SDG indicator 6.3.2

Caribbean Working Group

20th September 2022

Monitoring Programme Design

SUSTAINABLE DEVELOPMENT GOALS

UN environment programme

GEMS Water

Introduction

Efforts to collect monitoring data for indicator 6.3.2 should provide sufficient information on the current ambient water quality status at the national scale, and enable long-term trends to be identified.

In order to identify the trends, data for the five core parameter groups are required from sites across the country, and the measurements should be taken in a standardised and consistent manner.

This presentation provides guidance for countries:

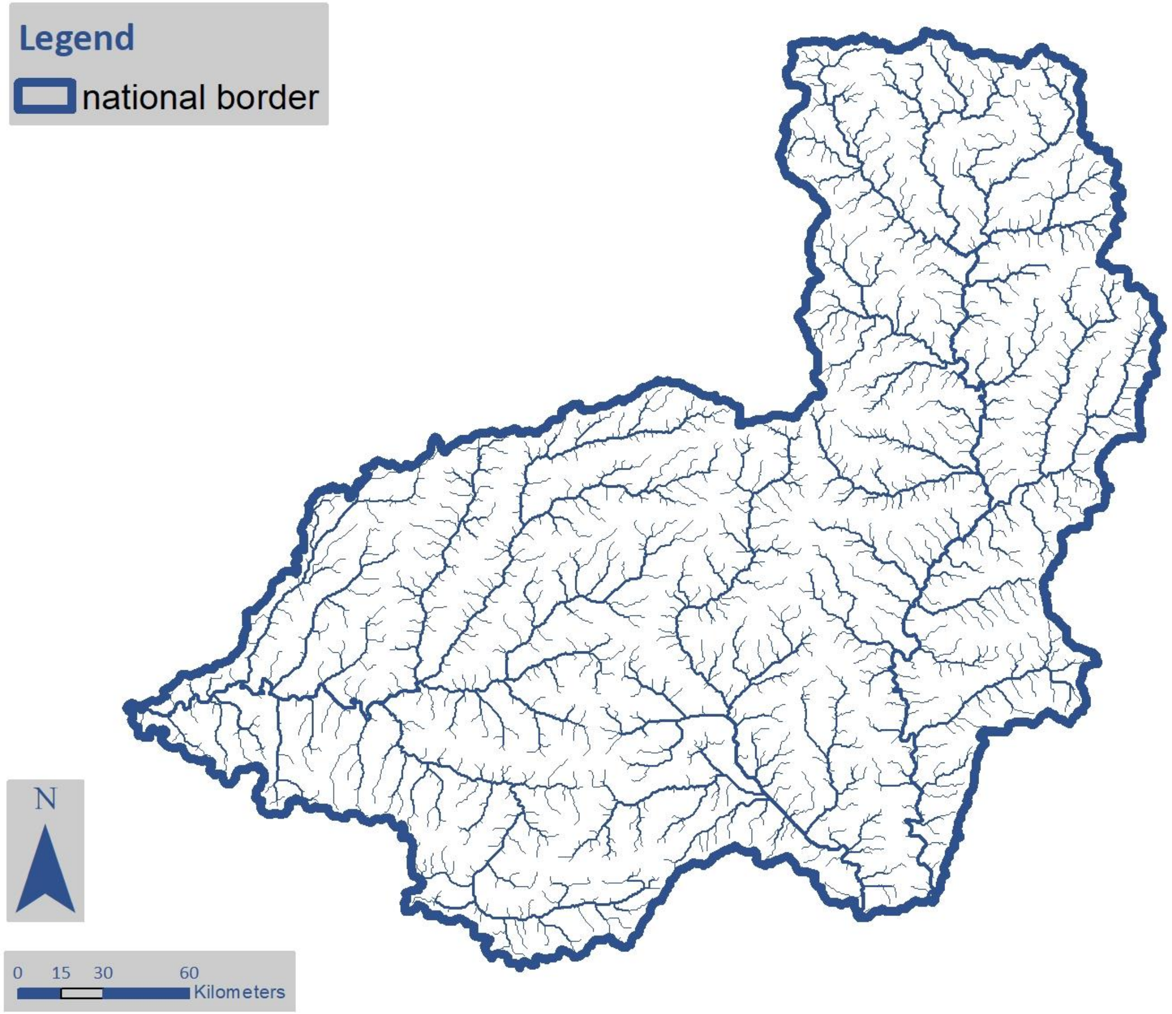
- to help meet the reporting requirements, and
- to help design a monitoring programme that makes efficient use of the available resources.

Introduction

There are five main steps of the indicator methodology:

1. define reporting basin districts (RBDs);
2. define water bodies;
3. define monitoring locations;
4. collect water quality data; and,
5. assess water quality.

Monitoring programme design is presented here within the context of these five steps.



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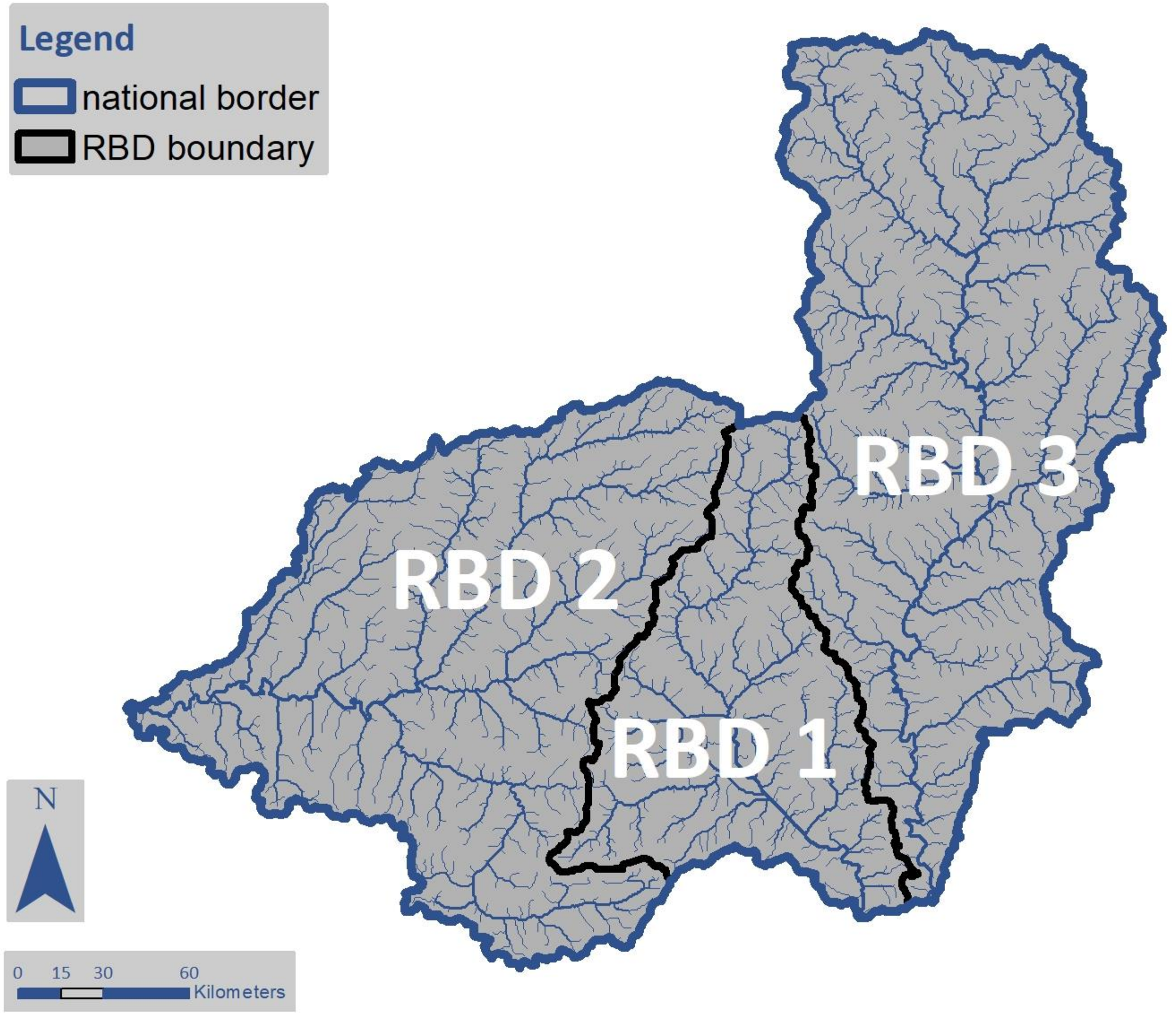
In this example, the country is divided into three **RBDs**.

