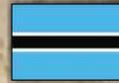




ORASECOM Document No. 007/2011



**SUPPORT TO PHASE 2 OF THE ORASECOM BASIN-WIDE
INTEGRATED WATER RESOURCES MANAGEMENT PLAN
Work Package 3:
Integrated Water Resources Quality Management Plan**

Development of Water Quality Monitoring Programme and Data Management Framework



April 2011

ORASECOM

The *Support to Phase 2 of the ORASECOM Basin-wide Integrated Water Resources Management Plan Study* was commissioned by the Secretariat of the Orange-Senqu River Basin Commission (ORASECOM) with technical and financial support from the German Federal Ministry for Economic Cooperation and Development (BMZ) in delegated cooperation with the UK Department for International Development (DFID) and the Australian Agency for International Development (AusAID). The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) implemented the study.



Prepared by



**SUPPORT TO PHASE 2 OF THE ORASECOM BASIN-WIDE INTEGRATED WATER
RESOURCES MANAGEMENT PLAN**

Work Package 3:

Integrated Water Resources Quality Management Plan

**Development of
Water Quality Monitoring Programme
and Data Management Framework**

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APPROVALS

For the Consultants:

RS MCKENZIE

Managing Director: WRP Consulting Engineers

For ORASECOM:

L THAMAE

Executive Secretary: ORASECOM Secretariat

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Irrigation Scenario Generation Tool	Software	None	

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ACRONYMS

AMD	Acid Mine Drainage
JBS	Joint Basin Survey
SP	Soluble Phosphorus
PP	Particulate Phosphorus
POP	Persistent Organic Pollutants
QA	Quality Assurance
QC	Quality Control
RQS	Resource Quality Studies
TDS	Total Dissolved Solids
WQDOWN	Water Quality Model to Assess Downstream Impacts of Non-conservative Pollutants
WQT	Water Quality Salinity Model
WRPM	Water Resources Planning Model
WRYM	Water Resources Yield Model

1 INTRODUCTION

1.1 General Context

The Orange - Senqu River originates in the highlands of Lesotho some 3 300m above mean sea level, and it runs for over 2300km to its mouth on the Atlantic Ocean. The river system is one of the largest river basins in southern Africa with a total catchment area of more than 850,000km² and includes the whole of Lesotho as well as portions of Botswana, Namibia and South Africa. The natural mean annual runoff at the mouth is estimated to be in the order of 11 500 million m³, but

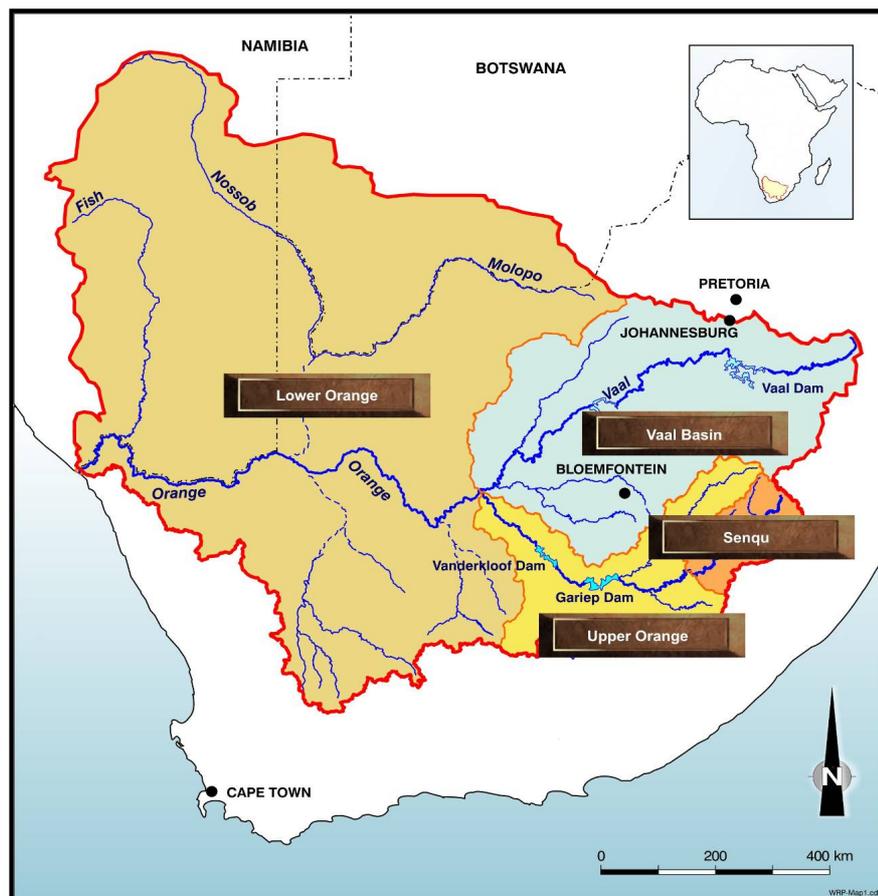


Figure 1: Orange - Senqu Basin

1.2 Management and Environmental Context

1.2.1 General

Management issues, including environmental protection, conservation and sustainable development have to deal with problems relating to, both water quantity and quality, potential conflicts between users, pollution sources from industry, mining, agriculture, watershed management practices and the need to protect ecologically fragile areas. The riparian countries have for some time recognized that a basin-wide integrated approach has to be applied in order to find sustainable solutions to these problems and that this approach must be anchored through strong political will. The development of this strong political will is one of the key initiatives of SADC, in particular the Revised Protocol on Shared Watercourses and the establishment of the

this has been significantly reduced by extensive water utilization for domestic, industrial and agricultural purposes to such an extent that the current flow reaching the river mouth is now in the order of half the natural flow. The basin is shown in **Figure 1**. The Orange-Senqu system is regulated by more than thirty-one major dams and is a highly complex and integrated water resource systems with numerous large inter and intra basin transfers.

Orange-Senqu River Basin Commission (ORASECOM). These initiatives are intended to facilitate the implementation of the complicated principles of equitable and beneficial uses of a shared watercourse system. It is accepted by all countries that the management of water resources should be carried out on a basin-wide scale with the full participation of all affected parties within the river basin.

Water supply in terms both of quantity and quality for basic human needs is being outstripped by the demands within and outside of the basin. Meeting the water supply needs of rapidly growing towns and cities at the same time having sufficient water of an acceptable quality to meet existing and proposed irrigation and other demands (including environmental) further downstream is a challenge for planners and decision makers and stakeholders in the Orange-Senqu river basin.

1.2.2 ORASECOM

Southern Africa has fifteen trans-boundary watercourse systems including the Orange–Senqu system. The Southern African Development Community (SADC) has adopted the principle of basin–wide management of the water resources for sustainable and integrated water resources development. In this regard, the region recognizes the United Nations Convention on the Law of Non-navigational Uses of International Watercourses, and has adopted the “Revised Protocol on Shared Watercourse Systems in the SADC Region”. Under this Revised Protocol, a further positive step has been the initiatives towards the establishment of river basin commissions in order to enhance the objectives of integrated water resources development and management in the region, while also strengthening the bilateral and multilateral arrangements that have been in existence for some time. The Orange–Senqu River Basin Commission (ORASECOM) which was established on 3 November, 2000 in Windhoek, Namibia. is a legal entity in its own right.

The highest body of the ORASECOM is the Council consisting of three permanent members, including one leader, for each delegation from the four riparian states. Support from advisors and ad hoc working groups can be established by the council. The main task of the Council is to “serve as technical advisor to the Parties on matters relating to the development, utilization and conservation of the water resources in the River System”, but the council can also perform such other functions pertaining to the development and utilization of water resources as the parties may agree.

