desirable values. Trigger Values are conservative assessment levels, not 'pass/fail' compliance criteria. A similar approach using Trigger Values for indicator parameters is also proposed for the Orange-Senqu River Basin.

Since local conditions vary naturally within the river basin (i.e. between the Upper Orange-Senqu and the Lower Orange catchments), it may be necessary to tailor Trigger Values to local conditions or local guideline levels. The national guidelines for water quality parameters in each Member State provide a process for refining the Trigger Values and these protocols should always be followed in the first instance. For comparison, the guideline or limit values for South Africa are reproduced in Annexes 2 and 3.

Where a parameter (indicator) is below the threshold value or within the desirable range for this Trigger Value in a particular river stretch, the risk is low. However, as illustrated in Figure 3.5, where an indicator is higher than the threshold value or outside the desirable range for its Trigger Value in a particular river stretch, there may be a risk that certain users or the environmental will not be protected. This may 'trigger' either:

- Immediate action by ORASECOM to address the likely causes of the value not being met, or
- Further investigation by ORASECOM to determine whether the trigger value is too conservative for local conditions, or the local conditions influence the ambient levels and toxicity of the contaminant of concern.

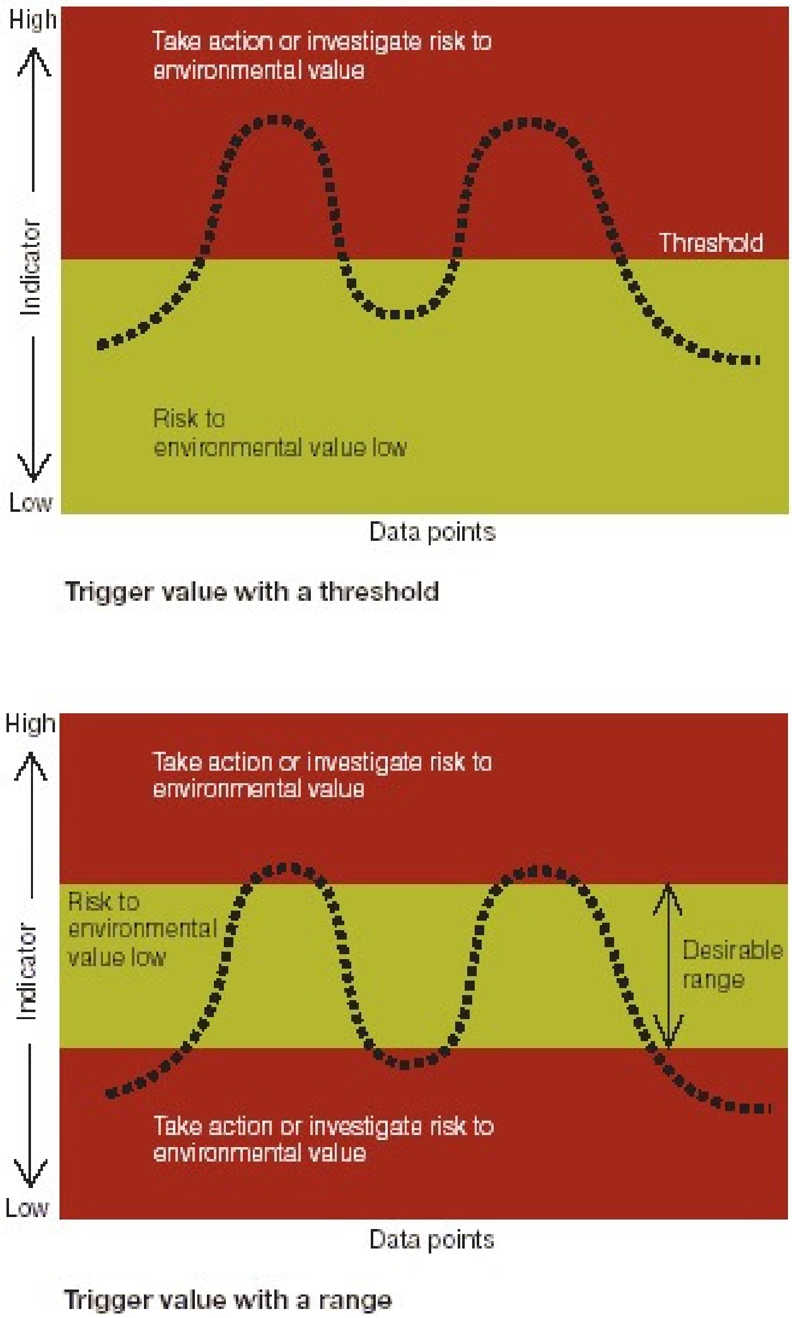


Figure 3.5 Illustration of Trigger Values Set for a Threshold Value or a Range of Values (reproduced from ANZEEC Guidelines)

The following range of options exist for the development of Trigger Values by the Member States:

Decision Box E: Options for Setting Trigger Values

1) On a bilateral basis, Member States negotiate and agree Trigger Values for specific parameters (indicators) based on the following principles:
   a. Water uses, i.e. the level of protection, and hence the Trigger Value, may differ for the same parameter depending on the use of the water (e.g. domestic versus industrial use)
   b. National guidelines/limit values for parameters on a site specific basis, i.e. Trigger Values may be different for the same parameter for different stretches of the river basin;
   c. The historical trend of the parameter, i.e. an certain % increase in the parameter value over a set timeframe, indicating a continued deterioration of water quality, may be set as a Trigger value for intervention.
2) Trigger Values may be set at a level that exceeds national guidelines or limit values in each Member State irrespective of the water use, historical trend or the current status of the water;
3) The concept of Trigger Values is not acceptable to the Member States, no action is taken in this regard.

Taking into consideration that (a) waters in the Orange-Senqu River Basin have many different uses, and (b) a specific set of parameters (or indicators) may be chosen to ensure protection of the waters to meet the water uses, it is important to develop Trigger Values for the specific parameters (indicators) as a management tool in order to prevent deterioration in water quality and significant harm to the water users.

In relation to Decision Box E, for Points 1, 2, 3, the Member States are asked to provide their preference for options for setting Trigger Values for specific parameters as part of the regional water quality monitoring framework

3.7 Data Management and Reporting

In order to be able to assess the progress in improvement of environmental conditions of waters in Orange-Senqu River Basin, and to assess effectiveness of measures set up, the role of information from water quality monitoring is crucial.

At the level of international agreements, there are several provisions as to the collection, dissemination and sharing of data among the Member States. In the framework of the Revised SADC Protocol on Shared Watercourses, the sharing of information is considered central to the cooperation and economic integration in the region. Under the ORASECOM agreement, parties are committed to sharing information relevant for River Basin management, including information on River flow, droughts, floods irrigation development, water uses and infrastructure operations. This Agreement also provides for stand forms of monitoring. The Commission was set up to serve, among other functions, as a platform for the exchange but also as an institution for the production of information.

There is clear reference to the sharing of data in the National Water Resource Strategy of South Africa. Also efforts like the SADC-HYCOS or other ORASECOM initiatives, funded by the German GTZ, the EU and other international organisations will ultimately contribute to better databases and information systems also at an international level.

However, one major shortcoming exists with regard to the exchange of information among the different Member States. In the framework of ORASECOM there is a pledge to exchange relevant data to support River Basin management. However, no integrated data and information systems have yet been established (other than the SADC-HYCOS system.

The primary purpose of data management is to transform raw data to needed information, coming from the monitoring objectives. The basic assumption for this process is to have in place a standard procedure for collection, validation, merging, storage, and processing of the data.

The importance of data management must be recognised in this very early stage of operation and a well-defined structure for data storage must been prepared. The data must be organised in a system of joined tables, containing information related to monitoring locations, determinants, methods of sampling, methods of analysis, remarks and information on taken samples and results of analysis. The following options are available to Member States with regard to management of data from a regional monitoring network:

Decision Box F: Data Management Options/Decisions

1) Agreement on the data to be exchanged by the Member States;
2) Agreement on the data exchange file format (DEFF) between the Member States;
3) Data can be provided by each Member State to a central database (common platform), which can be hosted in one of the Member State countries;
4) Data can be provided by each Member State to a central database (common platform), which can be hosted by ORASECOM;
5) Responsibility for the data collection, checking and preparation can be given to nominated individuals in each Member State, i.e. focal points for data management
6) Access to the data can be allowed with or without restrictions, i.e. data supplied can be held in a database behind a firewall so that it cannot be altered after it has been provided by Member States; access to visualisation of the data, which is in front of the firewall can also be restricted by means of a password.

It is essential that the procedure of data collection must start on a national level of each country. National Information Managers (NIMs - focal points for data management) can be nominated to take responsibly for collection of the data from National Reference Laboratories and other national laboratories involved in regional monitoring, where the data from sampling and analysis are generated. In the next step, the NIMs may take responsibility for data checking, preparation in an agreed data exchange file format (DEFF) ready for sending to the Central Point. At this location the data need to be checked again and suspicious data can be consulted with NIMs. After the consultation process the data will need to be merged and stored in one relational database for further use.

The most sophisticated arrangement for data management in the region is the Water Management System Water Quality Database held by South Africa's DWAF:

http://www.dwaf.gov.za/iwqs/wms/index.asp

Amongst other information, the WMS database provides for:

- WMS Procedural Manual and Help
- WMS Installation Manual
- Electronic Import Facility
- Geographical Water Quality Data Exploration Tools
- Text-based Monitoring Point Inventory
- Miscellaneous Documentation, Reports, Maps
- Features registered on WMS with unique identifiers

Access to this database is currently without any restriction. An internet-based browser tool provides access to more than sixty thousand water quality sites in South Africa, some monitored as early as the 1950s. Some are groundwater sites with only one record; others are River sites with thousands of samples. Links are available to pre-packaged PDF graphs and data files listing the more common water quality constituents.