Each RBD is derived from a single river basin, but they may be comprised of several smaller ones.



Data source HydroBASINS (Lehner and Grill, 2013)

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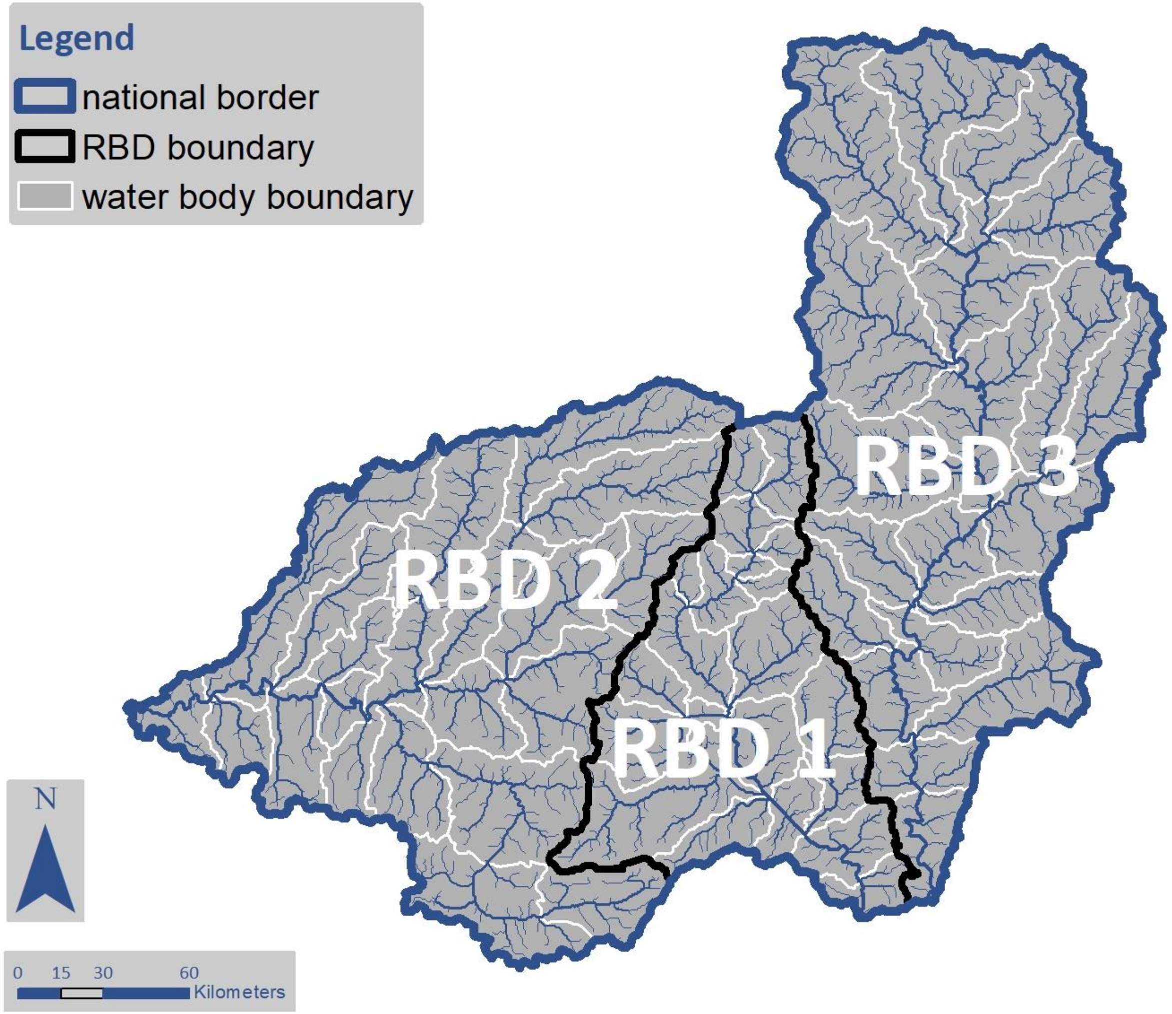
Each RBD is then subdivided into water bodies.

In this example showing river water bodies, each one is either a tributary, or a short section of river between two tributaries.