1.3 Context of the Study and this Report

1.3.1 GIZ Support to SADC and ORASECOM

The overall goal of the GIZ-supported ‘Transboundary Water Management in SADC’ programme is to strengthen the human, institutional, and organisational capacities for sustainable management of shared water resources in accordance with SADC’s Regional Strategic Action Plan (RSAP). The programme, which GIZ implements on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ), and in delegated cooperation with the UK Department for

International Development (DFID) and the Australian Agency for International Development (AusAID), consists of the following components:

- Capacity development of the SADC Water Division
- Capacity development of the river basin organisations (RBO) and
- Capacity development of local water governance and transboundary infrastructure.

The activities of this Consultancy, “Support to Phase II of the ORASECOM Basin-wide Integrated Water Resources Management Plan”, being undertaken by WRP (Pty) Ltd and Associates, contributes to Component 2 above. The work of Phase 2 comprises six work packages as briefly outlined in **Section 1.3.2** below

1.3.2 Support to Phase 2 of the ORASECOM Basin-wide Integrated Water Resources Management Plan

1.3.2.1 Objectives of the Overall Consultancy

The main objectives of this consultancy are to enlarge and improve the existing models for the Orange-Senqu Basin, so that they incorporate all of the essential components in the four Basin States and are accepted by each Basin State. These models must be capable of being used to meet the current and future information requirements of ORASECOM. These requirements will encompass additional options to achieve water security in each Basin State – including changing configurations for water supply and storage infrastructure - and ensure that ORASECOM is capable of demonstrating that its operations are aligned with the principles embodied in the SADC Water Protocol.

1.3.2.2 The Six Work Packages

In order to contribute to the realisation of the above-mentioned objectives, the project includes six work packages, as outlined in **Table 1**. The first of these work packages is central to Phase 2 of the IWRM Plan and will also be at the core of the final plan to be developed in Phase 3. In work package 1, the WRYM water resources simulation model is being updated and expanded to cover the entire basin.

Table 1: Summary of Work Package Objectives and Main Activities

Work Package	Main Objectives	Main Activities
WP 1: Development of Integrated Orange-Senqu River Basin Model	To enlarge and improve existing models so that they incorporate all essential components in all four States and are accepted by each State	<ul style="list-style-type: none"> • Extension and expansion of existing models • Capacity building for experts and decision-makers • Review of water balance and yields • Design/initiation of continuous review process
WP 2: Updating and Extension of Orange-Senqu Hydrology	Updating of hydrological data, hands-on capacity building in each basin state for generation of reliable hydrological data including the evaluation of national databases	<ul style="list-style-type: none"> • Assessment of Required Improvements to the Existing Gauging Networks • Capacity Development • Extension of Naturalized Flow Data • Review of Existing Data Acquisition Systems, proposals on basin-wide data acquisition and display system
WP 3: Preparation and development of integrated water resources quality management plan	Build on Phase 1 initial assessment to propose water quality management plan, based on monitoring of agreed water quality variables at selected key points	<ul style="list-style-type: none"> • Establishment of protocols, institutional requirements for a water quality monitoring programme, data management and reporting • Development of specifications for a water quality model that interfaces with the systems models • Capacity building to operate the water quality monitoring system and implement the water quality management plan
WP 4: Assessment of global climate change	Several objectives leading to assessment of adaptation needs	<ul style="list-style-type: none"> • Identification of all possible sources of reliable climate data and Global Climate Model downscaling for the Orange-Senqu Basin • Scenario assessment of impacts on soil erosion, evapotranspiration, soil erosion, and livelihoods • Identification of water management adaptation requirements with respect to observed and expected impacts on water resources • Assessment of major vulnerabilities and identification of measures for enhancing adaptive capacities
WP 5: Assessment of Environmental Requirements	Several objectives leading to management and monitoring system responsive to environmental flow allocations	<ul style="list-style-type: none"> • A scoping level assessment of ecological and socio-cultural condition and importance • Delineation into Management Resource Units and selection of EFR sites • One biophysical survey to collate the relevant data at each EFR site and two measurements at low and high flows for calibration • Assessment of the Present Ecological State and other scenarios • Assessment of flow requirements, Goods and Services, and monitoring aspects
WP 6: Water Demand management in irrigation sector	To arrive at recommendations on best management practices in irrigation sector and enhanced productive use of water	<ul style="list-style-type: none"> • Establish a standard methodology for collecting data on irrigation water applied to crops, water use by crops and crop yields • Document best management practices for irrigation in the basin and finalise representative, best-practice demonstration sites through stakeholder consultation • Consider and assess various instruments that support water conservation/water demand management

The other work packages are both self-standing and intended to provide inputs to an improved and more complete water resources simulation model for the whole basin. The model will be enhanced

through more complete hydrology (WP2), better and more complete water quality information (WP3), allowance for climate change impacts and adaptation (WP4), inclusion of environmental flow requirements at key points (WP5) and modelling of scenarios with improved water demand management in the key irrigation sector (WP6).

1.3.3 Background to Work Package 3 and this Report

1.3.3.1 Work Package Activities

- Establish the protocols, institutional requirements for a water quality monitoring programme, data management and a reporting system to provide water quality management information to the water resource managers of the basin states.
- Develop the specifications for a water quality model that models the water quality variables of concern and interfaces with the systems models.
- Provide training to build capacity within the basin states to operate the water quality monitoring system and implement the water quality management plan.
- Document findings in a report describing the detailed water quality management plan.

1.3.3.2 This Report

The water quality of the Orange River Basin is a cause for concern for the member states. The water quality is being threatened by acid mine drainage, industrial discharges, runoff from urban developments, agriculture (irrigation return flows), as well as wastewater treatment plant discharges. The member states sample the river at various monitoring points in the basin. The samples are tested in laboratories within each of the member states. The integrity of the water quality analysis is often questioned by the member states. The need for the development of a collaborative monitoring program and reporting system has been expressed by the member states so that trust can be developed in the data and the perceived water quality issues can be clarified.

This report presents the trans-boundary water quality monitoring program developed for the Orange Basin as part of the water quality work package number 3.

1.3.4 Parallel Water Quality Studies

The European Development Fund funded a water quality study which included the following work:-

- A fitness for use study undertaken for ORASECOM;
- A framework for monitoring water resource quality in the Orange-Senqu River Basin; and
- The Joint Basin Survey (JBS) undertaken of the Basin. The JBS was a once-off survey which included the sampling of sediments, persistent organic pollutants (POPs) and other water quality variables. The JBS involved the Basin States in a once-off joint sampling effort of the basin.

The protocols developed as part of this water quality work package were used in the JBS and the JBS was used for training of the member states.

1.4 Objectives of Water Quality Monitoring Program

The objectives of the monitoring program were:-

- To identify monitoring point locations in consultation with the Basin States;
- Select the water quality variables to monitor and the sampling frequency;
- Propose a structure to manage the water quality data; and
- Develop quality assurance and quality control procedures for inter-laboratory comparisons of results.

1.5 Study Approach

The study approach followed is summarised as follows:-

- The Basin states were visited to determine the current sampling points, expectations of the trans-boundary sampling program and the methods used to manage the water quality data currently collected. The meetings took place during October 2009.
- An inception meeting was held on 18 November 2009 to present the proposed scope and get comments on the scope of work.
- A water quality workshop was held on 2 March 2010 to select monitoring points, the water quality variables to be monitored, the monitoring frequency and to discuss the management of data.
- Participation in the JBS workshops and sampling program. The sampling points and the sampling protocols developed in this study were used in the JBS study. The JBS study was used to train the Basin State staff in sampling and sample management. The water quality analysis results were also used in an initial comparison of the laboratories.

2 DESCRIPTION OF MONITORING PROGRAM

2.1 Application

When?	Trans-boundary points have been selected and a monthly monitoring program is to be implemented. The Basin States that will sample the various points were selected.
Why?	The objective of the surface water sampling is to develop trust in the water quality data, identify issues and investigate training to address the issues.
How?	The following method defines the main steps in the collection of surface water samples and detailed procedure to do so.