Files for displaying data in Google Earth help visualise sites in relation to one another and to assess the strengths and weaknesses of the sampling network. A typical visual picture of the monitoring network as it would apply to this study can be seen as follows for the Lower Orange and the Upper Orange-Senqu portions of the River Basin (Figures 3.6 and 3.7):

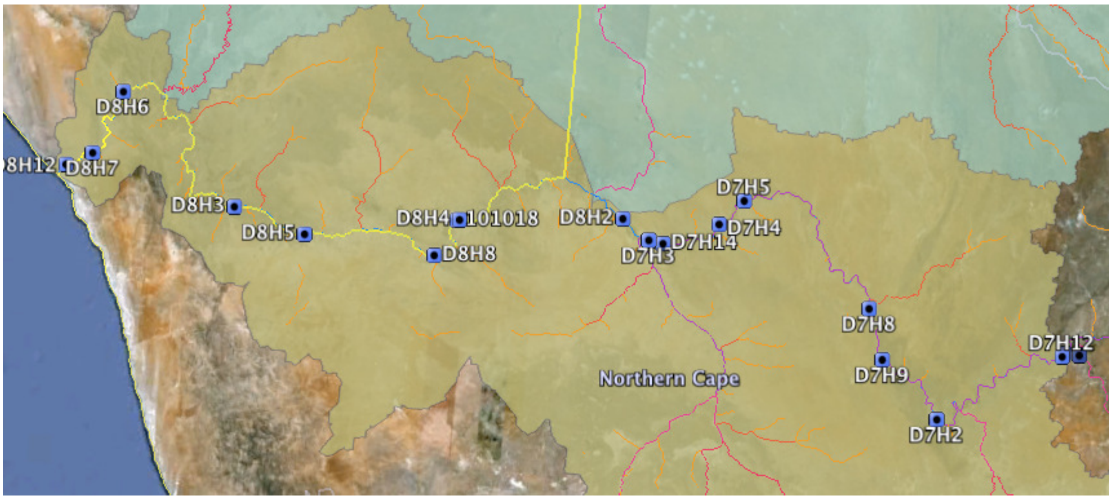


Figure 3.6 The Lower Orange Monitoring Points between Namibia and South Africa

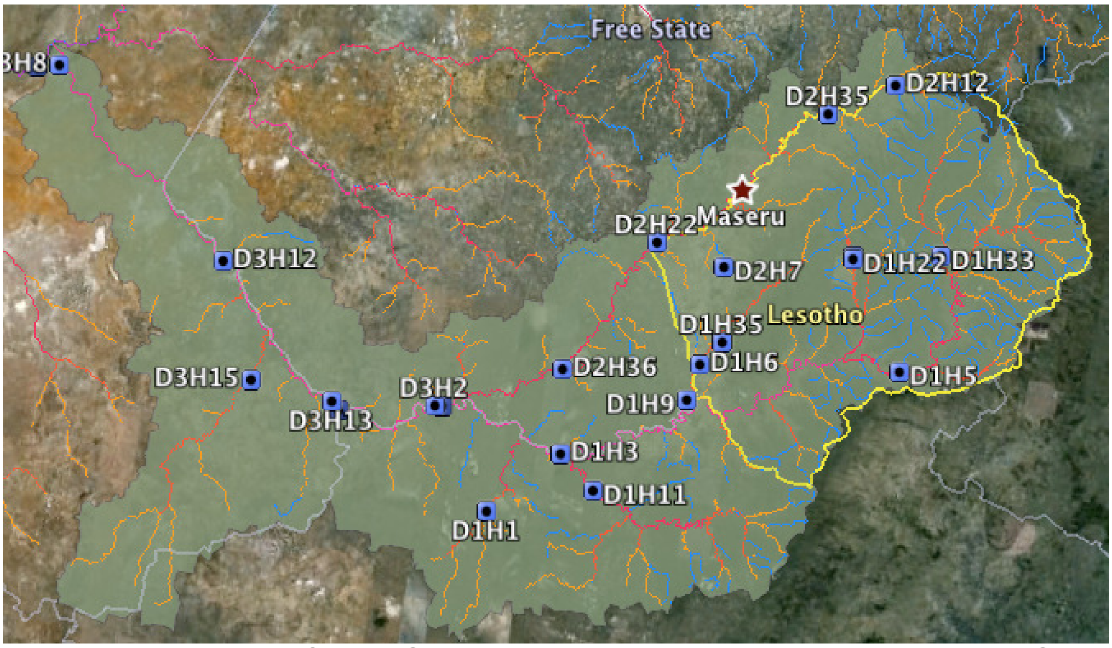


Figure 3.7 The Upper Orange-Senqu Monitoring Points between Lesotho and South Africa

As described on the DWA website, the vision of the WMS is to have a working integrated computer system for South Africa where different directorates and regions, with different mandates and functions, can support each other, sharing information and the workload, and in this way helping the Department of Water Affairs to be consistent in all its decisions and actions in the management of water resources.

The Consultant proposes that these same principles be extended to the Member States from DWA through ORASECOM in order to extend the present DWA WMS to include data from Botswana (groundwater only), Lesotho and Namibia. If such an extension of the WMS is agreed, the access to the database may need to be restricted to designated national authorities in each Member State. The reasoning behind this is simply to avoid confusion (false messages) in the region, which can result in the intentional or unintentional misuse of the data by non-experts, such as NGOs. An assessment of the collated data could be published by ORASECOM in a summary annual report, highlighting the status and future challenges of the Orange-Senqu River Basin with respect to water quality.

In relation to Decision Box F, for Points 1, 2, 3, 4, 5 and 6, the Member States are asked to provide their preference for (a) water quality data to be shared, (b) the data exchange file format to be used, (c) the location of a central platform to house the data, and (d) the level and type of access required.

4. Conclusions and Recommendations

1) In order to establish a regionally effective water quality management and quality assurance system, in terms of an organisational approach the Member States may choose to (a) provide support under the auspices of the current Technical Task Team, (b) designate an Implementing Agent, (c) employ consultants through ORASECOM, or (d) instigate the formation of a Task Team with specific responsibilities for monitoring, laboratory analysis, information and data management.

2) The proposed monitoring network for regional water quality can make use of the current monitoring locations. In the first instance, the selection of 11 surface monitoring locations based on transboundary criteria is recommended. Further monitoring stations, relating to point source discharges, abstraction points and water transfers may be added to the monitoring network by the Member States in the future as required. The initial surface water quality monitoring stations are proposed as follows:

    Upper Orange Senqu:
    - Caledon River at confluence with little Caledon
    - Little Caledon River at the Poplars
    - Caledon River at Ficksburg
    - Caledon River at Maseru
    - Kornetspruit at Maghaleen
    - Orange River at Oranjedraai

    Lower Orange:
    - Vaal River at Douglas
    - Orange River at Pella Mission
    - Orange River at Vioolsdrift
    - Orange River at Sendelingsdrift
    - Orange River at Alexander Bay

3) A use of priority monitoring variables and trigger values (TV) are proposed for the following water uses in the Upper Orange-Senqu and the Lower Orange catchment areas - agriculture (aquaculture, irrigation and livestock watering); domestic, ecosystem protection, industrial and recreation. The TVs will need to be agreed on a bilateral basis for each sampling station based on the current status, historical trend and level of protection required by the Member States.

4) The basis for a transboundary groundwater monitoring programme (as part of the regional monitoring programme) is suggested for the four main transboundary aquifers. A proposal is made for qualitative and quantitative monitoring. A decision is required from the Member States in relation to the choice of monitoring boreholes.

5) The basis for an effective regional analytical quality control is proposed. This includes the introduction of (i) analytical accuracy targets for monitoring the quality of water, and (ii) a performance-testing scheme, which needs to be established and implemented as the primary inter-laboratory quality control program in the Orange-Senqu River Basin, with the participation of the laboratories involved in the transboundary water quality monitoring.

6) The procedure of data collection must start on a national level of each country. National Information Managers (NIMs) are proposed to take responsibly for collection of the data from the national laboratories involved in regional monitoring where the data from sampling and analysis are generated. In the next step the NIMs may take responsible for data checking, preparation in an agreed data exchange file format (DEFF) ready for sending to the Central Point. After the consultation process the data will need to be merged and stored in one relational database for further use. The Consultant proposes that regional data be ultimately stored under the auspices of the South Africa DWA in

their Water Management System Water Quality Database in order to extend the present DWA WMS to include data from Botswana (groundwater only), Lesotho and Namibia.

7) An assessment of the collated data can be presented in a summary annual report on an annual basis, highlighting the status of the Orange-Senqu River Basin in respect to water quality.

Annex 1 Meetings Held with Stakeholders

The following meetings and discussions have taken place during the assignment:

1. Meeting with GTZ Project Management Team to discuss issues around the GTZ and EU support work on water quality.

2. Meeting with the ORASECOM Commissioner for Botswana to discuss the approach to development of RWQOs on a transboundary level.

3. Meeting with the Namibian representatives to discuss the approach to development of RWQOs on a transboundary level.

4. Meeting with the Lesotho representatives to discuss the approach to development of RWQOs on a transboundary level

5. Meeting with South Africa' s DWA representatives to discuss the approach to development of RWQOs on a transboundary level.

6. Workshop with all Member States conducted at The Airport Grand Hotel, Johannesburg on November 18th. The initial opinions and options for the Member States with respect to the development of a framework for regional water quality management are included in Decision Boxes A-F contained in the body of this report.

<table>
<tr><td colspan="2">Meeting No. 1</td></tr>
<tr><td colspan="2">Purpose of Meeting: To discuss issues around the GTZ and EU support work on water quality</td></tr>
<tr><td colspan="2">Location: WRP Offices, Pretoria</td></tr>
<tr><td colspan="2">Date: 12th October 2009

Time: 9.30-10.30am</td></tr>
<tr><td colspan="2">Persons Present: Steve Crerar (GTZ Project Coordinator for ORASECOM IWRM Plan – Phase 2), Ronnie Mackenzie (GTZ Project Management), Gavin Quibell (EU Project Coordinator), Patrick Reynolds (EU Short Term Expert).</td></tr>
<tr><td>Discussions/Outcomes:

Discussion focussed on the potential overlap between the EU work and Task 3.1 under the GTZ support water quality package, which aims to establish a framework for the water quality monitoring programme, data management and a reporting system to provide water quality management information to the water resources managers of the Basin states.