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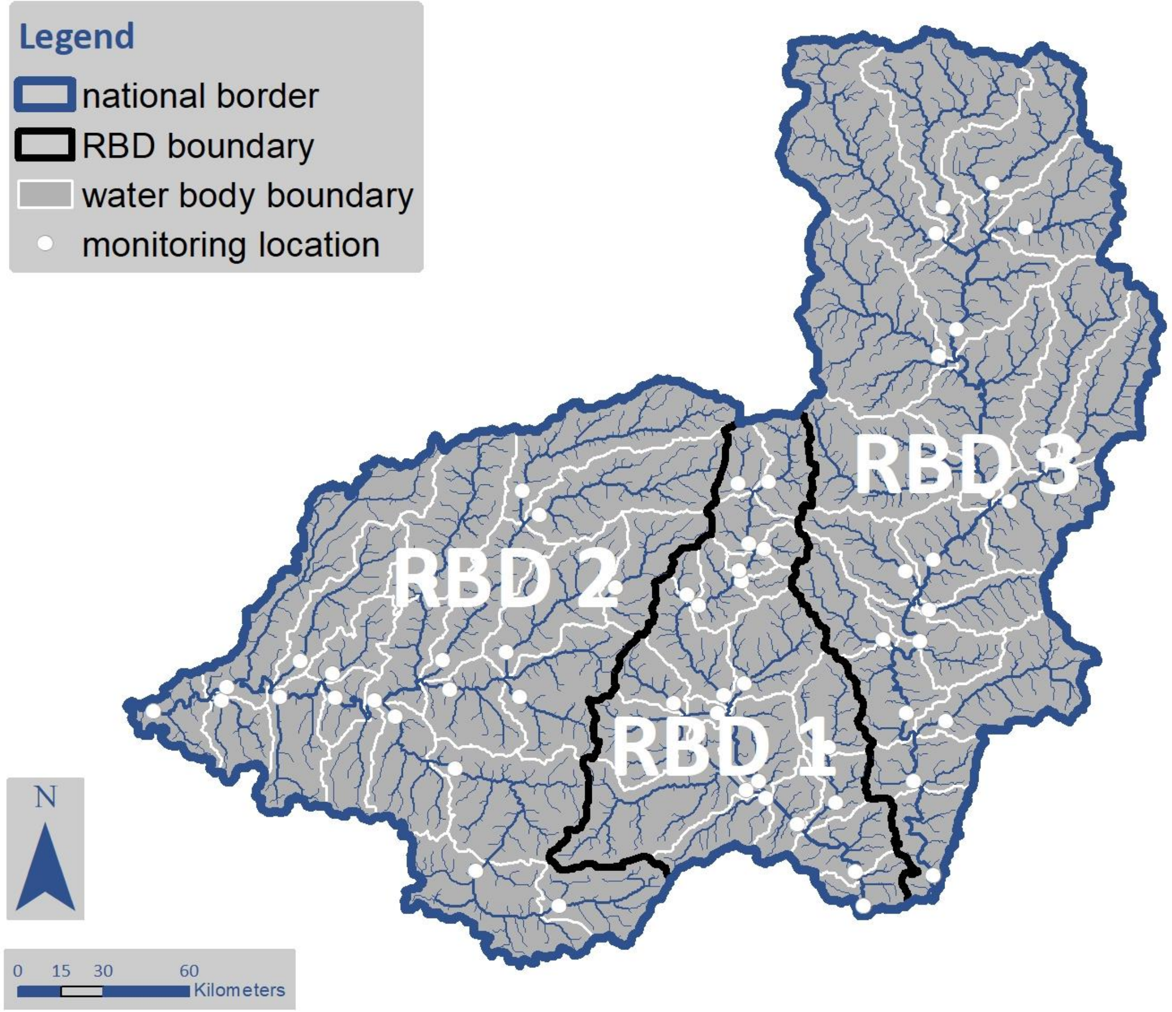
The next step is to define the monitoring network which includes defining the monitoring locations



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Introduction

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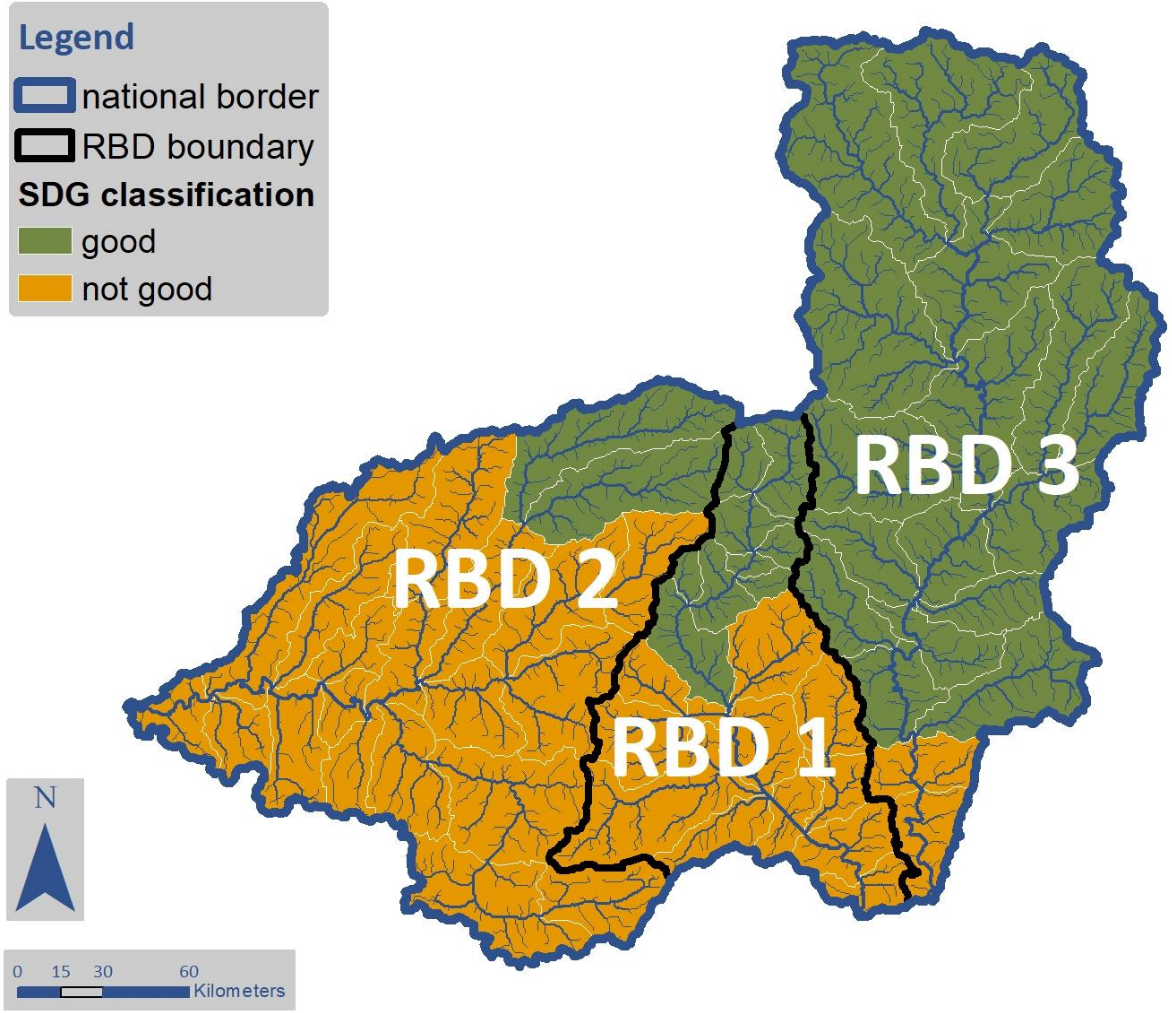
Then using the data collected from these locations, the water bodies are classified as either good or not good