2.2 Purpose of this Sampling Procedure

The purpose of this step by step procedure is to:

- ensure the use of a standardized method for water quality sampling by all member states at the identified sampling points in the Caledon, Senqu and Orange Rivers; and
- create consistency and standardization in the sampling to allow for bench marking of the laboratories in the ORASECOM member states. This will also allow for inconsistencies in the laboratory results to be identified and remedial measures to be taken.

2.3 Sampling Points

Surface water samples are to be taken at the 12 trans-boundary sites indicated in **Table 2**.

Table 2: Location of Trans-Boundary Sampling Points

Sampling Site	Co-ordinates		Details of Location	Member states responsible for sampling*
	South	East		
1	-28.6948	28.23486	D2H012Q01 Little Caledon River at the Poplars	Lesotho/South Africa
2	-28.8833	27.89	D2H035Q01 Caledon at Ficksburg at Ficksburg bridge	Lesotho/South Africa
3	-29.2978	27.48528	D2H011Q01 Caledon River at Maseru	Lesotho/South Africa
4	-30.16	27.40145	D1H006Q01 Kornetspruit at Maghaleen	Lesotho/South Africa
5	-30.3377	27.36277	D1H009Q01 Orange River at Oranjedraai	Lesotho/South Africa
6	-29.0528	23.68738	C9R003Q01 Vaal River at Douglas Barrage	South Africa
7	-28.4249	20.00087	D8H008Q01 Orange River at Pella Mission	South Africa/Namibia
8	-28.7621	17.72631	D8H003Q01 Orange River at Vioolsdrift (GEMS SITE)	South Africa/Namibia
9	-28.1229	16.89032	OSEAH 28 5 Orange River at Sendelingsdrift	South Africa/Namibia

10	-28.5669	16.50728	D8H012 Alexander Bay	South Africa/Namibia
11	-	-	Vaal Gamagara Pipeline providing water to Botswana	South Africa/Botswana
12	-29.123686	23.619969	Orange River Downstream of Vaal confluence	South Africa

*Botswana may join any of the teams at sites of preference. While Lesotho, South Africa and Namibia have allocated sites of responsibility for the inter-lab sampling exercise, they may also join in sampling at other sites. Sampling personnel from all four member states were trained.

2.4 Analytical Laboratories

The laboratories which will conduct the water quality sample analysis include:

- Lesotho - Department of Water Affairs, Water and Sewage Authority and National University of Lesotho;
- Republic of South Africa - Department of Water Affairs;
- Namibia – Namwater; and
- Botswana – Department of Water Affairs and Geological Surveys.

The sampling personnel will take bottles to the sampling sites. There will be two samples collected at each site for each laboratory. One bottle will contain a preservative and will be for the nutrient fraction and the second for the major cations and anions.

2.5 Water Quality Variables to be Analysed at Sampling Sites

The water quality variables agreed on at the workshops that will be analysed at the different points are listed in **Table 3**.

Table 3: Water Quality Variables to be Analysed at Sample Sites

Sampling site	Water quality variables	
	Physical	Chemical/microbiological
Caledon and Senqu Rivers Sites 1 to 5	pH, Electrical Conductivity/Total Dissolved Salts Suspended solids	Na, Cl, NH ₄ , NO ₃ -NO ₂ , PO ₄ , E-Coli
Orange River Sites 6 to 12	pH, Electrical Conductivity/Total Dissolved Salts	Na, Ca, Total alkalinity, Mg, Cl, K, SO ₄ , F, NH ₄ , NO ₃ -NO ₂ , PO ₄ , E-Coli At site 11 residual chlorine to be added

2.6 Sampling Frequency

The goal was to collect the optimal number of samples that would provide reliable results. For rivers (flowing water), more frequent samples are required. In general, bi-weekly samples from a river are adequate. This will be sufficient to identify any water quality changes. The minimum and recommended number of samples and sampling frequency for the Orange, Caledon and Senqu Rivers is listed in **Table 4**. Initially the sample frequency for the trans-boundary monitoring program will be monthly. This can be revised at a later date depending on the results and the objectives of the monitoring program.

The JBS study was a “once-off” sampling program that may be repeated about every 5 years. At this stage, the results from the JBS are being used to initiate the trans-boundary monitoring program.

Table 4: The Minimum and Recommended Number of Samples and Sampling Frequency for the Orange River Catchment

SAMPLING POINT	MINIMUM PER POINT		RECOMMENDED PER POINT	
	Number of samples per year	Sampling Frequency	Number of samples per year	Sampling Frequency
Points 1 to 11 (Orange, Caledon and Senqu Rivers)	4	3 monthly	26	2 weekly

If any serious water quality deterioration or contamination is detected, sampling frequency should be increased to weekly if possible.

3 SAMPLING PROTOCOLS

3.1 Procedures

The recommended sampling procedures are indicated in **Figure 3**.

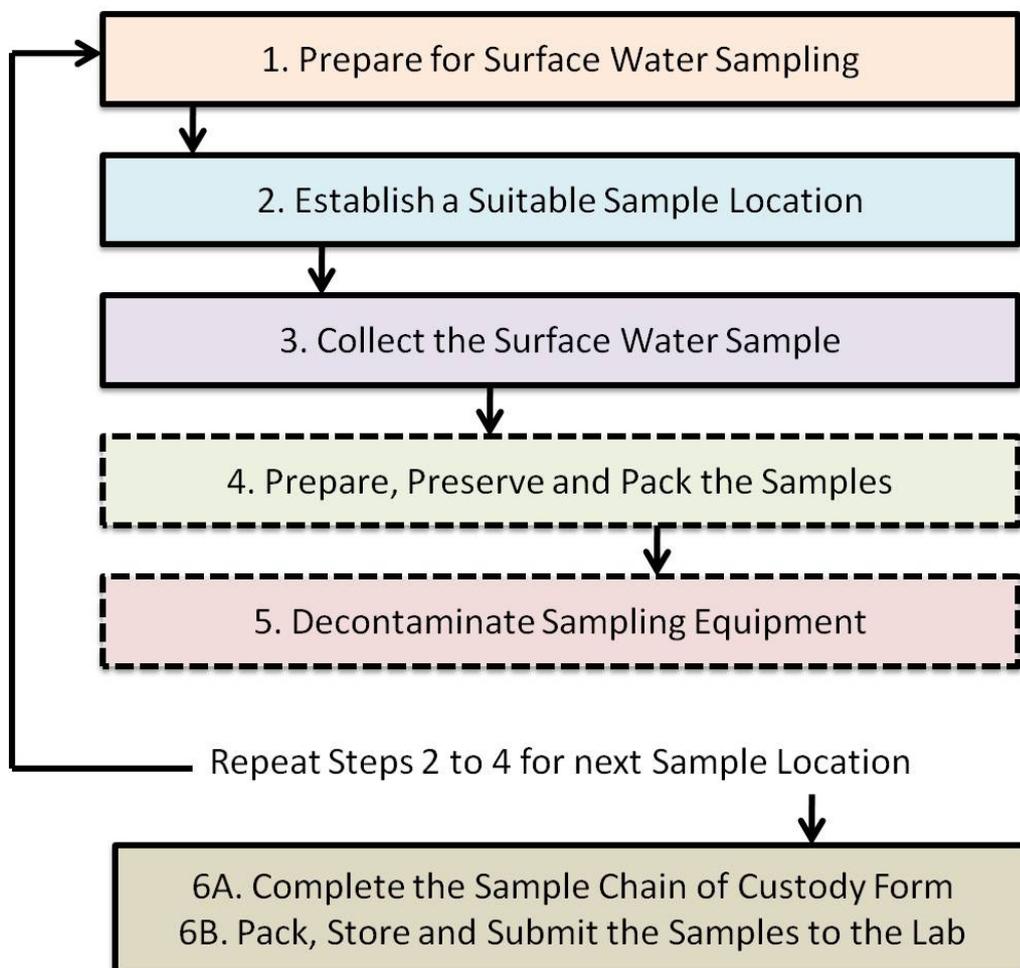


Figure 3: Recommended Sampling Procedures

3.2 Prepare for Surface Water Sampling

3.2.1 Equipment

The equipment required to collect a representative surface water sample depends on the size of the surface water body and access to the planned sampling locations. The following equipment will be needed for the JBS sampling program:

- Site map showing sampling locations;
- Appropriate health and safety equipment;
- Water level tape or depth-measuring device (e.g. yard stick);
- Sample bottles with labels, lids and preservatives (provided by analytical lab);
- Cooler with appropriate packing material;

- Ice packs;
- Markers for marking sample location;
- Digital camera;
- Field meters (pH, conductivity, temperature, dissolved oxygen, turbidity), 250 mL container and calibration solutions (see Appendix A);
- Decontamination equipment (see Appendix C);;
- Biodegradable phosphate free detergent;
- Distilled/deionized final rinse water;
- Paper towels;
- Brush;
- Washing container (bucket); and
- Rope and clean bucket.