In the meeting, it was agreed to work closely on it so that we can speak with one voice at a proposed joint water quality workshop and to ensure that the GTZ support water quality can proceed into the implementation phase (the EU support will effectively end with the Nov 18 workshop) on the right mutually agreed basis.</td><td>Actions:

SC to draft letter of invitation to be sent to member States by the ORASECOM Permanent Secretariat

PR to contact Trevor Coleman to arrange joint regional meetings with stakeholders</td></tr>
</table>

Meeting No. 2	
Purpose of Meeting: Meeting with the ORASECOM Commissioner for Botswana to discuss the approach to development of RWQOs on a transboundary level	
Location: Gaborone, International Water Unit, Botswana	
Date: 14th October 2009 **Time:** 10.30-12.30	
Persons Present: Thato Setloboko (Commissioner, Botswana), Bogadi Mathargwane (Chemist, Water Quality Expert, Botswana), Gavin Quibell (EU Project Coordinator), Patrick Reynolds (EU Short Term Expert).	
Discussions/Outcomes: Discussions were centred on a list of guiding questions that were prepared and circulated prior to the meeting. The questions and answers are shown below: 1. Institutional: c. What function/role do you perceive ORASECOM to hold in relation to monitoring and information management concerning water quality issues? TS stated that the function of ORASECOM would be to organise transboundary monitoring at key sites for selected determinants related to known issues of transboundary pollution, and to provide advice to Council on such issues. The mitigation of such pollution would ultimately be the responsibility of bilateral, and national water management and enforcement, organisations. d. What national and regional institutional arrangements would you propose in order to implement an effective system of water management with respect to water quality targets/objectives? PR proposed the idea of the formation of a regional monitoring, information and data management (MIDM) task team, which would act on behalf of ORASECOM to manage transboundary monitoring and provide the TTT with recommendations for Council. Such a task team would also act as a focal point for the subsequently planned studies under the GTZ and the GEF/UNDP projects concerning water quality (i.e. POPs monitoring and modelling studies). TS and BM agreed with the formation of such a task team. TS indicated that the formation of a monitoring task team (and Terms of Reference) is ultimately the decision of Council. TS also stated that the formation of such a task team would provide an essential and positive development in the ORASECOM institutional arrangements by spreading the ever-increasing workload, which is essential in the future functioning of the Member States responsibilities. The current situation places many demands on too few designated national personnel who are responsible for multi-functions in the	**Actions:**

operation and organisation of ORASECOM.

BM further commented that laboratories could be designated in each of the countries to act on behalf of ORASECOM for monitoring pre-agreed chemical and biological determinants.

2. Setting of Transboundary Water Quality Objectives:

g. What are the key transboundary issues you wish to see addressed by the establishment of water quality objectives? What do you regard as the driving forces of transboundary issues?

   Key issues of transboundary pollution, highlighted by GQ ad agreed by TS and BM, related to potential of future salt and nutrient overloading of the Vaal system and the potential inadequate quality of future transfer waters. TS and BM highlighted issues concerning the shared groundwaters where actual problems of water quality (and reserve quantity are not clear.

h. Would you envisage the development of narrative water quality objectives in the short-term with numeric values in the longer term?

   PR commented that the length of the assignment (2 months) does not provide enough time for agreement of Parties to numeric RWQOs. TS and BM agreed that the setting of numeric objectives might not be a practical approach at such an early stage of the development of transboundary RWQOs. Although TS stated that will however depend on the information available on water quality between the member States for transboundary locations. BM stated that if insufficient monitoring information is available for transboundary waters, such as for shared aquifers, then a programme of monitoring must be initially proposed and implemented.

i. In determining water quality objectives, would you regard 'fitness-for-use' as the driving factor?

   TS did not object to this approach. GQ commented that a 'fitness-for-use' study under the EU support was not finalised at this date. The results of the study will support the framework and development of RWQOs.

j. Do you wish to see ORASECOM's responsibility extending into the marine receiving/transitional waters with the development of specific water quality objectives?

   TS did not agree to an extension of the setting of RWQOs to the marine environment. TS explained that the ORASECOM Agreement under Article 7.14 tasks the Member States only with the protection and preservation of the estuary. TS did however agree that coordination with the organisations responsible for the protection of the marine environment would be necessary in the future,

k. Do you wish to establish short and medium term emission

targets in order to meet the proposed water quality objectives in the receiving water? There was a general agreement that the setting and enforcement of emission targets is critical in the protection of the Orange-Senqu ecosystem as a whole. However, TS pointed out that the responsibility for setting emission targets is a national (and bilateral) responsibility. In this regard, a transboundary monitoring programme implemented by ORASECOM would help identify problems that would need to be addressed by bilateral committees and ultimately on a national level. TS regarded this feedback loop as the most practical arrangement. l. How is water quality assessment of major aquifers carried out? Do you perceive the need for the implementation of groundwater quality objectives? TS and BM both agreed that the protection and future use of transboundary groundwaters was an area of concern, which lacked a comprehensive programme of monitoring and assessment. Botswana has transboundary aquifers with RSA and Namibia. TS commented that the ultimate aim of a monitoring and assessment programme must be to provide sustainable operation of shred aquifers between the Member States. BM stressed that a monitoring programme of transboundary groundwaters is required to determine water quantity and quality. It was suggested that key monitoring points be established for determination of chloride and surface recharge. Other determinants would be considered in a monitoring and assessment programme to be proposed by the EU team. m. Do you wish to have water quality objectives set for sub-Basin confluence points in addition to border areas? Which key points at border areas would you wish to see sampling/monitoring activities increased? TS and BM agreed that the monitoring of sub-Basin confluences was essential in order to ultimately protect the overloading of pollutants between one country and another. QB suggested that effective protection of the environment would be achieved by monitoring for chemical pollution together with biological sampling in the Vaal system at key points. This approach was generally accepted. Monitoring: c. Do you perceive any relationship between your national monitoring programme and a programme of monitoring which would be designed specifically to address transboundary issues? TS and BM regarded the transboundary monitoring as a defined programme of activity to be agreed by ORASECOM. GQ suggested that such a programme of monitoring might be carried out by an independent organisation in order to reduce the inevitable variability surrounding sampling and analysis by	

each of transboundary Member States. PR suggested that for future regional development and responsibility for the protection of the Orange-Senqu River Basin, it would be important to develop local expertise in transboundary monitoring with designated laboratories in each country. TS requested consideration for a transboundary monitoring programme that includes monitoring of both water flow and quality in the Member States. d. Are your national laboratories accredited by national or international schemes? How would you respond to the involvement in ORASECOM in issues related to data quality? BM stated that Botswana and South Africa already have in place a bilateral monitoring programme. This programme consists of common national sampling and analysis of transboundary sites and data sharing. Analysis of samples are carried out in by national laboratories in each country as well as by a third independent laboratory. Laboratories that take part in this monitoring programme are nationally accredited. GQ indicated that with a system is in place, this will provide a precedent for other Member States and bilateral associations. Information regarding the common monitoring was requested from BM. There was no disagreement for the involvement of ORASECOM in the issues related to data quality. Reporting/Data Handling: c. How do you envisage the process for reporting and management of data for transboundary monitoring of water quality? Answer provided in 1b above: under the auspice of a MIDM Task team in association with a bilateral associations. d. What would you expect ORASECOM's role would be in data management and reporting on defined and agreed water quality objectives? Answer provided in 1a above	BM to provide the EU project with information related to the bilateral monitoring programme.

Meeting No. 3

Purpose of Meeting: Meeting with the Namibian representatives to discuss the approach to development of RWQOs on a transboundary level

Location: Windhoek, Ministry of Agriculture, Water and Forestry (MAWF), Namibia

Date: 28th October, 2009

Time: 10.30-12.30

Persons Present: Elise Mbandeka (MAWF), Shishani Nakanwe (MAWF), Tobias Angula (MAWF), Kevin Roberts (MAWF), Matthew Hambabi (MAWF), Nicholene Kulobone (MAWF), Henry Beukes (MAWF), Gavin Quibell (EU Project Coordinator), Patrick Reynolds (EU Short Term Expert), Trevor Coleman (Water Quality Expert, GTZ Project), Rapule Pule (ORASECOM)

Discussions/Outcomes:

Discussions were centred on a list of guiding questions, which were prepared and circulated prior to the meeting. The questions and answers are shown below:

1. Institutional:

   a. What function/role do you perceive ORASECOM to hold in relation to monitoring and information management concerning water quality issues?

      Generally there was agreement that ORASECOM should act to coordinate transboundary data between Namibia and RSA as well as between Namibia and Botswana for groundwater.

   b. What national and regional institutional arrangements would you propose in order to implement an effective system of water management with respect to water quality targets/objectives?

      Currently the national monitoring system for water quality does not exist. However, there are 13 regions in the country as a whole. Data is collected by each region and collated in the central ministry at MAWF. The institutional arrangements have been discussed in Namibia recently but are not finalised as yet.

      The main issue for Namibia was related to the lack of capacity in country to carry out all functions of a national monitoring network and data management and reporting system.

2. Setting of Transboundary Water Quality Objectives:

   a. What are the key transboundary issues you wish to see addressed by the establishment of water quality objectives? What do you regard as the driving forces of transboundary issues?

      Unclear as regards groundwater since the data on water quality is not collected. Also for groundwater, the quantity of the resource is not known even though licences for abstraction are

Actions:

The list of questions was provided to Elise Mbandeka following our meeting – this was suggested as the best way to provide our project with full answers to the questions – brief answers obtained in the meeting are provided to the left

readily provided to water users. For surface waters, emphasis was on salt concentrations, which are believed to have caused vegetation to die, although there was confusion over transboundary effects of salt concentrations (TDS) and agricultural return flows/mining activities. A document of environmental monitoring of NAMDEB was received which details the impact of Daberas mine on the vegetation on the bank of the orange River. Eutrophication was also regarded as a problem although data was not available. It was also noted that recreational waters are not monitored in Namibia. b. Would you envisage the development of narrative water quality objectives in the short-term with numeric values in the longer term? Numeric values are preferred. This is common practice for MAWF. c. In determining water quality objectives, would you regard 'fitness-for-use' as the driving factor? Not discussed since the EU 'fitness-for-use' report has not been finalised as yet. d. Do you wish to see ORASECOM's responsibility extending into the marine receiving/transitional waters with the development of specific water quality objectives? General agreement on the management only of transitional/estuarine waters with objectives set for water quality. e. Do you wish to establish short and medium term emission targets in order to meet the proposed water quality objectives in the receiving water? Not discussed. f. How is water quality assessment of major aquifers carried out? Do you perceive the need for the implementation of groundwater quality objectives? There are two types of aquifers in Namibia, perched with potential high salt concentrations and deep aquifer containing a valuable source of freshwater. A total of 10 boreholes are measured for water levels using data loggers. No water quality is measured. The development of RWQOs for was agreed as a necessary part of future management of the groundwater. Cooperation with Botswana for the management of groundwater was also regarded as essential- a series of studies are required together with Botswana, which include determination of groundwater recharge and water quality measurements. Data sharing on a governmental level between Namibia and Botswana is not carried out, and as such, the role of ORASECOM is seen as essential in developing such an operating structure.	