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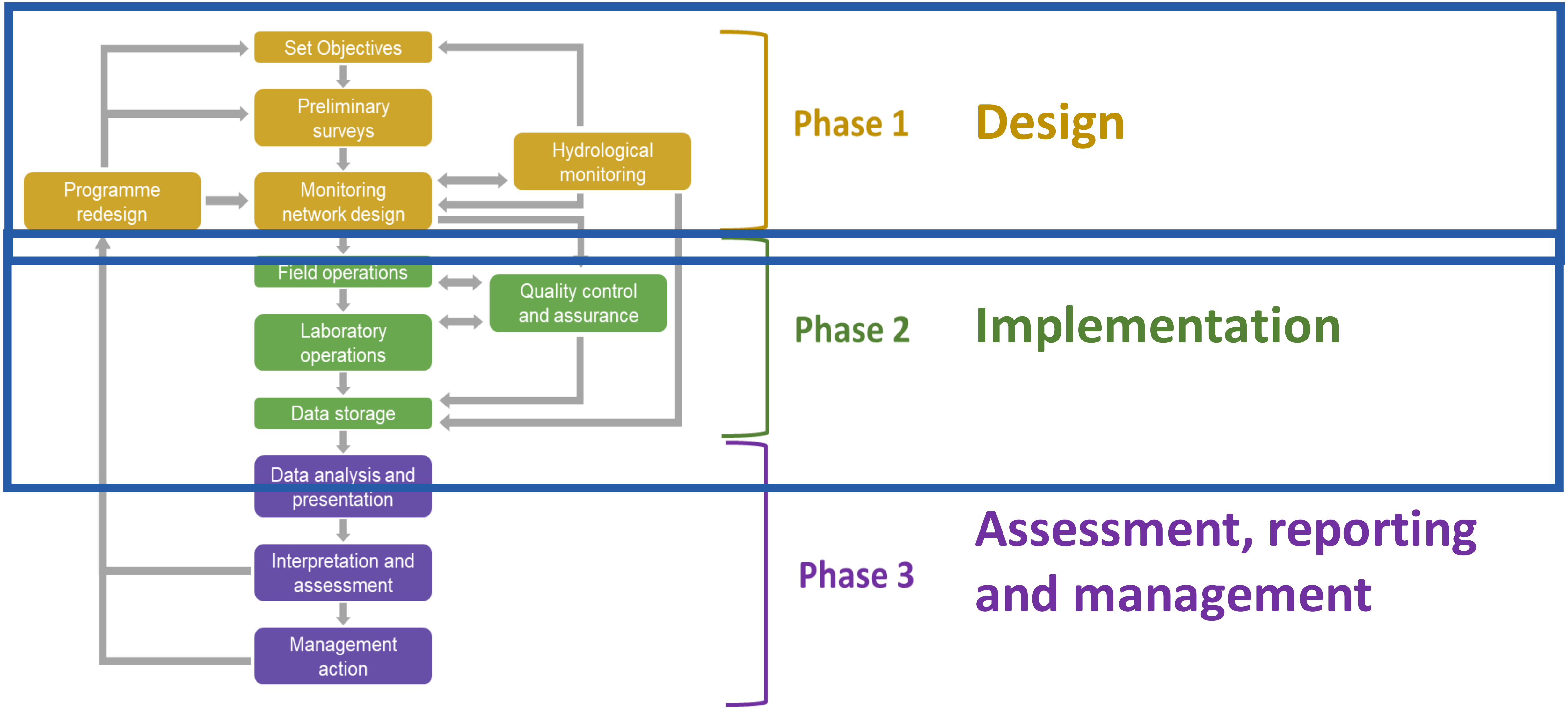
Monitoring Programme Cycle



Adapted from Chapman *et al.*, 2005

Monitoring Programme Cycle

Set objectives

The success of a monitoring programme is dependant on having clearly defined objectives

Monitoring programme objectives can only be defined when:

- a monitoring programme team have identified the information that is needed to support water quality management
- the data that need to be collected to provide the information, and the reasons behind their selection, have been defined.

For indicator 6.3.2 reporting, the aims of the monitoring programme are:

- to provide long-term trend monitoring data for the five core parameter groups (as a minimum),
- in as many water bodies as possible using the resources available, and
- to provide the most extensive and reliable data possible for the classification of ambient water quality.

Monitoring Programme Cycle

Preliminary Surveys

Preliminary surveys identify and fill knowledge gaps in the study area to inform monitoring programme design, for example they can determine natural variability in a system

They provide background information that can greatly assist in designing the monitoring programme.

All available information from other studies and monitoring programmes in the same, or similar geographical areas, or using similar monitoring techniques, may be useful.

These could include:

- historical water quality measurements,
- hydrological records,
- biological data and information on geology and land-use,
- site investigations such as sampling to assess the homogeneity of potential monitoring locations, or
- to confirm easy and safe access to water bodies and suggested monitoring stations.

Monitoring Programme Cycle

Monitoring network design

Good monitoring network design makes efficient use of resources while still producing high quality data that allow the objectives of the monitoring programme to be met. There are three main activities involved in the monitoring network design:

- Selecting the monitoring media and the sampling and analysis methods
- Selecting monitoring locations
- Choosing sampling frequency

Monitoring Programme Cycle

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Monitoring Programme Cycle

Selecting the monitoring media and the sampling and analysis methods

Parameter group	Parameter	River	Lake	Groundwater	Reason for Inclusion
Oxygen	Dissolved oxygen	●	●		Measure of oxygen depletion
	Biological oxygen demand, Chemical oxygen demand	●			Measure of organic pollution
Salinity	Electrical conductivity Salinity, Total dissolved solids	●	●	●	Measure of salinisation and helps to characterises the water body
Nitrogen*	Total oxidised nitrogen Total nitrogen, Nitrite, Ammoniacal nitrogen	●	●		Measure of nutrient pollution
	Nitrate**			●	Health concern for human consumption
Phosphorous*	Orthophosphate Total phosphorous	●	●		Measure of nutrient pollution
Acidification	pH	●	●	●	Measure of acidification and helps to characterises the water body

*** Countries should include the fractions of N and P which are most relevant in the national context**

**** Nitrate is suggested for groundwater due to associated human health risks**

Monitoring Programme Cycle

Selecting the monitoring media and the sampling and analysis methods

The method that is to be used for each parameter should be decided during the Design Phase.

This includes information such as the specific analytical method, and whether the analysis takes place in the field, or if samples are to be transported to a laboratory.

Consideration should be given to the limit of detection of the chosen methods, and if samples are being transported to a laboratory, the transportation time and preservation method.

In some cases, it may not be possible to transport the samples from remote monitoring stations to the laboratory within the recommended time, and therefore analysis in the field may be the only option.

Monitoring Programme Cycle

Selecting the monitoring media and the sampling and analysis methods

All of the core parameters of Level 1 can be monitored in the field using kits and probes such as those shown here.

Countries may decide that the analytical facilities of a laboratory, with improved levels of accuracy and precision are preferable. This is especially relevant for the nutrients (N and P).