3.3 Field Forms

- Water Sampling Data Sheet (Appendix D).

3.4 Surface Water Sample Collection

3.4.1 Field Preparation

- Organize sampling equipment and forms.
- Ensure sampling equipment is clean (see Appendix C).
- Ensure that sample bottles are available with labels and lids.

3.4.2 Selecting an Appropriate Sampling Location

- Surface water at the sample location should be free of debris and should have a relatively uniform velocity (e.g., not directly downstream of a bend).
- Although bridges are often a convenient sampling location, contamination of surface water in these areas may result from eroding structures and traffic use.
- Investigate the area to ensure that there are no outfalls or merging creeks just upstream of the sample location, as inflow may not be thoroughly mixed before reaching the sample location.
- As the location will be sampled at different times of the year, determine whether the sample site would still be usable under high or low water conditions.
- Record all details of the sample location, especially anything that might be influencing the chemistry of the water. Also note the water depth (using a measuring rod) and estimate (qualitatively) the flow velocity (e.g., .fast, slow, stagnant).

- Take a photograph of the sample location and keep a record of photos taken in the field book.

3.4.3 Surface Water Sample Types

The number and type of Quality Assurance (QA) / Quality Control (QC) samples to be collected may include some of the following:

- **Grab Samples:** Sample containing water collected during a single sampling event (i.e. water taken from a given place at a given time).
- **Equipment Blanks:** Equipment blanks are used to detect contamination from sampling equipment. They are prepared by rinsing pre-cleaned equipment with deionized water and collecting the rinsate into an appropriate container.
- **Field Blanks:** Field blanks are used to detect contamination during sample collection and transport. They are prepared during a sampling event by filling the appropriate container with deionized water. Field blanks are usually used in situations where there is reason to suspect that contamination will occur during sample collection and transport.
- **Travel Blanks:** Travel blanks detect sample contamination during transport. Travel blanks consist of pre-filled bottles provided by the analytical laboratory. They accompany empty sample bottles to the field site, where they are left intact and unopened inside the shipping cooler. The unopened travel blanks are then returned to the analytical lab to be analyzed along with the collected samples.
- **Standard Reference Samples:** Standard reference samples, or blind QA samples, are samples of known concentrations that are submitted to the analytical lab as a normal sample. The laboratory is not informed about the identity of the sample until after all analyses are complete.
- **Replicate/Duplicate Samples:** Replicate samples are used to evaluate within-site variation. Replicate samples are collected by filling multiple containers at a single site. They are labeled and preserved individually and are submitted separately to the analytical laboratory.
- **Split Samples:** Split samples are used to check analytical variation. A single sample (e.g. grab) is collected and is split into two sample containers. These are labeled and preserved individually and are submitted separately to the analytical laboratory.

Split samples will be collected during the JBS survey, with a sample for each of the laboratories for each of the sites. The standard reference or blind samples will be provided by the independent laboratory and will be inserted in the samples to the laboratories by the independent laboratory.

3.4.4 Sample Size and Types of Sample Bottles

A 1 litre bottle and a 350 millilitre preserved sample will be collected at each site for each laboratory. The laboratory will provide the appropriate bottles. If a laboratory is unable to analyse preserved samples, only the 1litre unpreserved sample will be collected.

3.4.5 Sample Preservation and Transport

Some water samples must be preserved to keep the quality of the water sample as stable as possible until the analysis is carried out.

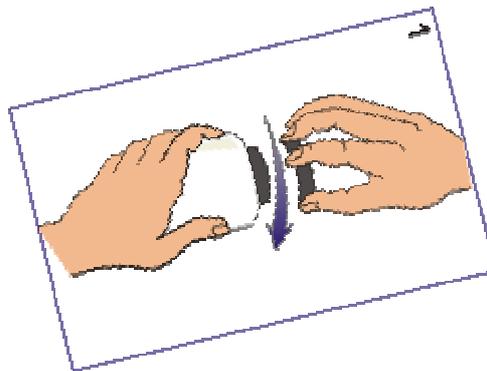
Preservation is normally recommended only when the water sample cannot be delivered to the laboratory within 24 hours after sampling. As some of the sites are remote, a preserved sample is required for the nutrients.

3.5 Collecting the Water Sample

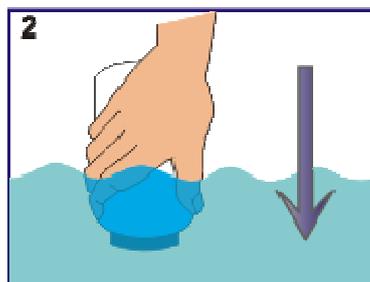
A bucket will be used to collect 10 litres or so of water to be split amongst the bottles for the different laboratories. The procedure to collect a sample in a bottle and a bucket are included for completeness.

The following procedure should be followed when taking the samples with a bottle:

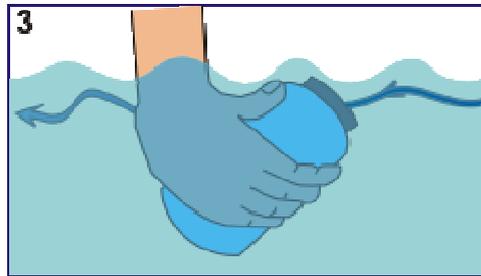
- If the water is shallow and slow enough, the sampler can wade into the surface water to obtain a sample. Samples can also be collected from the banks if a suitable location is available, or by straddling small streams.
- Always ensure that the sample is collected from the upstream side of any object that is being used for sampling (to avoid washing contaminants into the sample).
- Select the appropriate sample bottles and preservatives, and follow the sample handling guidelines.
- Take the grab sample as follows (WRC, 2000):
- Step 1: At the sampling point remove the cap of the sample bottle but do not contaminate the inner surface of cap and neck of sample bottle with hands.



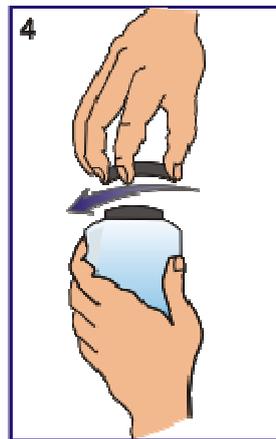
- Step 2: Take sample holding bottle with hand near base and plunge sample bottle, neck downward, below the water surface (wear gloves to protect your hands from contact with the water).



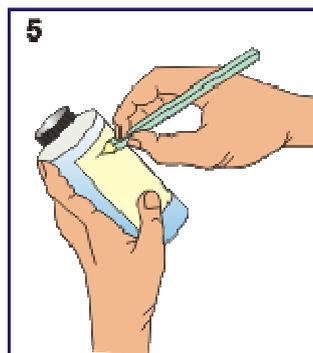
- Step 3: Turn bottle until neck points slightly upward and mouth is directed toward the current (this can also be created artificially by pushing the bottle forward horizontally in a direction away from the hand).



- Step 4: Fill sample bottle without rinsing and replace cap immediately. Before closing the sample bottle leave ample air space in the bottle (at least 2.5 cm to facilitate mixing by shaking before examination).