g. Do you wish to have water quality objectives set for sub-Basin confluence points in addition to border areas? Which key points at border areas would you wish to see sampling/monitoring activities increased? Key points for the setting of RWQOs will be provided to the EU team after further internal discussion. The Noord Oewer was highlighted as a common border point with downstream users but no upstream users. This is also a water abstraction point. Future low flow gauging will be carried out by Namibia and RSA where each country will have their own station and will not be allowed to operate the other country station. Monitoring: a. Do you perceive any relationship between your national monitoring programme and a programme of monitoring which would be designed specifically to address transboundary issues? A relationship with national and transboundary monitoring was agreed. The development of the latter was not disagreed as a function of ORASECOM. The new Water Act (under finalisation) was regarded as the correct way forward for the development of clauses in conjunction with ORASECOM and project recommendations. b. Are your national laboratories accredited by national or international schemes? How would you respond to the involvement in ORASECOM in issues related to data quality? Two national laboratories function for water quality: Analytical Laboratory Services for all chemical-physical data, and NAMM Water for algae and Chl a measurements. A national accreditation scheme is not in place. Analytical measurements are by ISO methodologies– more information will follow to determine which methods are used for which determinants. Reporting/Data Handling: a. How do you envisage the process for reporting and management of data for transboundary monitoring of water quality? Water quality data collected in the future will be deposited in the GROWAS database, which is being upgraded to accept water quality data in the near future. Currently, the water quality data is complied for the MAFW an annual report (2007/2007 report has been finalised – 2007/2008 is not finalised as yet). There were no disagreements to the selection of transboundary stations and the sharing of data with other Member States. b. What would you expect ORASECOM's role would be in data management and reporting on defined and agreed water quality objectives? The ORASECOM role was seen as one of coordination and reporting to Council.	

Meeting No. 4

Purpose of Meeting: Meeting with the Lesotho representatives to discuss the approach to development of RWQOs on a transboundary level

Location: Maseru, Department of Water Affairs (DWA), Lesotho

Date: 30th October 2009

Time: 10.00-12.30

Persons Present: Matsolo Migwi (DWA), Vuyani Monyake (DWA), Nena Leshoboro (DWA), Mootlatsi Lesupi (DWA), Sekhonyana Lerotholi (DWA), Gavin Quibell (EU Project Coordinator), Patrick Reynolds (EU Short Term Expert), Trevor Coleman (Golders, SA), Rapule Pule (ORASECOM)

Discussions/Outcomes:

Discussions were centred on a list of guiding questions, which were prepared and circulated prior to the meeting. The questions and answers are shown below:

1. Institutional:

   a. What function/role do you perceive ORASECOM to hold in relation to monitoring and information management concerning water quality issues?

      General agreement that ORASECOM should coordinate the process of joint monitoring of transboundary stations

   b. What national and regional institutional arrangements would you propose in order to implement an effective system of water management with respect to water quality targets/objectives?

      Currently the DWA meet with RSA's DWAF to discuss monitoring of waters. In fact, the meetings are between Lesotho and the Free State and not RSA as a whole. Generally agreed that ORASECOM should be the key player in this process

2. Setting of Transboundary Water Quality Objectives:

   a. What are the key transboundary issues you wish to see addressed by the establishment of water quality objectives? What do you regard as the driving forces of transboundary issues?

      Issues were discussed relating to chemical pollution in groundwaters from agricultural activities, suspended solids in surface waters, heavy metals in surface waters from industrial sources, eutrophication (as a result of the poor treatment at the SWT plant in Maseru).

   b. Would you envisage the development of narrative water quality objectives in the short-term with numeric values in the longer term?

Actions:

The list of questions was provided to all DWA representatives who attended the meeting – this was suggested as the best way to provide our project with full answers to the questions – brief answers obtained in the meeting are provided to the left

No discussion except the agreement that the assimilative capacity of the surface water must be calculated before any numeric values are proposed and agreed.

c. In determining water quality objectives, would you regard 'fitness-for-use' as the driving factor?

   Not discussed since the EU 'fitness-for-use' report has not been finalised as yet.

d. Do you wish to establish short and medium term emission targets in order to meet the proposed water quality objectives in the receiving water?

   This was to be expected in the future especially concerning industrial discharges.

e. How is water quality assessment of major aquifers carried out? Do you perceive the need for the implementation of groundwater quality objectives?

   There are two main transboundary aquifer types: the Carrie system and numerous dyke aquifers. Currently, activities are not carried out in a coordinated fashion by both countries. A series of activities are required prior to the development of RWQOs for groundwater (these will be further elucidated by return of questionnaire from DWA staff in Lesotho).

f. Do you wish to have water quality objectives set for sub-Basin confluence points in addition to border areas? Which key points at border areas would you wish to see sampling/monitoring activities increased?

   A proposal for monitoring points will be provided.

Monitoring:

a. Do you perceive any relationship between your national monitoring programme and a programme of monitoring which would be designed specifically to address transboundary issues?

b. Are your national laboratories accredited by national or international schemes? How would you respond to the involvement in ORASECOM in issues related to data quality?

   No accreditation currently in place – the set up of a monitoring and information management advisory group to ORASECOM would be regarded as a positive development for inclusion of monitoring specialists from the Member States and for a further and much needed dissemination of information to all persons working on water quality

Reporting/Data Handling: a. How do you envisage the process for reporting and management of data for transboundary monitoring of water quality? To be addressed in a response to the questionnaire. b. What would you expect ORASECOM's role would be in data management and reporting on defined and agreed water quality objectives? The ORASECOM role was seen as one of coordination and reporting to Council for further decision/consideration of appropriate actions.	

Meeting No. 5

Purpose of Meeting: Meeting with the South African representatives to discuss the approach to development of RWQOs on a transboundary level

Location: Pretoria, Department of Water Affairs and Forestry (DWAF),

Date: 11th November, 2009

Time: 08.30-11.00

Persons Present: Pieter Viljoen (DWAF), Geert Grobler (DWAF), Jurgo van Wyk (DWAF), Gavin Quibell (EU Project Coordinator), Patrick Reynolds (EU Short Term Expert),

Discussions/Outcomes:	Actions:
Discussions were centred on a list of guiding questions, which were prepared and circulated prior to the meeting. The questions and answers are shown below: 1. Institutional: a. What function/role do you perceive ORASECOM to hold in relation to monitoring and information management concerning water quality issues? Generally there was agreement that ORASECOM should act to coordinate transboundary data between RSA other member States b. What national and regional institutional arrangements would you propose in order to implement an effective system of water management with respect to water quality targets/objectives? DWAF system for water quality management is available for other Member States to add data to and use. 2. Setting of Transboundary Water Quality Objectives: a. What are the key transboundary issues you wish to see addressed by the establishment of water quality objectives? What do you regard as the driving forces of transboundary issues? Eutrophication, increasing salt concentrations, heavy metals (possibly). Microbial and nutrient pollution arising from the upper Orange-Senqu. b. Would you envisage the development of narrative water quality objectives in the short-term with numeric values in the longer term? Numeric values are preferred. c. In determining water quality objectives, would you regard 'fitness-for-use' as the driving factor?	

Not discussed d. Do you wish to see ORASECOM's responsibility extending into the marine receiving/transitional waters with the development of specific water quality objectives? General agreement on the management only of transitional/estuarine waters with objectives set for water quality. e. Do you wish to establish short and medium term emission targets in order to meet the proposed water quality objectives in the receiving water? Not discussed. f. How is water quality assessment of major aquifers carried out? Do you perceive the need for the implementation of groundwater quality objectives? Not discussed g. Do you wish to have water quality objectives set for sub-Basin confluence points in addition to border areas? Which key points at border areas would you wish to see sampling/monitoring activities increased? RWQOs are provided for all designated key monitoring points in South Africa (document received). Monitoring: a. Do you perceive any relationship between your national monitoring programme and a programme of monitoring which would be designed specifically to address transboundary issues? A relationship with national and transboundary monitoring was agreed although only certain points can be regarded as being of transboundary importance. Reporting/Data Handling: a. How do you envisage the process for reporting and management of data for transboundary monitoring of water quality? Under the current DWAF water quality management system. b. What would you expect ORASECOM's role would be in data management and reporting on defined and agreed water quality objectives? The ORASECOM role was seen as one of coordination and reporting to Council.	

Annex 2 Water Quality Limits Based on Water Use

Note: All tables reproduced from the DWAF study entitled "Resource Water Quality Objectives for the Upper and Lower Orange Water Management Areas (WMAs)", 2009

Table 1: Generic water quality limits for Domestic Use (Modified from DWAF, 1996; 2006, 2008).