Monitoring Programme Cycle

Monitoring network design

- Selecting the monitoring media and the sampling and analysis methods
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Monitoring Location

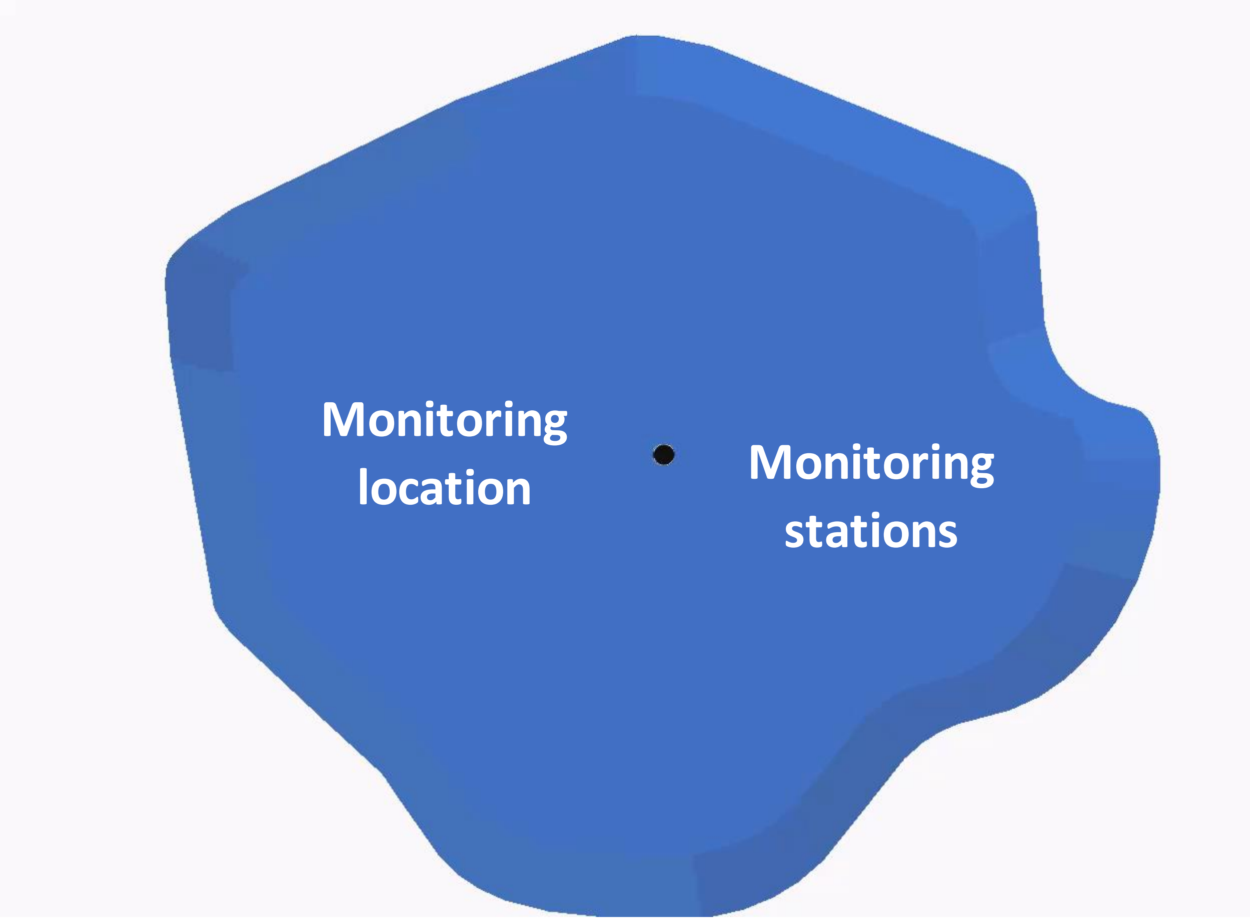
Selecting monitoring locations

Monitoring locations are less specific than monitoring stations

Monitoring location = general location of where a sample is taken, such as a section of a river.

Monitoring station = specific detail (e.g. geographic position and depth) on exactly where samples are to be collected or analyses are to be performed.

For example, a monitoring location for a lake may be defined by geographical coordinates but, at this single location, there may be several monitoring stations at different depths.



Rivers

Selecting monitoring locations

As a general rule, the larger or more heterogeneous a water body, the more monitoring stations are needed for reliable classification.

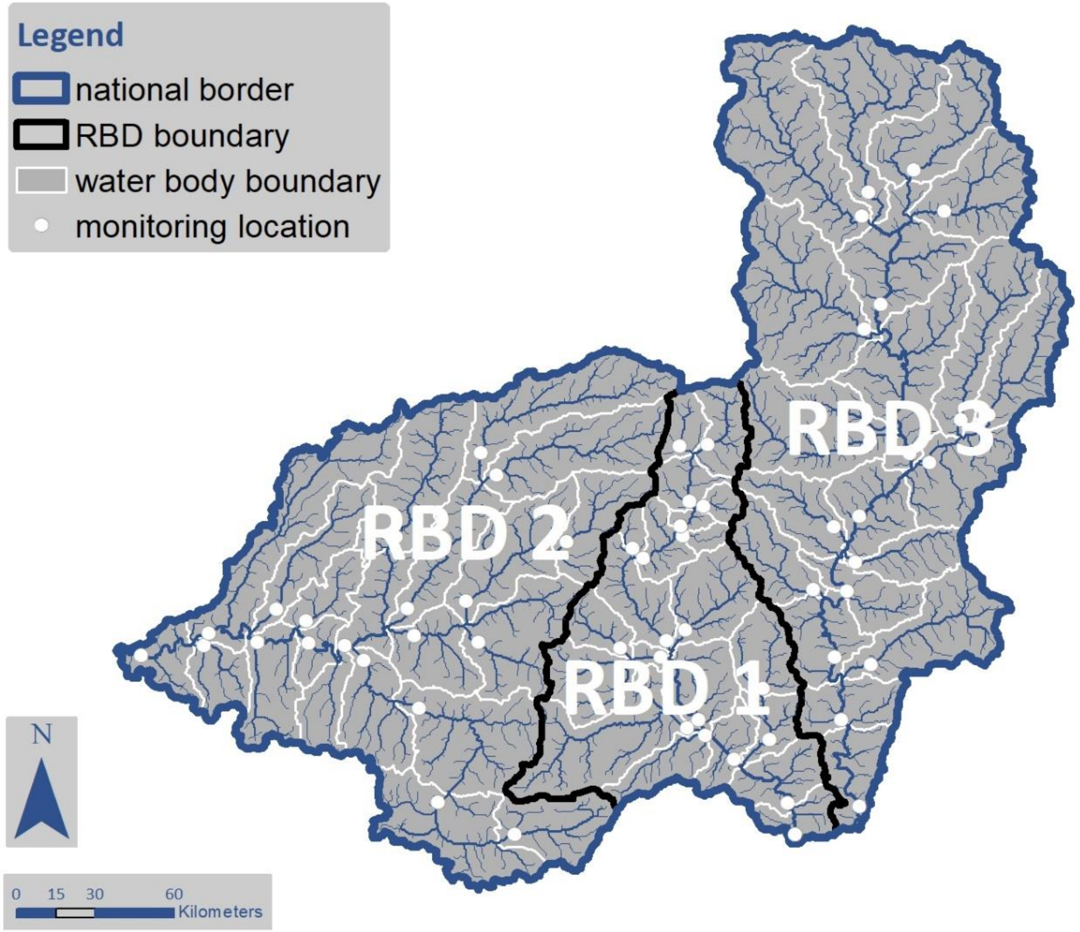
If more than one station is needed per river water body, they should be located at both impacted and unimpacted locations.