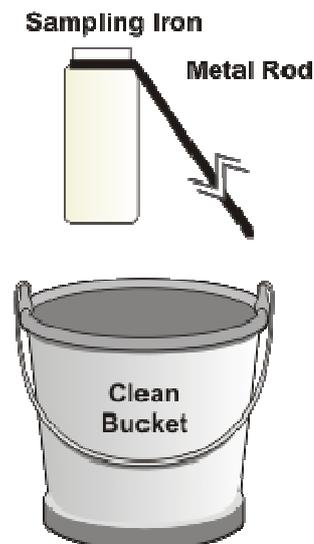


- Step 5: Complete label and data sheet.



- It is always preferable that a sterile laboratory bottle is used directly to collect the sample. If there are problems with accessibility, some other collection device such as a bucket may be used. Make sure that the bucket is cleaned properly and then rinse the bucket three times with the water to be sampled. Beware of contamination risk when using the same bucket for likely contaminated sites and pristine sites.

- If the sample is to be collected from the shore, bank, or an overhead bridge, a sampling iron or a bottle attached to a rope may be used to obtain the sample. Always ensure that the free end of the rope is tied to something solid, to avoid loss of the bottle or iron.
- Collect a sufficient volume of water to be able to fill the bottles necessary to conduct the various required analyses.
- Do not include any large, non-homogeneous particles such as leaves or sticks.
- Avoid disturbing the bottom sediments while sampling as this will increase the turbidity of the collected sample and the sediments may be contaminated.
- Transfer sufficient water to a clean container (e.g. bucket) and measure field parameters. Record the readings on the Water Sampling Data Sheet. Measurements can also be conducted directly in the water body where no changes in water quality are likely during the measuring period, as some change in sample composition can begin to occur.
- Record field observations on the Water Sampling Data Sheet (colour, turbidity, odor (if present) and sheen (if present) of sample).



3.6 Preparing, Preserving and Packing the Samples

The results of the laboratory analysis are dependent both on the ability to collect a representative sample and to maintain that sample until it can be analysed. Sample preparation, preservation and storage procedures are necessary to ensure that the sample is properly maintained.

- Fill the bottles for those samples that require special handling first (e.g., filtering, preservative) followed by those that do not.
- If samples require a preservative:
 - If the preservative is already present in the sample bottle provided by the analytical laboratory, do not rinse the bottle, but fill to the rim.
 - If the preservative is not already present in the sample bottle provided by the laboratory, rinse the bottle and cap with the sample water three times, and then fill the sample bottle to the base of the neck, taking care to leave sufficient room for the preservative. Add preservative immediately.
- If samples do not require a preservative, rinse sample bottle and bottle cap three times, and then fill bottle to the rim.
- Seal all sample bottles tightly.
- Label all samples clearly with an indelible marker.

Site ID:
Sample ID:
Date/Time Sampled:
Parameters:
Preservatives
Filtered Y/N:
Sampler Initials:

- Include sample number/ID, date and time collected, sampler, project descriptor, parameter to be analysed and preservative (if added).
- Consider collecting duplicate samples if access to the sampling location is difficult or if the sampling procedure is particularly time consuming. This will help ensure that a sample is available if breakage of some of the bottles occurs during transport or at the laboratory.
- Pack samples in a cooler and maintain at 4 degrees Celsius using ice packs.
- Pack the samples in a transport container such that they will not break due to impact or vibration. Do not allow sample bottles to touch each other or they may break. Place generous amounts of packing material between all glass bottles.

3.7 Equipment Decontamination

- Thoroughly decontaminate the bucket or sampling iron (if used) prior to proceeding to the next sampling location.

3.8 Chain-of-Custody Form

Complete the sample chain of custody form once all surface water locations have been sampled. Refer to Appendix E for the sample chain of custody form.

3.9 Sample Storage and Package

- If the samples are not to be transported immediately, store the samples in a refrigerator or cooler equipped with cold packs. Take precautions to prevent contamination of the fridge contents if it is not exclusively reserved for samples.
- If samples are to be transported a significant distance, consideration should be given as to:
 - the type of container for transportation;
 - the type of packing material; and
 - the type of coolant.
- Sample coolers with a sufficient number of frozen cold packs (self-contained), spaced evenly in the lid of the cooler, are ideal for maintaining the samples at about 4°C.

- If ice is used, make sure that it is contained in two or three well-sealed plastic bags, to avoid leakage of melted water, and placed above the samples.
- If freezing conditions are likely, consider the use of heat packs to maintain the samples at 4 °C.
- Check and refresh the ice packs if the transportation time is greater than about 4 or 5 hours.
- Pack the samples to avoid breakage. Packing material such as bubble wrap, crumpled newspaper, or foam chips should be placed on all sides of the samples (top, bottom and sides) to fill the cooler.
- Avoid packing the samples too loosely (which may result in jarring and breakage) or too tightly (compression and breakage).
- Close the cooler and bind it securely using packing tape or duct tape. Label the outside of the cooler as “Water Quality Samples” or with other relevant information.

3.10 Sample Transport

- Samples should be submitted to the laboratory as soon as possible following their collection.
- Ensure that the samples are delivered to the laboratory, and that the laboratory has enough time to start the analysis, within the recommended holding time
- Samples should be transported with the signed chain of custody. If the samples are collected by a laboratory courier, the courier should sign in the appropriate space at the bottom of the form, retaining one copy and leaving one copy with the sampler. If the samples are transported by the sampler, one copy should be retained by the sampler.
- Ensure that the laboratory forwards a copy of the sample chain of custody form with the final lab analytical results.
- If the lab has any important comments regarding the condition of the received samples, these should be communicated following receipt of samples.
- Sometimes delivery of samples at the end of the day or work week can result in delays in commencing the analysis, so keep this in mind when transporting the samples. In addition, some parameters may only be analysed by the laboratory on certain days of the week. This must be verified with the laboratory.

3.11 At the laboratory

The procedure at the laboratories is as follows:

- The chain of custody form will be filled on receipt of samples.
- The samples will be split into two samples viz an A and a B sample.
- The samples must be appropriately labelled with the letter A and B added to the sample ID.
- The samples will be added to the laboratory testing system.
- The samples will be tested within 10 days and the results sent to the ORASECOM/GiZ teams.

4 DATA MANAGEMENT

4.1 Current Data Management Methods

The water quality data management in the basin states involves a combination of spreadsheets, database systems and GIS systems linked to a database. The current systems used in the basin states are summarised as follows:

- Lesotho has a GIS linked database system developed using donor funds. The system is used to store groundwater and surface water quality data. The system is used to produce maps showing the water quality status in Lesotho. The water quality data, however, is provided in spreadsheet format. The sample testing is undertaken by laboratories in Lesotho for most of the water quality variables. The laboratories are based at the Department of Water Affairs, Water and Sewage Authority and the National University of Lesotho.
- Namibia has a database system which is currently used to store the groundwater data. Namibia is planning to expand the database to include surface water samples. The data is generally available in spreadsheet format. The testing of the data is carried out by Namwater and a private laboratory in Windhoek.
- The data supplied by Botswana was in spreadsheet format. The laboratories used in Botswana are the Department of Water Affairs and Geological Surveys.
- South Africa has a sampling program for the country that is operated by the Department of Water Affairs Regional Offices and the Directorate Resource Quality Studies (RQS). The water quality analysis is generally undertaken at the laboratory at the RQS. The results of the tests are stored in a water quality database system known as WMS. The WMS system is a GIS system linked to a database. The system outputs statistics and graphs. The data can also be output to spreadsheet for further analysis. The system is maintained by RQS, but access to input data can be carried out remotely from within the Department of Water Affairs firewall security system. The results can also be accessed over the internet using Google maps as the interface.