Variable	Units	Domestic use				BHN
		Ideal	A#	T#	U#	Ideal
Algae (Chl-a)	µg/ℓ	≤ 1	10	15	>15	–
Aluminum (Al)	mg/ℓ	≤ 0.15	0.5	>0.5	>0.5	–
Ammonia (NH_3-N)	mg/ℓ	1.0	2.0	10.0	>10.0	–
Arsenic (As)	µg/ℓ	≤ 10	50	200	>200	–
Cadmium (Cd)*	µg/ℓ	≤ 3	10	20	>20	–
Calcium (Ca)	mg/ℓ	≤ 32	150	300	>300	80
Chloride (Cl)	mg/ℓ	≤ 100	200	600	>600	200
Chromium (VI)	mg/ℓ	≤ 0.05	1.0	5.0	>5.0	–
Copper (Cu)*	mg/ℓ	≤ 1.0	1.3	2.0	>2.0	–
EC	mS/m	≤ 70	150	370	>370	–
Fecal coliforms	cfu/100 mℓ	0	1	10	>10	–
Fluoride (F)	mg/ℓ	≤ 0.7	1.0	1.5	>1.5	–
Hardness – Total	mg $CaCO_3$/ℓ	≤ 200	300	600	>600	–
Iron (Fe)	mg/ℓ	≤ 0.5	1.0	5.0	>5.0	–
Lead (Pb)*	µg/ℓ	≤ 10	50	100	>100	–
Magnesium (Mg)	mg/ℓ	≤ 70	100	200	>200	100
Manganese (Mn)	mg/ℓ	≤ 0.1	0.4	4.0	>4.0	–
Mercury (Hg)	µg/ℓ	≤ 1.0	5.0	20.0	>20	–
Nitrate + Nitrite (NO_3- & NO_2-N)	mg/ℓ	≤ 6.0	10.0	20.0	>20	–
pH (lower)	Units	5.0	4.5	4.0	< 4.0	5
pH (upper)	Units	9.5	10.0	10.5	> 10.5	9.5
Potassium (K)	mg/ℓ	25	50	100	>100	150
Selenium (Se)	µg/ℓ	≤ 20	50	100	>100	–
Sodium (Na)	mg/ℓ	≤ 100	200	400	>400	200
Sulphate (SO_4)	mg/ℓ	≤ 200	400	600	>600	400
TDS	mg/ℓ	≤ 450	1 000	2 400	>2 400	1 000
Total coliforms	cfu/100 mℓ	0	10	100	>100	–
Vanadium (V)	mg/ℓ	≤ 0.1	0.5	1.0	>1.0	–
Zinc (Zn)	mg/ℓ	≤ 3	5	10	>10	–

A# Acceptable; T# Tolerable; U# Unacceptable; BHN, Basic Human Needs; EC, Electrical conductivity; * moderately hard water; – no value.

Table 2: Generic water quality limits for Aquatic ecosystem and Agricultural Use – Aquaculture (Modified from DWAF 1996, 2006 & 2008).

Variable	Units	Aquatic ecosystem			Aquaculture		
		Ideal	A#	T#	Ideal	A#	T#
Algae (Chl-a)	µg/ℓ	≤ 10	20	30	–	–	–
Alkalinity	mg $CaCO_3$/ℓ	–	–	–	≤ 20	97.5	175
Aluminum (Al)	µg/ℓ	≤ 20	85	150	≤ 30	70	100
Ammonia (NH_3-N)	µg/ℓ	≤ 15	58	100	≤ 30	300	1 000
Arsenic (As)	µg/ℓ	≤ 20	75	130	≤ 50	–	–
Cadmium (Cd)*	µg/ℓ	≤ 0.2	1.3	2.8	≤ 0.8*	–	–
Chloride (Cl)	mg/ℓ	–	–	–	≤ 2.0	6.0	10
Chromium (III)	µg/ℓ	≤ 24	160	340	–	–	–
Chromium (VI)	µg/ℓ	≤ 14	110	200	< 20	20	20
Copper (Cu)*	µg/ℓ	≤ 1.5	3.8	4.6	≤ 5	300	600
Cyanide (CN)	µg/ℓ	≤ 4.0	45	110	≤ 20	110	200
DIN	mg/ℓ	≤ 0.25	0.7	1.0	–	–	–
DO (lower)	mg/ℓ	–	–	–	6	5	4
DO (upper)	mg/ℓ	–	–	–	8	16	20
DO	% saturation	80 – 120	60	40	–	–	–
EC	mS/m	≤ 30	55	85	≤ 40	90	270
Fluoride (F)	mg/ℓ	≤ 1.5	3.0	3.52	–	–	–
Hardness – Total	mg $CaCO_3$/ℓ	–	–	–	≤ 50	175	300
Iron (Fe)	mg/ℓ	–	–	–	≤ 0.01	0.88	1.75
Lead (Pb)*	µg/ℓ	≤ 1.0	4.0	7.0	≤ 10	1 080	2 150
Manganese (Mn)	mg/ℓ	≤ 0.18	0.37	1.3	≤ 0.1	0.3	0.5
Mercury (Hg)	µg/ℓ	≤ 0.08	0.90	1.7	≤ 1.0	140	280
Nitrate (NO_3-N)	mg/ℓ	–	–	–	≤ 300	650	1 000
Nitrite (NO_2-N)	mg/ℓ	–	–	–	≤ 0.05	70.0	140
Salts - inorganic:							
Salt: $MgSO_4$	mg/ℓ	≤ 16	27	37	–	–	–
Salt: Na_2SO_4	mg/ℓ	≤ 20	36	51	–	–	–
Salt: $MgCl_2$	mg/ℓ	≤ 15	33	51	–	–	–
Salt: $CaCl_2$	mg/ℓ	≤ 21	63	105	–	–	–
Salt: NaCl	mg/ℓ	≤ 45	217	389	–	–	–
Selenium (Se)	mg/ℓ	≤ 0.002	0.005	0.030	≤ 0.3	19	35
pH (lower)	Units	≤ 6.5	5.75	5.0	6.5	5.25	4.0
pH (upper)	Units	8.0	9.0	10.0	9.0	9.0	9.0
Phosphate (PO_4-P)	µg/ℓ	≤ 10	30	130	≤ 80	340	600
TDS	mg/ℓ	≤ 195	360	550	≤ 450	1 000	2 400
Zinc (Zn)	mg/ℓ	≤ 0.002	0.0036	0.036	≤ 1	5	>5

* Moderately hard water; A#, Acceptable; T#, Tolerable; EC, Electrical conductivity; DIN, Dissolved inorganic nitrogen; DO, Dissolved oxygen; TDS, Total dissolved solids; – no value.

Table 3: Generic water quality limits for Agricultural Use – Irrigation and Livestock Watering (Modified from DWAF 1996 and Model).

Variable	Units	Irrigation			Livestock watering		
		Ideal	A#	T#	Ideal	A#	T#
Aluminum (Al)	mg/ℓ	≤ 5.0	12.5	20.0	≤ 5.0	7.5	10.0
Arsenic (As)	mg/ℓ	≤ 0.1	1.05	2.0	≤ 1.0	1.25	1.5
Boron (B)	mg/ℓ	≤ 0.5	0.75	1.0	≤ 5.0	27.5	50
Cadmium (Cd)	µg/ℓ	≤ 10	30	50	≤ 10	15	20
Calcium (Ca)	mg/ℓ	–	–	–	≤ 1 000	1 500	2 000
Chloride (Cl)	mg/ℓ	≤ 100	137.5	175	≤ 1 000	1 750	2 000
Chromium (VI)	mg/l	≤ 0.1	0.55	1.0	≤ 1.0	1.5	2.0
Cobalt (Co)	mg/ℓ	≤ 0.05	2.53	5.0	≤ 1.0	1.5	3.0
Copper (Cu)	mg/ℓ	≤ 0.2	2.6	5.0	≤ 0.5	0.75	1.0
EC	mS/m	≤ 40	270	540	≤ 150	300	450
Fecal coliforms	cfu/100 mℓ	≤ 200	600	1 000	≤ 200	600	1 000
Fluoride (F)	mg/ℓ	≤ 2.0	8.5	15	≤ 2.0	4.0	6.0
Iron (Fe)	mg/ℓ	≤ 5.0	12.5	20	≤ 10	30	50
Lead (Pb)	mg/ℓ	≤ 0.2	1.1	2.0	≤ 0.1	0.15	0.2
Magnesium (Mg)	mg/ℓ	–	–	–	≤ 500	750	1 000
Manganese (Mn)	mg/ℓ	≤ 0.02	5.0	10	≤ 10	30	50
Mercury (Hg)	mg/ℓ	–	–	–	≤ 1.0	3.5	6.0
Molybdenum (Mo)	µg/ℓ	≤ 10	30	50	≤ 10	15	20
Nickel (Ni)	mg/ℓ	≤ 0.2	1.1	2.0	≤ 1.0	3.0	5.0
Nitrate (NO_3-N)	mg/ℓ	≤ 5.0	17.5	30	≤ 100	150	200
pH	Units	6.5 – 8.4	–	–	–	–	–
SAR – crop*	mmol/ℓ	≤ 2.0	8.0	15	–	–	–
SAR – soil**	mmol/ℓ	≤ 1.5	3.0	6.0	–	–	–
Selenium (Se)	µg/ℓ	≤ 20	40	50	≤ 50	63	75
Sodium (Na)	mg/ℓ	≤ 70	92.5	115	≤ 2 000	2 250	2 500
Sulphate (SO_4)	mg/ℓ	–	–	–	≤ 1 000	1 250	1 500
TDS	mg/ℓ	≤ 260	1 755	3 510	≤ 1 000	2 000	3 000
TSS	mg/ℓ	50	75	100	–	–	–
Vanadium (V)	mg/ℓ	≤ 0.1	0.55	1.0	≤ 1.0	1.5	2.0
Zinc (Zn)	mg/ℓ	≤ 1.0	3.0	5.0	≤ 20	30	40

A# Acceptable; T# Tolerable; EC, Electrical conductivity; SAR, Sodium Adsorption Ratio; TDS, Total dissolved salts; TSS, Total suspended solids; * Effect on crop yield and quality; ** Effect on soil physical conditions; – no value

Table 4: Generic water quality limits for Industrial Use (category 3) and Recreational Use – full contact (Modified from DWAF 1996 and 2006).

Variable	Units	Industrial Use: Category 3			Recreational: Full Contact		
		Ideal	A#	T#	Ideal	A#	T#
Algae (Chl-*a*)	µg/ℓ	–	–	–	≤ 15	22.5	30
Alkalinity	mg $CaCO_3$/ℓ	≤ 300	450	600	–	–	–
Chloride (Cl)	mg/ℓ	≤ 100	150	200	–	–	–
Clarity (Secchi disk)	m	–	–	–	≥ 3	2	1
COD	mg/ℓ	≤ 30	50	100	–	–	–
Coliphages	cfu/100 mℓ	–	–	–	≤ 20	60	100
EC	mS/m	≤ 70	120	250	–	–	–
Escherichia coli	cfu/100 mℓ	–	–	–	≤ 130	200	400
Fecal coliforms	cfu/100 mℓ	–	–	–	≤ 130	600	2 000
Fecal streptococci	cfu/100 mℓ	–	–	–	≤ 30	65	100
Hardness – Total	mg $CaCO_3$/ℓ	≤ 250	375	500	–	–	–
Iron (Fe)	mg/ℓ	≤ 0.3	6.5	10	–	–	–
Manganese (Mn)	mg/ℓ	≤ 0.2	6.0	10	–	–	–
pH (lower)	Unit	≤ 6.5	5.75	5	6.5	5.75	5.0
pH (upper)	Unit	8.0	9.0	10.0	8.5	8.75	9.0
Silicon (Si)	mg/ℓ	≤ 20	85	150	≤ 50	63	75
Sulphate	mg/ℓ	≤ 200	250	300	–	–	–
TDS	mg/ℓ	≤ 450	800	1 600	≤ 1 000	2 000	3 000
TSS	mg/ℓ	≤ 5	20	50	–	–	–

A# Acceptable; T# Tolerable; EC, Electrical conductivity; COD, Chemical oxygen demand; TSS Total suspended solids; – no value

Annex 3 Ecological Classification

Note: All tables reproduced from the DWAF study entitled "Resource Water Quality Objectives for the Upper and Lower Orange Water Management Areas (WMAs)", 2009

Table 1: **Ecological** Classification system for the assessment of the ecological integrity status of surface water resources (Source: DWAF 1997).