Where resources restrict monitoring to a single location for a water body, the optimum location is the most downstream point where the river drains into the next designated water body, which may be, for example, another river section or a lake. This location will integrate all the influences on water quality arising from the catchment upstream of that location.

Selecting monitoring locations

The criteria used in this example were:

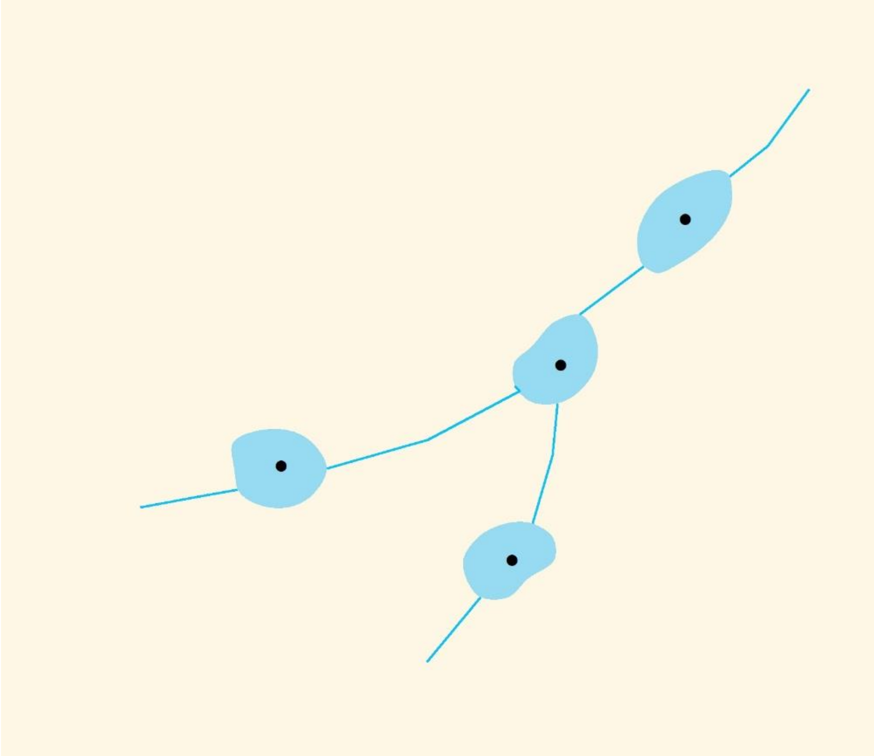
- at least one monitoring location per water body;
- they are situated at an intersection between a river and a road;
- safe access;
- co-location with existing hydrological stations;
- not close to a known point source of pollution;
- representative of impacted and unimpacted catchment areas.



Selecting monitoring locations

The number and locations of monitoring stations in lakes depend on the lake size and morphology. If a:

- lake is small and well-mixed, one sampling location near the centre or at the deepest part of the lake may be adequate.
- if a lake has multiple basins, a monitoring location may be required within each basin
- a large, single-basin lake, four monitoring locations, one in each homogeneous sector, may be adequate
- small lakes along a river course have a monitoring location in each lake.

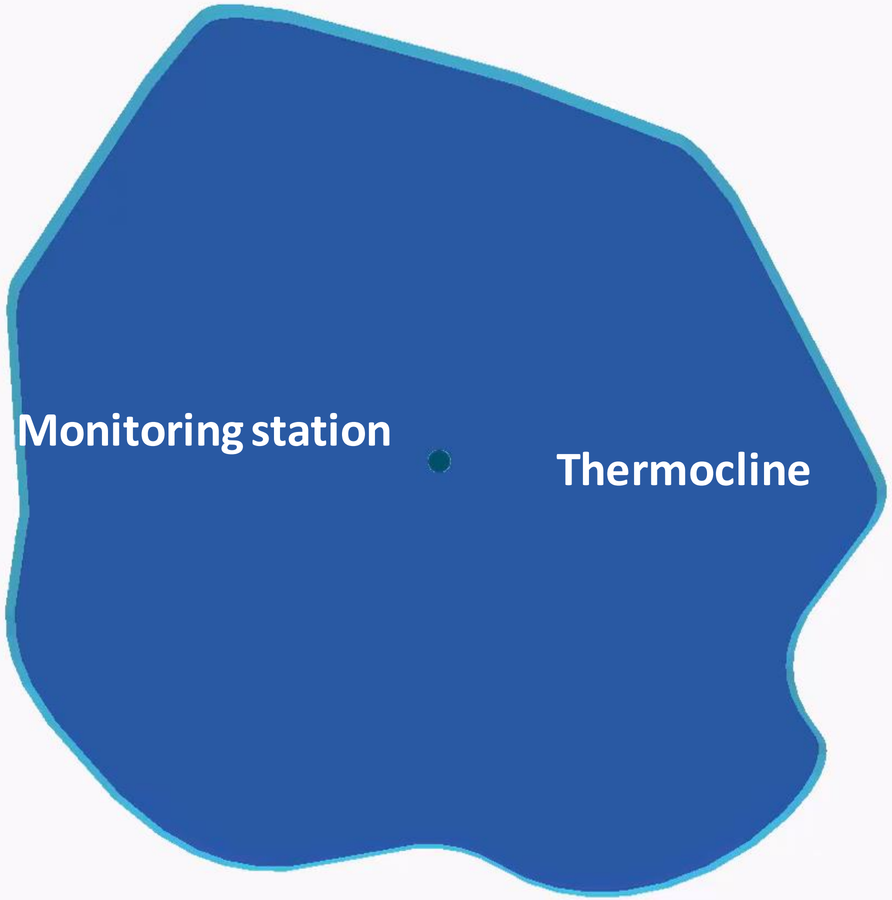


More detail can be found in Thomas *et al.*, 1996

Selecting monitoring locations

For the purposes of SDG indicator 6.3.2, lake monitoring locations:

- should be away from direct inputs of pollution, and
- samples from lakes that stratify seasonally should always be taken at a fixed depth below the surface. **This depth should above the thermocline**.
- Alternatively, an integrated depth sample can be collected. This kind of sample can be achieved by taking discrete depth samples and mixing them together or by using a hosepipe sampler (flexible plastic pipe or tube) which takes a sample through different depths of the water column.



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Monitoring Programme Cycle

Monitoring network design

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Monitoring network Design

Choosing sampling frequency

Trend monitoring requires a long-term record of relatively consistent data for the same places, and at the same frequencies, for a number of years.

Ideally, samples should not be collected during extreme events, such as during flood events when discharge is very high, unless this is a regular seasonal occurrence.

The samples should be taken during comparable conditions at the same times and locations over consecutive years.

Simultaneous river discharge measurements can assist in the interpretation of water quality data where the reasons for fluctuations in concentrations may be unclear.