4.2 Proposed Data Management Structure

The proposed data management system is based on the individual basin states' ability to provide data in spreadsheets. The proposed data management structure is shown in **Figure 4**. The member states will manage the data in their individual data management systems. The data will be output from these systems, in spreadsheet format, and sent to ORASECOM by e-mail. ORASECOM will collate the water quality data, carry out QA/QC on the data and produce the required reports for distribution to the member states. The final set of water quality data will be sent to RQS Directorate of the South African Department of Water Affairs. The data will be stored on the WMS system and access will be provided through the Google viewing system.

This is a practical interim proposal to manage the water quality data. Ultimately the water quality data management system should be linked to the hydrology data management system. The proposed system does, however, rely heavily on ORASECOM having suitable capacity and funding to manage the data.

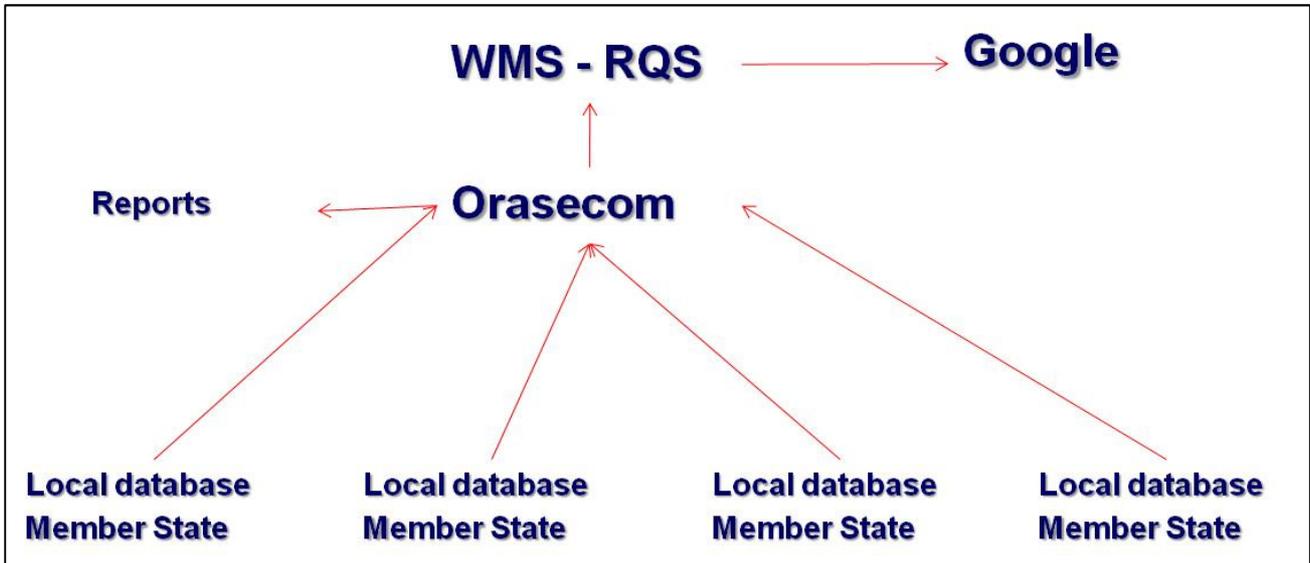


Figure 4 : Proposed Data Management Structure

5 INTER-LABORATORY BENCH MARKING

The Joint Basin-wide Survey (JBS) survey was carried during September and October 2010. The analysis results from the participating laboratories were collated and compared. The results are listed in **Table 5** for one of the sampling points where 1 and 2 designate duplicate samples. An independent laboratory and a spiked sample were also included in the inter-laboratory bench marking exercise. The spiked sample was prepared by the South African Bureau of Standards (SABS). The comparison of the laboratory results to the spiked sample is shown in **Table 6** where a variation of more than 10% from the spiked sample is shown shaded in grey.

Table 5: Results of Inter Laboratory Benchmarking

Variable	RSA DWA RQS		Botswana DWA	NAMWATER		Botswana Geo	Lesotho		Waterlab
	1	2	1	1	2	1	1	2	1
Ammonia as NH ₄	<0.05	<0.05							
Sodium (Na)	36.1	35.9	33.5	36	36	35.4			36
Fluoride (F)	0.312	0.32	0.18	0.3	0.3	0.31			0.3
Conductivity	46.7	46.7	47			46.6			46.1
pH	8.29	8.29	7.19			7.94			8.4
Temperature	24	24							
Potassium (K)	2.44	2.48	11.34	2	2	2.22			2.2
Calcium	34.84	33.085	34.13	31	32	32.4			36
Chloride (Cl)	29.436	29.856	41.73	26	26	32.62			35
Magnesium (Mg)	16.746	17.138	17.15	16	16	17.8			18
Nitrate + Nitrite as	<0.05	<0.05							
Nitrate as N				<0.5	<0.5	1.28	5.5	3.6	0.2
Nitrite as N				<0.1	<0.1		0.002	0.001	
Phosphate (PO ₄)	<0.01	<0.01	0.03				1.72	1.76	<0.01
Silica (Si)	8.077	8.07							4.5
Sulphate (SO ₄)	40.261	40.01	29.81	39	39	39.2	48	47	44
Total Alkalinity	161.868	163.388					123	128	156
TDS			334		293				316
Count	12	12	11	7	7	11	5	5	13
Total	18	18	18	18	18	18	18	18	18
Percentage	66.7	66.7	61.1	38.9	38.9	61.1	27.8	27.8	72.2

Table 6: Comparison of Laboratory Results to the SABS Spike Sample

Sample 1	Lab 1		Lab 2		Lab 3		Lab 4		Lab 5	Lab 6	Lab 7	Lab 8	SABS VALUES
	Run 1	Run 2	Run 1	Run 2	Run 1	Run 2	Run 1	Run 2	Run 1	Run 1	Run 1	Run 1	
pH	8.6	8.41	8.11	7.99	8.108	8.111			7.95	7.22		8.1	7.9
EC	292 uS/cm	293 uS/cm	28.4mS/m	28.4mS/m	29.73 mS/m	29.78 mS/m			291	31 mS/m		29.8 mS/m	30.5 mS/m
TAL (mg/l CaCO3)					97.879 mg/l	94.401 mg/l				86.95 mg/l		80 mg/l	94.22 mg/l
Sample 2													
Ca					461.36 mg/l	461.79 mg/l	1280 mg/l	1240 mg/l	2896 mg/l	1336 mg/l		1643 mg/l	1444.98 mg/l
Mg					360.73 mg/l	364.6 mg/l	280 mg/l	280 mg/l	345 mg/l	361 mg/l			358.83 mg/l
Na					99.4 mg/l	98.5 mg/l	900 mg/l	920 mg/l	863.6 mg/l	869 mg/l		1103 mg/l	934.65 mg/l
K	175.2 mg/l	175.2 mg/l			17.1 mg/l	16.9 mg/l	370 mg/l	370 mg/l	335 mg/l	752 mg/l		416 mg/l	359.50 mg/l
Sample 3													
Cl			1477 mg/l		1179.42 mg/l	1179.42 mg/l	1220 mg/l	1220 mg/l	1291 mg/l	1413.65 mg/l		1363 mg/l	1352.86 mg/l
SO4					1238.14 mg/l	1239.03 mg/l	1480 mg/l	1480 mg/l	1154 mg/l	1273.45 mg/l		1035 mg/l	1291.88 mg/l
F					20.1 mg/l	23.9 mg/l	19.7 mg/l	19.7 mg/l		9.21 mg/l		18 mg/l	19.99 mg/l

6 TRIGGER VALUES

The trigger values set at the sampling points are listed in **Table 7** and **Table 8**. The trigger values are instream concentrations which, if the measured values exceed a response, must be triggered by ORASECOM to further investigate the cause of the trigger values being exceeded. The trigger values are based on DWA (2009) and ORASECOM (2009). The Resource Water Quality Objectives set in DWAF (2009) were used in the ORASECOM (2009) to recommend trigger values for the various sampling points.