	Class	Ecological Integrity Status
Ecologically Sustainable	A	**Unmodified, natural**; the resource base reserve has not been decreased - the resource capability has not been exploited.
	B	**Largely natural** with few modifications; the resource base reserve has been decreased to a small extent. A small change of natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
	C	**Moderately modified**; the resource base reserve has been decreased to a moderate extent. A change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.
	D	**Largely modified**; the resource base reserve has been decreased to a large extent. Large changes in natural habitat, biota and basic ecosystem functions have occurred.
Ecologically Unsustainable	E	**Seriously modified**; the resource base reserve has been seriously decreased and regularly exceeds the resource base. The loss of natural habitat, biota and basic ecosystem functions is extensive.
	F	**Critically modified**; the resource base reserve has been critically decreased and permanently exceeds the resource base. Modifications have reached a critical level and the resource has been modified completely with an almost total loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

Table 2: Ecological importance and sensitivity categories

Ecological importance and sensitivity categories
Very high Quaternary catchments that are considered unique on a national or even international level based on unique biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These Rivers (in terms of biota and habitat) are usually very sensitive to flow modifications and have no or only a small capacity for use.
High Quaternary catchments that are considered to be unique on a national scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These Rivers (in terms of biota and habitat) may be sensitive to flow modifications but may have a substantial capacity for use.
Moderate Quaternary catchments that are considered to be unique on a provincial or local scale due to biodiversity (habitat diversity, species diversity, unique species, rare and endangered species). These Rivers (in terms of biota and habitat) are usually not very sensitive to flow modifications and often have a substantial capacity for use.
Low/marginal Quaternary catchments that are not unique at any scale. These Rivers (in terms of biota and habitat) are generally not very sensitive to flow modifications and usually have a substantial capacity for use.

Annex 4 Monitoring Variables, Current Status, RWQOs and Trigger Values

This Annex provides the detailed information of the RWQOs derived by DWA for each water use for each of the 11 selected transboundary monitoring sites. Each of the tables (one per proposed transboundary monitoring location) includes the following basic information:

- A description of the location and coordinates;
- The reason for their inclusion in the proposed regional monitoring network, according to criteria for transboundary or basin-wide monitoring;
- The water uses identified at the monitoring location;
- The monitoring variables, the available data, their present state and the proposed RWQOs (by South Africa's DWA).
- Priority variables for inclusion in the initial phase of the regional monitoring programme (highlighted in red)
- Suggested Trigger Values (TV) for priority variables for intervention by ORASECOM (See Section 3.6). In most cases, as an example, the TVs were matched to the acceptable level of the most sensitive water use to ensure that a further degradation of the present water quality does not take place without intervention. Please note, these values are based on the South African limit values (Annex 2) and as such may not be appropriate for all Member States.

The RWQOs are determined through the integration of the ecological and water user requirements, with the most stringent water quality or most sensitive water user, defining the RWQOs within the desired category or management class.

With respect to the setting of RWQOs, it is important to visualise the required level of protection afforded to water for each user. The tables below present the actual RWQOs for each variable measured, however, such detail may distract from the actual objectives, which are set for the level of water protection as ideal, acceptable or tolerable.

The water user category RWQOs that are used in this Annexure are fully based on the recently published report "Resource Water Quality Objectives for the Upper and Lower Orange Water Management Areas (WMAs)" by DWA. The report uses South African Water Quality Guidelines (reproduced in Annex 2) through application of DWA's RWQOs Model 4.1.

The DWA study was guided by the catchment visions of the WMAs that describe the level of protection required by the water users and stakeholders in the area. In the DWA report, emphasis is fully placed on water quality, *i.e.* "to ensure that water supplies are of an acceptable quality to all water users." In their report, the DWA water users selected includes either the Ecological Reserve Category or Ecological WQ guidelines and then usually Basic human needs, Domestic use, Agriculture – Stock watering, Agriculture – Irrigation, (occasionally Agriculture-aquaculture), Industrial category 3 & 4, Recreational – full contact and intermediate contact. The specific water users in the catchment were identified for the applicable reach in the Orange River.

Proposed Station 1 (Upper Orange-Senqu)

Description	**Caledon River at confluence with the Little Caledon**
Transboundary Criteria	**Criteria 1** - Just upstream/downstream of an international border; **Criteria 2** - Upstream of confluences between the main River and main tributaries (or main tributaries and larger sub-tributaries), which arise from an upstream country
Coordinates	**S28.69363; E28.23445**
Alternate ID	**South Africa - New ID: CS1**
Data Availability	**Reference State: No data** **Present State: Snapshot data (n=2)**

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/TV	Status	RWQO/TV	Status	RWQO/TV	Status	RWQO/TV	Status	RWQO/TV	Status	RWQO/TV	Status	RWQO/TV
Hardness	mg/l	104	175/175												
EC	mS/m			18	30/270			18	30/150			18	30/120		
pH (95th)	unit			8.3	8.4/8.4							8.3	8.4/8.4		
Alkalinity	mg/l	102	175/175												
NH4-N	µg/l	10	15/15												
Calcium	mg/l							25.4	80/150						
Chloride	mg/l			4.4	25/137			4.4	25/200						
Fluoride	mg/l							0.05	0.7/1.0						
Magnesium	mg/l							9.8	30/100						
Potassium	mg/l							0.97	25/50						
SAR (crop)	mmol/l			0.95	1.5/8.0										
Sodium	mg/l			9.3	50/92										
Sulphate	mg/l							15.5	80/400			15.5	80/250		
TDS	mg/l			175	195/360										
PO4-P	µg/l	28	50/340							28	50/30				
TP	µg/l									ND	TBD				

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV
NO3+NO2-N	mg/l							0.29	0.4/10	0.29	0.4/0.7				
DIN	mg/l									0.4	0.5/0.7				
TN	mg/l									ND	TBD				
Si	mg/l											7.8	20/85		
Chl-a	µg/l									2	10/20				
Diatoms	SPI									13.9	13/<13				
E-coli	/100ml													1244	400/400
Ecological Importance and Sensitivity Category: High							Present Ecological Status: C				Recommended Ecological Status: B				

ND: no data; it is suggested that measurements be introduced at this site

TBD: To be determined

TV: Trigger Value. If level is above the TV, intervention by ORASECOM is required

Priority variable for inclusion in the monitoring network

Proposed Station 2 (Upper Orange-Senqu)

Description	**Little Caledon River at the Poplars**
Transboundary Criteria	**Criteria 1** - Just upstream/downstream of an international border; **Criteria 2** - Upstream of confluences between the main River and main tributaries (or main tributaries and larger sub-tributaries), which arise from an upstream country
Coordinates	**S28.69477; E28.23486**
Alternate ID	**South Africa - D2H012Q01; New ID: CSL2/2**
Data Availability	**Reference State: 1975-1978 (n=106)** **Present State: 2005-2007 (n=24)**

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV
Hardness	mg/l							77.3	200/300						
EC	mS/m			47.5	60/270			47.5	60/150			47.5	60/120		
pH (95th)	unit											8.5	8.5/8.5		
Alkalinity	mg/l											216	300/450		
NH4-N	µg/l									10	15/58				
Calcium	mg/l							49.3	80/150						
Chloride	mg/l			10.3	50/137			10.3	50/200						
Fluoride	mg/l							0.2	0.7/1.0						
Magnesium	mg/l							22.2	30/100						
Potassium	mg/l							2.5	25/50						
Aluminium	µg/l			144	150/150	144	150/150								
Arsenic	µg/l							6	10/50						
Cadmium	µg/l							1	5/10						
Copper	µg/l			3	3.8/3.8										
Iron	µg/l											196	300/650		

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV
Manganese	µg/l			64	50/5										
Lead	µg/l					<10	4/50								
Vanadium	µg/l			<6	10/10										
Zinc	µg/l			5	10/10										
SAR (crop)	mmol/l			0.48	1.5/8.0										
Sodium	mg/l			16.1	70/92										
Sulphate	mg/l							22.9	80/400			22.9	80/250		
TDS	mg/l			381	400/360										
PO4-P	µg/l									41	50/30				
TP	µg/l									ND	TBD				
NO3+NO2-N	mg/l							0.2	0.4/10	0.2	0.4/0.7				
DIN	mg/l									0.33	0.5/0.7				
TN	mg/l									ND	TBD				
Si	mg/l											11.3	20/85		
Chl-a	µg/l									10	15/20				
Diatoms	SPI									11.1	9/<13				
E-coli	/100ml													119	130/400
Ecological Importance and Sensitivity Category: High						Present Ecological Status: D					Recommended Ecological Status: C				

ND: no data; it is suggested that measurements be introduced at this site
TBD: To be determined
TV: Trigger Value. If level is above the TV, intervention by ORASECOM is required

Priority variable for inclusion in the monitoring network

Proposed Station 3 (Upper Orange-Senqu)

Description	**Caledon at Ficksburg. The site is situated at Ficksburg bridge and is included to determine the industrial impacts from Lesotho**
Transboundary Criteria	**Criteria 1** - Just upstream/downstream of an international border; **Criteria 2** - Upstream of confluences between the main River and main tributaries (or main tributaries and larger sub-tributaries), which arise from an upstream country
Coordinates	**28o53’00"S 27o53’24"E**
Alternate ID	**South Africa - D2H035Q01; New ID: CS2**
Data Availability	**Reference State: 1994-1995 (n=51)** **Present State: 2003-2007 (n=23)**