Monitoring network Design

Choosing sampling frequency

The frequency of data collection can range widely, from continuous measurement using an automated instrument situated at the sampling location, to annual grab samples.

Sampling frequency should be higher at locations where water quality varies greatly than at stations where the water quality is relatively consistent.

The recommended frequency is at least one sample per season. If resources allow, it is recommended to sample **once a month** but, preferably, **no less than four times each year**. Sampling at these intervals every year will provide information for long-term trend monitoring applicable for SDG indicator 6.3.2.

Monitoring network Design

Choosing sampling frequency

Information on the variability of lake quality should be used to inform the choice of sampling frequency.

Locations where water quality varies should be sampled more frequently than locations where water quality is relatively consistent.

The frequency of sampling should also take into consideration seasonal variations, whether the lake stratifies and the residence time of the water in the lake.

At least annual sampling is necessary, but one sample per season is preferable if resources allow.

Hydrological Measurements

Hydrological measurements should accompany water quality data collection activities.
These may include water level, flow and velocity measurements.
The concentrations measured for some water quality parameters can be influenced by the hydrological conditions of a water body. These conditions change over time depending on weather events, seasons, and natural or anthropogenic alterations to the water body.
Therefore, hydrological measurements made at the same time, and at the same location from which water quality samples are taken, can assist in interpreting the water quality data.

Field Operations

Field operations comprise a significant component of the overall water quality monitoring programme budget. Fieldwork and data collection should follow Standard Operating Procedures (SOP) to ensure consistency and reliability. Field observations made during each sampling campaign may prove useful to help interpret the resultant data and thereby increase data value.

Field notes should include the date and time of sample collection, weather conditions, sample identity or code, notes on any field measurements taken, the methods used, and the results obtained. Additional observations might include, notes on the aquatic flora, unexpected colours or smells of the water, or the presence of potential sources of contamination such as a broken pipe or evidence of livestock entering the water body.

Health and safety should be of the utmost importance for any fieldwork. The sampling locations should be safe to access and free from hazards. The appropriate personal protective equipment (PPE) should be brought and worn during sampling.

A first aid kit should also be brought on any field campaign. Efforts to avoid working alone should be taken but when unavoidable, strict call-in times and response plans should be put in place.

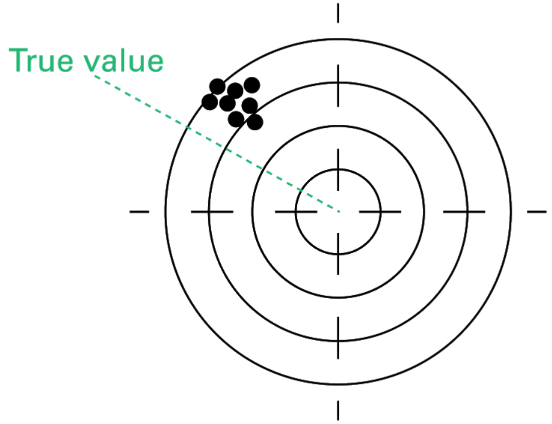
Quality Assurance and Quality Control

Quality assurance (QA) is the management system used to maintain a desired level of quality in a service,

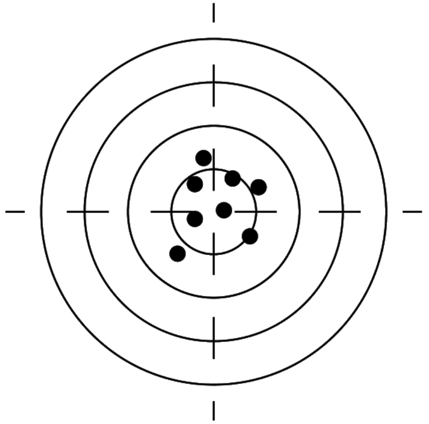
A water quality monitoring programme with adequate QA produces credible and defensible data that can be relied upon to assess water quality and plan management actions.
Obtaining credible data can be done by using recognised or standard methods such as those from the International Organisation for Standardisation (ISO) (www.iso.org) and by following good laboratory practice as prescribed in ISO 17025 (ISO 2017).

Within a QA plan for a monitoring programme, there should be SOPs for all sampling, calibration processes, analytical processes and audits.

Quality control (QC) consists of a series of technical activities that aim to evaluate and improve the quality of data produced. It helps to reduce the possibility of introducing error into results. This is relevant for all aspects of the implementation phase of a monitoring programme including collection, preservation, transportation, storage, analysis, data handling and reporting.



High precision but low accuracy


High accuracy but low precision

Data Management

The data storage system used should allow the relevant data to be extracted for analysis and classification of water bodies for indicator 6.3.2 reporting easily. For example, if stored correctly, it should be straightforward to extract data for a particular time period or RBD.

Investing time and effort into managing data appropriately, adds value for the future and ensures the data will remain valid beyond the planned lifetime of a monitoring programme.

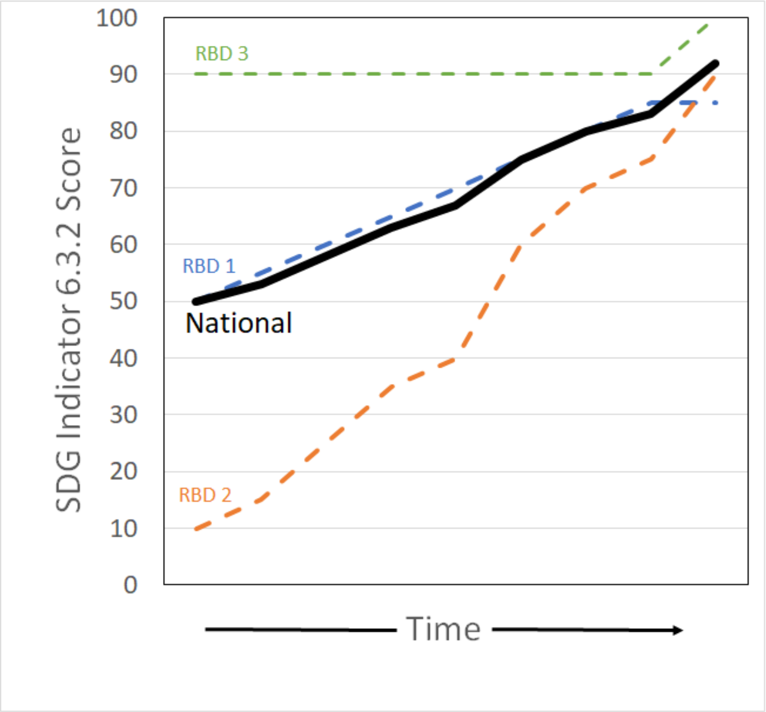
Water quality data often go through many processes and are manipulated by many people, resulting in several opportunities for errors to be introduced.
Incorrect measurement units or conversions, limits of detection, significant figures or other anomalies, should be detected before the data are stored or reported.