Table 7: Trigger Values for Sampling Points 1 - 5

Water Quality Variable	Trans-boundary Point					
	Unit	1	2	3	4	5
pH		8.5	8.5	8.5	8.5	8.5
EC	mS/m	120	55	55	40	40
SS	mg/l	-		-	-	-
Na	mg/l	70	50	70	45	30
Cl	mg/l	50	40	40	40	40
NH ₄ as N	mg/l	0.015	0.015	0.058	0.015	0.015
NO ₃ /NO ₂ as N	mg/l	0.4	0.2	0.7	0.20	0.30
PO ₄ as P	mg/l	0.05	0.03	0.10	0.04	0.045
E-Coli	Cfu/100ml					

Table 8: Trigger Values for Sampling Points 6 - 12

Water Quality Variable	Trans-boundary Point							
	Unit	6	7	8	9	10	11	12
pH		8.5	8.5	8.5	8.5	8.5	8.5	8.5
Total Alkalinity		300	300	300	250	300	300	300
EC	mS/m	100	85	85	85	85	100	85
Ca	mg/l	80	80	80	80	80	80	80
Na	mg/l	115	93	93	93	93	115	93
Mg	mg/l	70	70	70	70	70	70	70
K	mg/l	25	25	25	25	10	25	25
Cl	mg/l	200	100	100	100	100	200	100
SO ₄	mg/l	200	150	150	200	150	200	150
F	mg/l	0.7	1.0	1.0	0.7	0.7	0.7	1.0
NH ₄	mg/l	0.015	0.03	0.03	0.015	0.015	0.015	0.03
NO ₃ /NO ₂ as N	mg/l	0.4	0.15	0.15	0.4	0.25	0.4	0.15
PO ₄ as P	mg/l	0.05	0.03	0.03	0.05	0.03	0.05	0.03
E-Coli	Cfu/100ml	400	130	130	130	130	0	130

7 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations can be made as a result of this study:

- The success of the monitoring program in future will depend on the support of the basin states and the capacity of ORASECOM. ORASECOM must continue to actively support the initiatives and progress developed during this project and the JBS. If ORASECOM does not drive the process going forward, the trans-boundary monitoring program will not be a success.
- The trigger values, sampling point locations, sampling frequency and the water quality variables to be tested for can be changes as the trans-boundary monitoring program evolves going forward.
- The linking of the sampling points to the hydrology network and the installation of continuous monitoring equipment should be considered going forward.
- The establishment of a central database and management system at ORASECOM to handle the data must be developed in the future. The system should be web enabled which allows the input and access to the data by the Basin States.
- Key groundwater trans-boundary sampling points of the major aquifers should be added to the reporting system in future.
- The initial inter-laboratory bench marking indicated that a number of the laboratories, including the independent laboratory used in the JBS, did not compare well with the spiked sample concentrations. In the future, training and continued use of samples must be carried out during the trans-boundary sampling program, to bring all the laboratories to the same level.

8 REFERENCES

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APPENDICES

APPENDIX A: FIELD PROCEDURE

A1 pH

General Information

- To obtain a representative pH value, measurement of pH must be conducted in the field. Differences between field and laboratory pH's may be greater than two pH units.
- A pH meter will be used to measure the pH of a water sample. Measurements should be made immediately on the obtained aliquot.

Calibration

- Before using the pH probe, it must be calibrated in accordance with the manufacturer's instructions (provided with the instrument).
- Calibration should be performed with standardized buffered pH solutions and conducted prior to each use.
- It is preferable to calibrate with pH 4 and pH 7 buffers for neutral to acidic water and a pH 7 and pH 10 buffers for neutral to alkaline water. A three point (pH 4, pH 7 and pH 10) calibration is recommended for waters with a large variability in pH.
- After calibration, the following procedure should be followed prior to sample measurement.
 - Remove the electrode, rinse with distilled/deionized water and place it in the pH 7 buffer to check for proper calibration of the electrode system.
 - If the pH does not return to within 0.02 units of the appropriate value, repeat the calibration. Although 0.5 pH units may be accurate enough for some field work, it is advisable to be precise, as the calibration curve may not be completely linear. The precision of the instrument should also be considered when assessing the accuracy of the calibration.
 - Rinse the electrode thoroughly and insert it into the 250 mL sample.
 - Gently mix the sample with pH probe until the reading stabilizes. After a stable pH reading is achieved, rinse the electrode thoroughly and re-check the buffers again. If they agree within 0.02 units, record the pH (0.5 pH units may be accurate enough for some field work).
 - Rinse the electrode well with distilled/deionized water before taking measurements of the next sample.
- Calibration should be conducted prior to sampling. Meter calibration should be checked throughout the day and at the end of sampling.

pH Measurement

- Before and after each reading, thoroughly rinse the probe with distilled/deionized water.
- Record the pH to one-tenth (or one-hundred if meter is stable enough) of a pH unit.

The following precautions are recommended when taking pH measurements.

- Samples used for pH measurements should be discarded after the measurement.
- pH meters should be kept on a dry surface, out of direct sunlight. They should be kept at a constant temperature during a single sample measurement.
- pH electrodes should not be allowed to dry out. They will “age” with time and show sluggish response. They can be rejuvenated by various procedures, usually described by the manufacturer. The electrodes should stabilize in the buffers within several seconds.

A2 Electrical Conductance

General Information

- A conductivity probe will be used for conductivity measurement on an aliquot of water obtained just before, during, or after sampling. Measurements should be made as soon as possible on the obtained aliquot.

Calibration

- The meter should be calibrated in accordance with manufacturer's instructions (provided with the instrument) with standardized KCl solutions.
- The most commonly used standard is that of a 0.01 M KCl solution, which has an electrical conductance of 1,288 ($\mu\text{S}/\text{cm}$ at 25°C).
- At a minimum, calibration should be performed at the beginning and end of each day's use.

Conductivity Measurement

- Electrical conductance is a relatively easy parameter to measure, by placing the probe in a 250 mL container filled with the water sample. The probe should be kept away from the sides and bottom of the container in which measurements are taken and the probe should be held steady during the measurement.
- The conductivity should be recorded to two significant figures.
- The temperature of the sample at the time of conductivity measurement should also be recorded. Electrical conductance increases by one to three percent or more for every 1°C increase in temperature. Readings are generally standardized to 25°C by the use of a temperature compensator on the meter (check to make sure it works) which adjusts values 2 percent per 1°C compared to the expected value at 25°C. Otherwise, the corrected conductivity must be calculated.
- The probe must be thoroughly rinsed with distilled/deionized water before and after each use.
- All measurements should be multiplied by the cell constant of the probe in order to get the true conductance shown on meter. Manufacturers' specified cell constants may be in error by 10 percent. Any probe should be recalibrated for the meter with which it is used.

A3 Dissolved Oxygen

General Information

- A dissolved oxygen meter is used to measure dissolved oxygen (DO) in water samples.
- Measurements should be made immediately on aliquots.

Calibration

- The meter should be calibrated in accordance with the manufacturer's instructions using distilled/deionized water that has been allowed to equilibrate with the atmosphere at a given elevation.

DO Measurement

- Measure the temperature and concentration of dissolved oxygen in the sample while the salinity is on the fresh setting.
- The sample should be gently agitated while the measurement is being recorded.
- The probe must be thoroughly rinsed with distilled/deionized water before and after each use.
- Measurements shall be recorded to the nearest 0.1 ppm (mg/L) concentration.

A4 Temperature

Calibration

- The meter should be calibrated in accordance with manufacturer's instructions.

Temperature Measurement

- Measure the temperature of the sample immediately after collection.
- Following stabilization, record the temperature to the nearest 0.5 degree centigrade.
- The thermometer shall be rinsed with distilled/deionized water before and after each use.

A5 Turbidity

General Information

- A turbidity meter shall be used to make turbidity measurements on aliquots of water. Measurements shall be made as soon as possible on the obtained aliquot.

Calibration

- Calibration should be in accordance with the manufacturer's procedures. Standardized formazin solutions shall be used for calibration.
- The instrument should be calibrated at the beginning and end of each day's use.