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/TV	Status	RWQO/TV	Status	RWQO/TV	Status	RWQO/TV	State	RWQO/TV	Status	RWQO/TV	Status	RWQO/TV
Hardness	mg/l							154	200/500						
EC	mS/m			37	55/270			37	55/150			37	55/120		
pH (95th)	unit			8.4	8.4/8.4							8.4	8.4/8.4		
Alkalinity	mg/l											159	300/450		
NH4-N	µg/l									9	15/58				
Calcium	mg/l							36.5	80/150						
Chloride	mg/l			7.3	40/137			7.3	40/200						
Fluoride	mg/l							0.18	0.7/1.0						
Magnesium	mg/l							15.2	70/100						
Potassium	mg/l							1.6	10/50						
SAR (crop)	mmol/l			0.38	1.5/8.0										
Sodium	mg/l			9.7	50/92										
Sulphate	mg/l							16.4	80/400			16.4	80/250		
TDS	mg/l			275	360/360										
PO4-P	µg/l									29	30/30				

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV
TP	µg/l									ND	TBD				
NO3+NO2-N	mg/l							0.14	0.2/10	0.14	0.2/0.7				
DIN	mg/l									0.18	0.2/0.7				
TN	mg/l									ND	TBD				
Si	mg/l											11.8	20/85		
Chl-a	µg/l									6	15/20				
Diatoms	SPI									6.1	9/<13				
E-coli	/100ml													1643	400/400
Ecological Importance and Sensitivity Category: High							Present Ecological Status: C				Recommended Ecological Status: B				

ND: no data; it is suggested that measurements be introduced at this site
TBD: To be determined
TV: Trigger Value. If level is above the TV, intervention by ORASECOM is required
Priority variable for inclusion in the monitoring network

Proposed Station 4 (Upper Orange-Senqu)

Description	**Caledon River at Maseru**
Transboundary Criteria	**Criteria 1** - Just upstream/downstream of an international border; **Criteria 2** - Upstream of confluences between the main River and main tributaries (or main tributaries and larger sub-tributaries), which arise from an upstream country
Coordinates	**29o17’52"S 27o29’07"E**
Alternate ID	**South Africa - D2H011Q01; New ID: CS3**
Data Availability	**Reference State: 1981-1994 (n=489)** **Present State: Snapshot values only as monitoring ceased in 1994**

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		State	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV
Hardness	mg/l							118	200/300						
EC	mS/m			27.5	55/270			27	55/150			27.5	55/120		
pH (95th)	unit			8.1	8.4/8.4							8.1	8.4/8.4		
Alkalinity	mg/l											125	300/450		
NH4-N	µg/l									30	58/58				
Calcium	mg/l							29	80/150						
Chloride	mg/l			7.3	40/137			17.8	100/200						
Fluoride	mg/l							0.08	0.7/1.0						
Magnesium	mg/l							11.2	30/100						
Potassium	mg/l							3	25/50						
SAR (crop)	mmol/l			1	1.5/8.0										
Sodium	mg/l			30	70/92										
Sulphate	mg/l							37.4	200/400			37.4	200/250		
TDS	mg/l			258	360/360										

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		State	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV
PO4-P	µg/l									80	100/30				
TP	µg/l									ND	TBD				
NO3+NO2-N	mg/l							0.36	0.7/10	0.14	0.7/0.7				
DIN	mg/l									0.71	1/0.7				
TN	mg/l									ND	TBD				
Si	mg/l											5.7	20/85		
Chl-a	µg/l									10	15/20			10	15/23
Diatoms	SPI									6.9	9/<13				
E-coli	/100ml													2420	400/400
Ecological Importance and Sensitivity Category: High								Present Ecological Status: C				Recommended Ecological Status: B			

ND: no data; it is suggested that measurements be introduced at this site
TBD: To be determined
TV: Trigger Value. If level is above the TV, intervention by ORASECOM is required

Priority variable for inclusion in the monitoring network

Proposed Station 5 (Upper Orange-Senqu)

Description	Kornetspruit at Maghaleen
Transboundary Criteria	**Criteria 1** - Just upstream/downstream of an international border; **Criteria 2** - Upstream of confluences between the main River and main tributaries (or main tributaries and larger sub-tributaries), which arise from an upstream country
Coordinates	**S30.16003; E27.40145**
Alternate ID	**South Africa – D1H006Q01; New ID: OSL2/1**
Data Availability	**Reference State: 1975-1978 (n=82)** **Present State: 2005-2007 (n=44)**

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV
Hardness	mg/l	42.1	50/175												
EC	mS/m			30.6	40/270			30.6	40/150			30.6	40/120		
pH (95th)	unit			8.4	8.4/8.4							8.4	8.4/8.4		
Alkalinity	mg/l	131	175/98												
NH4-N	µg/l	7	15/300							7	15/58				
Calcium	mg/l							33.6	80/150						
Chloride	mg/l			7.3	40/137			7.7	40/200						
Fluoride	mg/l							0.24	0.7/1.0						
Magnesium	mg/l							12	70/100						
Potassium	mg/l							1.9	25/50						
SAR (crop)	mmol/l			0.72	1.5/8.0										
Sodium	mg/l			8.7	45/92										
Sulphate	mg/l							16.7	80/400			16.7	80/250		
TDS	mg/l			237	260/360										
PO4-P	µg/l									31	40/30				

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV
TP	µg/l									ND	TBD				
NO3+NO2-N	mg/l							0.06	0.2/10	0.06	0.2/0.7				
DIN	mg/l									0.16	0.25/0.7				
TN	mg/l									ND	TBD				
Si	mg/l											11.4	20/85		
Chl-a	µg/l									3	10/20			3	10/23
Diatoms	SPI									13.3	13/<13				
E-coli	/100ml													2750	130/400
Ecological Importance and Sensitivity Category: High							Present Ecological Status: C				Recommended Ecological Status: B				

ND: no data; it is suggested that measurements be introduced at this site

TBD: To be determined

TV: Trigger Value. If level is above the TV, intervention by ORASECOM is required

Priority variable for inclusion in the monitoring network

Proposed Station 6 (Upper Orange-Senqu)

Description	**Oranjedraai**
Transboundary Criteria	**Criteria 1** - Just upstream/downstream of an international border; **Criteria 2** - Upstream of confluences between the main River and main tributaries (or main tributaries and larger sub-tributaries), which arise from an upstream country
Coordinates	**S30.33772; E27.36277**
Alternate ID	**South Africa - D1H009Q01; New ID: OS1**
Data Availability	**Reference State: 1976-1979 (n=122)** **Present State: 2005-2007 (n= 45)**

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV
Hardness	mg/l	107	175/175												
EC	mS/m			25	40/270			25	40/150			25	40/120		
pH (95th)	unit			8.2	8.4/8.4							8.2	8.4/8.4		
Alkalinity	mg/l	111	175/100												
NH4-N	µg/l	8	15/300							8	15/58				
Calcium	mg/l							29.7	60/150						
Chloride	mg/l			7.3	40/137			7.3	40/200						
Fluoride	mg/l							0.2	0.7/1.0						
Magnesium	mg/l							10.1	30/100						
Potassium	mg/l							1.6	10/50						
SAR (crop)	mmol/l			0.3	1.5/8.0										
Sodium	mg/l			6.3	30/92										
Sulphate	mg/l							12.8	60/400			12.8	60/250		
TDS	mg/l			194	260/360										

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV
PO4-P	µg/l									39	45/30				
TP	µg/l									ND	TBD				
NO3+NO2-N	mg/l							0.21	0.2/10	0.21	0.3/0.7				
DIN	mg/l									0.28	0.4/0.7				
TN	mg/l									ND	TBD				
Si	mg/l											10.8	20/85		
Chl-a	µg/l									2	5/20			6	15/23
Diatoms	SPI									7-15	13/>13				
E-coli	/100ml													792	130/400
Ecological Importance and Sensitivity Category: High						Present Ecological Status: B				Recommended Ecological Status: B					

ND: no data; it is suggested that measurements be introduced at this site
TBD: To be determined
TV: Trigger Value. If level is above the TV, intervention by ORASECOM is required

Priority variable for inclusion in the monitoring network

Proposed Station 7 (Lower Orange Entry Point)

Description	**Vaal at Douglas**
Transboundary Criteria	**Criteria 2** - Upstream of confluences between the main River and main tributaries (or main tributaries and larger sub-tributaries), which arise from an upstream country
Coordinates	
Alternate ID	**South Africa – New ID: VS21**
Data Availability	**Reference State:** **Present State: Snapshot Data**

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	State	RWQO/ TV
Hardness	mg/l											285	300/375		
EC	mS/m			90	100/270			90	100/150			90	100/120		
pH (95th)	unit											7.8	8.5/8.4		
Alkalinity	mg/l											144	300/450		
NH4-N	µg/l									12	15/58				
Calcium	mg/l							46.7	80/150						
Chloride	mg/l			185.5	200/137			185.5	200/200						
Fluoride	mg/l							0.33	0.7/1.0						
Magnesium	mg/l							43.4	70/100						
Potassium	mg/l							5.7	25/50						
SAR (crop)	mmol/l			2.88	6.0/8.0										
Sodium	mg/l			114.6	115/92										
Sulphate	mg/l							157	200/400			157	150/250		
TDS	mg/l			700	800/360										
Aluminum	µg/l					29	85/63								

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	State	RWQO/ TV
Cadmium	µg/l			<1	20/30			<1	20/10						
Copper	µg/l			4.5	10/200					4.5	10/4.6				
Iron	µg/l											28	300/300		
Manganese	µg/l			9	50/50			9	50/100						
Lead	µg/l					<10	50/150								
Vanadium	µg/l			<6	100/100										
Zinc	µg/l			8	36/100										
PO4-P	µg/l									43.4	50/30				
TP	µg/l									ND	TBD				
NO3+NO2-N	mg/l							0.32	0.4/10	0.32	0.4/0.7				
DIN	mg/l									0.43	0.5/0.7				
TN	mg/l									ND	TBD				
Si	mg/l											3.86	20/85		
Chl-a	µg/l									28.5	30/20				
Diatoms	SPI									11.3	9/<13				
E-coli	/100ml													318	400/400
Ecological Importance and Sensitivity Category: ?						Present Ecological Status: ?					Recommended Ecological Status: ?				