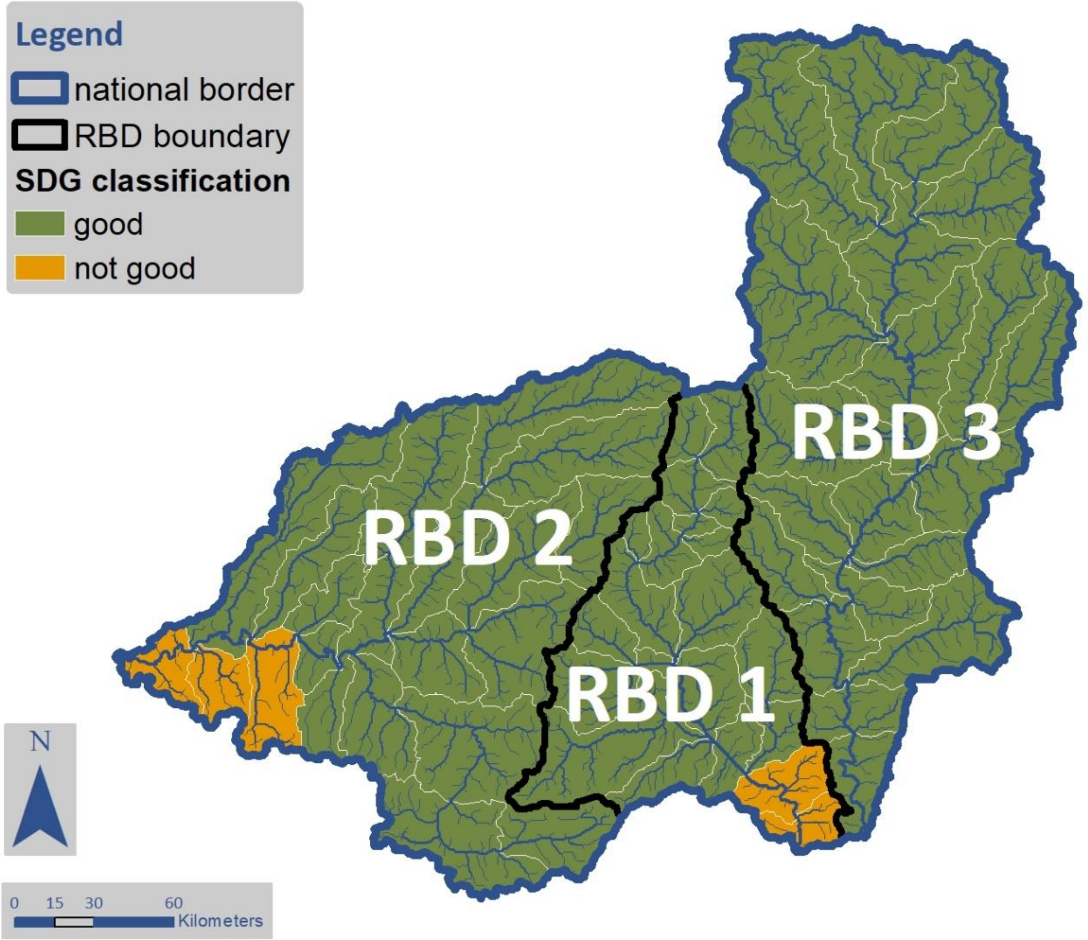
A centralised storage system should be backed up regularly. The central data repository should keep all relevant metadata associated with the water quality measurements, including geographical co-ordinates for each monitoring location, type of water body and other recorded notes.

Summary

Knowing where water quality is good and where it is not, is essential if countries are to implement management decisions for its improvement.

Good monitoring programme design is critical in this process, and ensures programmes deliver sufficient and reliable data, that are capable of tracking improvements in ambient water quality over time.

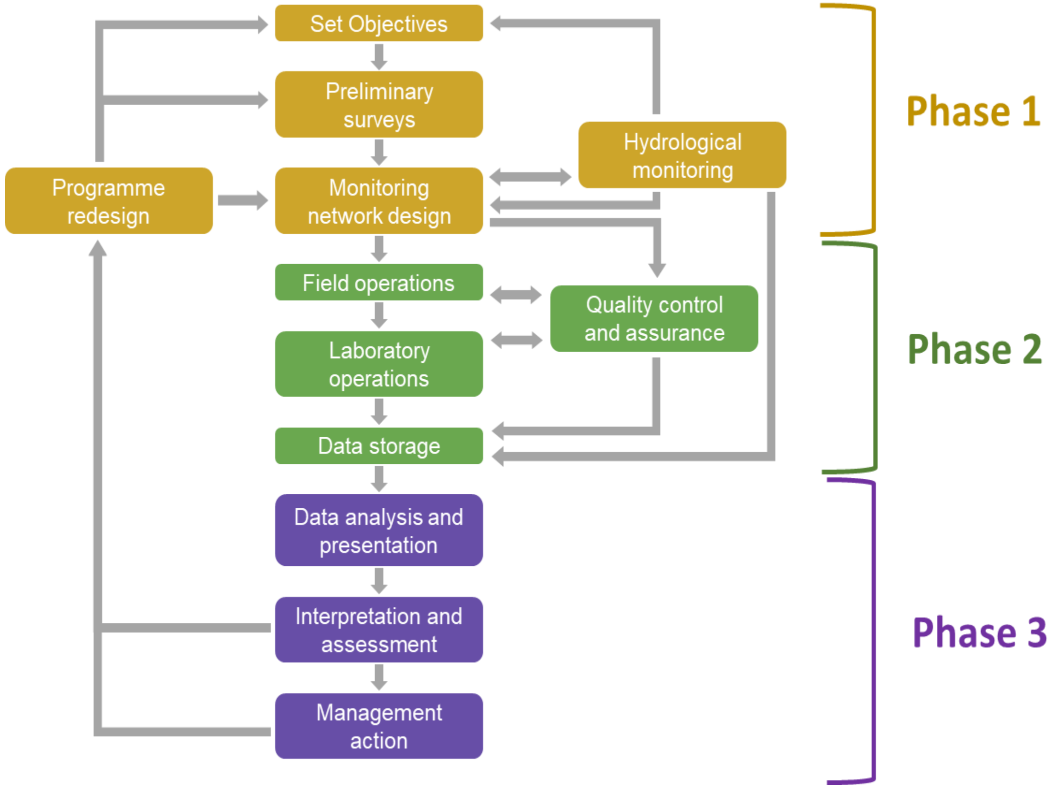




Summary

This presentation provided information for ambient water quality monitoring programme design, particularly in the context of the implementation of SDG indicator 6.3.2.

Reporting Basin Districts and water bodies should be delineated and defined before a monitoring programme can be designed. The monitoring programme design flowchart summarises the essential steps into three phases: design; implementation; and assessment, reporting and management. These three phases help to produce and maintain a successful water quality monitoring programme. Consistent quality assurance and periodic re-evaluation of the monitoring programme help to ensure the programme is capable of supplying sufficient and reliable data for indicator reporting.



Thank you

Indicator 6.3.2 Support Platform

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References and Further Resources

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Online courses on various aspects of freshwater monitoring and assessment are available from the GEMS/Water Capacity Development Centre. Information can be found at https://www.ucc.ie/en/gemscdc/onlinecourses/