Turbidity Measurement

- Operation should be in accordance with the manufacturer's procedures. The outside of the glass vials used for containing the aliquot for measurement must be wiped thoroughly dry before and after each use.
- Measurements should be recorded to the nearest 0.1 NTU when less than 1 NTU; the nearest 1 NTU when between 1 and 10 NTU; and the nearest 10 NTU when between 10 and 100 NTU.
- Care should be taken not to scratch cuvettes, to ensure that they are cleaned properly (inside and outside) between uses and to ensure correct alignment when taking readings.

APPENDIX B: FIELD FILTERING

B1 Equipment – Syringe or Filter Filtering

- Equipment for surface water sampling
- Sample collection bottle
- Deionized/distilled water
- Syringe Filtering:
 - Sterile 60 mL polypropylene syringe with conical nozzle (Luer Lock)
 - Sterile 25 mm polypropylene filter (CamLab serial no. LFP 1519 is a 25 mm 0.45 µm nylon filter with a 10 µm polypropylene pre-filter or suitable substitutes)
- Filter
 - 0.45 µm, 15-mm diameter or larger, tortuous path capsule filter (Gelman Supor 12175 or equivalent)
 - peristaltic pump (for filtered samples)
- Temporary sample container if not filtering directly from source. It is preferable not to use an intermediate sample container.
- Latex gloves
- Waste container for waste water

B2 Field Filtering Using a Syringe Filter

- Ensure that the sample bottle contains preservative. The bottles supplied by the lab may contain preservative already, or it may need to be added.
- If using a temporary sample container, rinse the temporary sample container twice with deionized/distilled water.
- Rinse the temporary sample container twice with sample water.
- Fill the temporary sample container with sample water.
- Completely fill the syringe twice with sample and discharge it both times into the waste water container.
- Fill the syringe with sample and fix the filter to the syringe nozzle.
- Filter 10 mL of water into the waste container.
- Filter water into the sample container.
- If the syringe needs refilling, repeat procedure above being careful not to allow drops of unfiltered water to enter the sample bottle as the filter unit is removed and reattached to the syringe.
- Label the sample bottle as a “filtered sample”.
- Dispose of the syringe and filter.

- Place the sample into a cooler with ice packs for shipment to the laboratory.

B3 Field Filtering Using a Peristaltic Pump and Filter

The following procedure describes collection of an equipment blank and sample for analysis. An equipment blank will not be collected at all stations.

- Set up the filtration system. Attach a capsule filter to the outlet end of the tubing.
- The water sample bottle is placed near two empty, sample bottles, a bottle of laboratory grade distilled/deionized water (for the equipment blank) and a waste container.

Equipment Blank

- Remove the lid of the distilled/deionized water bottle and place the end of the pump tubing in the bottle.
- Start the pump and pass approximately 200 mL of distilled/deionized through the tubing and filter to the waste container. Move the outlet tubing to a clean bottle and collect the remaining reagent water as an equipment blank.

Site Sample

- Remove the lid of the sample bottle and place the intake end of the tubing in the bottle.
- If sample bottles do not contain preservative - start the pump and pass approximately 50 mL through the tubing and filter into the remaining clean sample bottle and then stop the pump. Use the filtrate to rinse the bottle, and then discard this water into the waste container (omit this step if the preservative is in the bottle). Return the tubing to the sample bottle. Start the pump and pass the sample through the filter and collect in the sample bottle.
- Label the sample bottle as a “filtered sample”.
- Dispose of the filter.
- Place the sample into a cooler with ice packs for transport to the laboratory.
- Peristaltic pump modules do not require cleaning but they do contain a metal head and controls. It should be kept in mind that touching the head or controls during sample collection necessitates changing gloves before touching the apparatus.

APPENDIX C: DECONTAMINATION OF EQUIPMENT

C1 Essential Information

- Available information on the known or suspected characteristics, location and extent of contamination.
- Information pertaining to the field program, including the type of sampling equipment to be used (e.g. bailer).
- Details of facilities available at site, including source(s) of and access to potable water, potential water discharge location(s) such as a sanitary sewer, any applicable discharge permits.

C2 Equipment

Several of the following may be required:

- Potable water supply (available on-site or brought in)
- Deionized water
- Distilled water
- Laboratory-grade non-phosphate detergent
- Paper towels
- Containers (e.g., buckets or drums with lids, or a tank) to collect wash water, if necessary
- Appropriate solvents (e.g. acetone, methanol)
- Squeeze bottles (for distilled/deionized water)
- Garbage bag
- Scrub brush
- Plywood or plastic sheeting
- Several pairs of latex gloves (or other gloves as appropriate)
- Any existing decontamination procedures identified as part of the sampling programme.

C3 Planning and Preparing for Decontamination of Equipment

General Planning

- Review available information regarding the site characteristics, including type and extent of contamination.
- Determine whether a source of potable water is required (e.g., for decontamination purposes) and whether it is available on-site.
- Establish which types of equipment will be used during the field program, including water sampling equipment such as bailers.

Considerations for Water Sampling

- If possible, plan the timing of the sampling program so that the first samples are collected from the areas expected to have the lowest concentrations of contaminants, and the last samples are collected from the areas expected to have the highest concentrations of contaminants - in order to limit concerns with respect to cross contamination.
- Consider placing sampling equipment (e.g., water level probes, sample bottles, lids and filters) on clean plywood sheeting or plastic next to the sampling location.

Selection of Appropriate Cleaning Methods, Detergents and Solvents

- In selecting appropriate decontamination methods, consider the characteristics of the known or suspected contaminant(s) and the sample data quality required.
- In choosing an appropriate detergent (if applicable), consider the surface to be cleaned, the level of cleanliness and residue removal required, the cleaning method to be used and the performance of the detergent.
- A laboratory-grade, non-phosphate detergent is typically used for decontamination purposes.
- Solvents such as technical-grade hexane, acetone and/or methanol may be necessary and appropriate if extensive contamination with organic residues is encountered.
- Solvents should be used sparingly and only if necessary, to avoid expense associated with the generation and disposal of large volumes of wash water containing solvents, as well as associated health and environmental hazards.
- In cases where the use of solvents is considered necessary, the equipment should first be scrubbed using water and detergent, followed by a rinse with distilled or potable water. Solvent rinses should then be applied (make sure excess is collected) sequentially, and allowed to evaporate.
- The sequence of solvents applied is commonly hexane, followed by acetone and/or methanol. These chemicals help dry the equipment and remove any solvent-soluble residues that may remain. The equipment should then be rinsed thoroughly with deionized water.

C4 Implementing Decontamination Procedures During Field Program

- Document the selected decontamination procedures and ensure that they are available for reference in the field.
- Ensure that any deviations from the established procedures are recorded in the field book for future reference.
- Ensure that containers for the collection of wash water (if necessary) are ready at the sampling location.
- Make sure that all wash water generated is appropriately disposed of or collected in a suitable container.
- If possible/appropriate, separate wash water that is expected to have low concentrations of contaminants and/or solvents from water expected to have high concentrations.

APPENDIX D: WATER SAMPLE DATA SHEET

Sampling Point
Co-ordinates Latitude.....
Longitude.....
Date of sampling
Time of Sampling
Contact Person
Telephone
Purpose of sampling
.....
.....
.....
Water body
Flowing or standing water
Analyses required:
Major organic ions.....
Microbiological.....
Organic.....
Other (specify).....
Sample depth below surface
.....
On-site observations:
Odour Present/Absent
Color Normal/Abnormal.....
Appearance of water
.....
Temperature of water°C
pH of waterpH units
Conductivity of watermS/m
Preservation added:
Yes/no.....
If so, what preservative
OTHER INFORMATION
Water flowing yes/no
Flow measurement (if available)
Rainfall (if available)
Weather
General notes/other observations
.....
.....
.....
.....

APPENDIX E: CHAIN OF CUSTODY SHEET