ND: no data; it is suggested that measurements be introduced at this site

TBD: To be determined

TV: Trigger Value. If level is above the TV, intervention by ORASECOM is required

Priority variable for inclusion in the monitoring network

Proposed Station 8 (Lower Orange)

Description	**Orange River at Pella Mission**
Transboundary Criteria	**Criteria 1** - Just upstream/downstream of an international border
Coordinates	**S28.96443; E19.15276**
Alternate ID	**South Africa – D8H008Q01; New ID: OS15**
Data Availability	**Reference State: 1971-1976 (n=30)** **Present State: 2005-2007 (n=45)**

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	State	RWQO/ TV
Hardness	mg/l							200	250/300			200	250/375		
EC	mS/m			68.5	85/270			68.5	85/150			68.5	85/120		
pH (95th)	unit			8.4	8.4/8.4							8.4	8.4/8.4		
Alkalinity	mg/l											167	300/450		
NH4-N	µg/l									13	30/58				
Calcium	mg/l							41.9	80/150						
Chloride	mg/l			66.1	100/137			66.1	100/200						
Fluoride	mg/l							0.42	1.0/1.0						
Magnesium	mg/l							24.4	70/100						
Potassium	mg/l							3.3	25/50						
SAR (crop)	mmol/l			1.97	3.0/8.0										
Sodium	mg/l			64.8	92.5/92										
Sulphate	mg/l							77.3	150/400			77.3	150/250		
TDS	mg/l			474	550/360										
Aluminium	µg/l					35	62.5/63								
Boron	µg/l			206	500/500										

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	State	RWQO/ TV
Cadmium	µg/l			77	20/30			77	20/10						
Chromium	µg/l									3	24/24				
Copper	µg/l									6	10/3.8				
Iron	µg/l											44	100/300		
Manganese	µg/l			6	50/50										
Molybd.	µg/l			16	20/30	16	20/20								
Nickel	µg/l			4	200/200										
Lead	µg/l					358	100/150								
Vanadium	µg/l			13	100/100										
Zinc	µg/l			5	35/100										
PO4-P	µg/l									22	30/30				
TP	µg/l									ND	TBD				
NO3+NO2-N	mg/l							0.14	0.2/10	0.14	0.15/0.7				
DIN	mg/l									0.12	0.25/0.7				
TN	mg/l									ND	TBD				
Si	mg/l											10.3	20/85		
Chl-a	µg/l									10.3	15/20				
Diatoms	SPI									11.3	9/<13				
E-coli	/100ml													12	130/400
Ecological Importance and Sensitivity Category: High							Present Ecological Status: B				Recommended Ecological Status: B				

ND: no data; it is suggested that measurements be introduced at this site

TBD: To be determined

TV: Trigger Value. If level is above the TV, intervention by ORASECOM is required

Priority variable for inclusion in the monitoring network

Proposed Station 9 (Lower Orange)

Description	**Orange River at Vioolsdrift (GEMS SITE)**
Transboundary Criteria	**Criteria 1** - Just upstream/downstream of an international border
Coordinates	**S28.76208; E17.72631**
Alternate ID	**South Africa – D8H003Q01 ; New ID: OS16**
Data Availability	**Reference State: 1976-1978 (n=66)** **Present State: 2005-2007 (n=111)**

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	State	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV
Hardness	mg/l	205	250/175									205	250/375		
EC	mS/m			74.5	85/270			74.5	85/150			74.5	85/120		
pH (95th)	unit			8.4	8.4/8.4							8.4	8.4/8.4		
Alkalinity	mg/l											170	300/450		
NH4-N	µg/l	8	30/300							8	30/58				
Calcium	mg/l							41.1	80/150						
Chloride	mg/l			78.5	100/137			78.5	100/200						
Fluoride	mg/l							0.48	1.0/1.0						
Magnesium	mg/l							26.2	70/100						
Potassium	mg/l							3.4	25/50						
SAR (soil)	mmol/l			2.2	3.0/3.0										
Sodium	mg/l			73.4	92.5/92										
Sulphate	mg/l							85.5	150/400			85.5	80/250		
TDS	mg/l			509	550/360										
Aluminium	µg/l	168	150/70												
Boron	µg/l			109	500/500										
Cadmium	µg/l							12	20/15						

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	State	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV
Chromium	µg/l									9	24/24				
Copper	µg/l									6	10/3.8				
Iron	µg/l	30	300/300												
Manganese	µg/l			4	50/50										
Molybden.	µg/l			45	30/30	45	30/15								
Nickel	µg/l			44	200/200										
Lead	µg/l							54	50/50	54	50/4				
Vanadium	µg/l			37	100/100										
Zinc	µg/l			10	35/100										
PO4-P	µg/l									25	30/30				
TP	µg/l									ND	TBD				
NO3+NO2-N	mg/l							0.14	0.2/10	0.14	0.15/0.7				
DIN	mg/l									0.1	0.25/0.7				
TN	mg/l									ND	TBD				
Si	mg/l											9.4	20/85		
Chl-a	µg/l									10.6	15/20				
Diatoms	SPI									13	13/<13				
E-coli	/100ml													7	130/400
Ecological Importance and Sensitivity Category: High							Present Ecological Status: B				Recommended Ecological Status: B				

ND: no data; it is suggested that measurements be introduced at this site

TBD: To be determined

TV: Trigger Value. If level is above the TV, intervention by ORASECOM is required

Priority variable for inclusion in the monitoring network

Proposed Station 10 (Lower Orange)

Description	**Orange River at Sendelingsdrift**
Transboundary Criteria	**Criteria 1** - Just upstream/downstream of an international border; **Criteria 2** - Upstream of confluences between the main River and main tributaries (or main tributaries and larger sub-tributaries), which arise from an upstream country
Coordinates	**S28.12288; E16.89032**
Alternate ID	**South Africa – New ID: OS17**
Data Availability	**Reference State:** **Present State: Snapshot Data**

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV
Hardness	mg/l							176	250/500						
EC	mS/m			45	85/270			45	85/150			45	85/120		
pH (95th)	unit			8.7	8.5/8.4							8.7	8.5/8.4		
Alkalinity	mg/l											156	300/450		
NH4-N	µg/l									8	15/58				
Calcium	mg/l							35.4	80/150						
Chloride	mg/l			71	100/137			71	100/200						
Fluoride	mg/l							0.4	0.7/1.0						
Magnesium	mg/l							21.1	70/100						
Potassium	mg/l							2.95	25/50						
SAR (soil)	mmol/l			2.16	3.0/3.0										
Sodium	mg/l			66	92.5/92										
Sulphate	mg/l							78	200/400			78	200/250		
TDS	mg/l			433	550/360										
Aluminium	µg/l					27	85/100								
Cadmium	µg/l							<1	10/3						

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV
Copper	µg/l			13	10/2.6										
Iron	µg/l											18	300/300		
Manganese	µg/l			6	50/50										
Lead	µg/l					<10	50/150								
Vanadium	µg/l			<6	100/100										
Zinc	µg/l			<6	36/100										
PO4-P	µg/l									37	50/30				
TP	µg/l									ND	TBD				
NO3+NO2-N	mg/l							0.24	0.4/10	0.24	0.4/0.7				
DIN	mg/l									0.29	0.5/0.7				
TN	mg/l									ND	TBD				
Si	mg/l											2.1	20/85		
Chl-a	µg/l									34	30/20				
Diatoms	SPI									11.3	9/<13				
E-coli	/100ml													25	130/400
Ecological Importance and Sensitivity Category: High						Present Ecological Status: B					Recommended Ecological Status: B				

ND: no data; it is suggested that measurements be introduced at this site
TBD: To be determined
TV: Trigger Value. If level is above the TV, intervention by ORASECOM is required

Priority variable for inclusion in the monitoring network

Proposed Station 11 (Lower Orange)

Description	**Alexander Bay**
Transboundary Criteria	**Criteria 1** - Just upstream/downstream of an international border;
Coordinates	**S28.56689; E16.50728**
Alternate ID	**South Africa – D8H012; New ID: OS19**
Data Availability	**Reference State: 1995-1996 (n=123)** **Present State: Snapshot 2008 (n=2)**

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Statu s	RWQO/ TV
Hardness	mg/l							186	250/300						
EC	mS/m			49	85/270			49	85/150			49	85/120		
pH (95^{th})	unit			8.5	8.5/8.4							8.5	8.5/8.4		
Alkalinity	mg/l											155	300/450		
NH_4-N	µg/l									7	15/58				
Calcium	mg/l							38.7	80/150						
Chloride	mg/l			79.4	100/137			79.4	100/200						
Fluoride	mg/l							0.38	0.7/1.0						
Magnesium	mg/l							21.7	70/100						
Potassium	mg/l							1.6	10/50						
SAR (soil)	mmol/l			2.24	3.0/3.0										
Sodium	mg/l			70.8	92.5/92										
Sulphate	mg/l							83.5	150/400			83.5	150/250		
TDS	mg/l			456	550/360										
Aluminium	µg/l					30	85/100								
Cadmium	µg/l							<1	10/3						
Copper	µg/l			13	10/2.6										

Variables	Unit	Water Use													
		Agriculture						Domestic		Aquatic Ecosystem		Industrial		Recreation	
		Aquaculture		Irrigation		Livestock Water									
		Status	RWQO/ TV	Status	RWQO/ TV	State	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Status	RWQO/ TV	Statu s	RWQO/ TV
Iron	µg/l											24	300/300		
Manganese	µg/l			5	50/50										
Lead	µg/l					<10	50/150								
Vanadium	µg/l			<6	100/100										
Zinc	µg/l			3	36/100										
PO4-P	µg/l									25	30/30				
TP	µg/l									ND	TBD				
NO3+NO2-N	mg/l							0.18	0.25/10	0.18	0.25/0.7				
DIN	mg/l									0.25	0.3/0.7				
TN	mg/l									ND	TBD				
Si	mg/l											2.7	20/85		
Chl-a	µg/l									25	30/20			25	30/23
Diatoms	SPI									13.7	13/<13				
E-coli	/100ml													85	130/400
Ecological Importance and Sensitivity Category: Low/Marginal						Present Ecological Status: C					Recommended Ecological Status: B				

ND: no data; it is suggested that measurements be introduced at this site

TBD: To be determined

TV: Trigger Value. If level is above the TV, intervention by ORASECOM is required

Priority variable for inclusion in the monitoring network