

# TECHNICAL GUIDANCE ON WATER QUALITY MONITORING



**Department of Environment  
Ministry of Natural Resources and Environment  
Malaysia**

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**LIST OF ABBREVIATIONS**

°C	Degree Celsius
AN	Ammoniacal Nitrogen
APHA	American Public Health Association
ASMA	Alam Sekitar Malaysia Sdn. Bhd.
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DID	Department of Irrigation and Drainage
DO	Dissolved Oxygen
DOE	Department of Environment
E. Coli	Escherichia coli
EIA	Environmental Impact Assessment
EHS	Environment, Health and Safety
EPMC	Environmental Performance Monitoring committee
EMP	Environmental Management Plan
EO	Environmental Officer
ESCP	Erosion and Sediment Control Plan
GC-MS	Gas Chromatography–mass Spectrometry
GPS	Global Positioning Systems
HPLC	High-performance Liquid Chromatography
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectroscopy
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
INWQS	Interim National Water Quality Standards
MWQS	Marine Water Quality Standards
m	Metre
m <sup>3</sup> /s	Cubic metre per second
ml	Milli-litre
O&G	Oil and Grease
PAH	Polycyclic Aromatic Hydrocarbon
QA / QC	Quality Assurance / Quality Control
SAMM	Skim Akreditasi Makmal Malaysia
TOC	Total Organic Carbon
TSS	Total Suspended Solids
UNEP	United Nations Environment Programme
US EPA	US Environmental Protection Agency
UV	Ultraviolet
WHO	World Health Organisation

SECTION 1 : PURPOSE OF GUIDANCE DOCUMENT

**1.1 PURPOSE OF GUIDANCE DOCUMENT**

This guidance document aims to ensure that water quality sampling and monitoring is carried out in a consistent and systematic manner. The guidelines will lead to better planned water quality sampling and monitoring programme in which to provide good quality data and useful information for the assessment of water quality and management of our natural resources.

This guidance document is intended for the use of registered Environmental Consultants, water sampling field personnel, laboratories, Project Proponents, Environmental Officers (EO) at project sites and Contractors engaged for the construction of the project.

Besides the recommendations outlined in this document, other requirements specified in the approval conditions (Environmental Impact Assessments, EIA) and other instructions or notices issued by the Department of Environment (DOE) from time to time are to be complied with.

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## **2.1 ROLES OF PROJECT PROPONENT, ENVIRONMENTAL OFFICER AND CONTRACTOR**

The Project Proponent refers to the organization that plan, manage and finance the implementation of the project or activity. The Project Proponent would engage a main Contractor for the construction of the project. In most cases, an Environmental Officer (EO) is appointed to oversee the environmental aspects of the project and reports to the Project Manager who is responsible for the overall implementation of the project.

The roles of the Project Proponent, Environmental Officer and Contractor in relation to executing self-regulations in the environmental monitoring process are described below.

### **2.1.1 Project Proponent**

The Project Proponent is ultimately responsible to ensure that the project implementation does not adversely affect the surrounding environment and receiving ecosystems.

The roles of the Project Proponent include:

- Appoint a qualified and registered Environmental Consultant to conduct the baseline studies and prepare the EIA report
- Appoint a full time EO who is trained on environmental matters including legislations, pollution control and mitigation measures, and familiar with requirements for project compliance (EIA and EMP approval conditions).
- Engage a Contractor with good track records of environmental compliance
- Engage an accredited laboratory for environmental monitoring
- Provide copy of EIA report and conditions of approval to the Contractor for compliance. Conditions of approval should be made part of the contractual agreement with the Contractor
- Include compliance to conditions of the EIA approval in the contract documents with the Contractor
- Review reports from EO on environmental monitoring performed
- Review reports from Contractor on control measures implemented

### **2.1.2 Environmental Officer (EO)**

The EO can be either employed by the Project Proponent or the Contractor. In the former, the EO is usually the Environment, Health and Safety (EHS) officer, as in the case of large industries. If the EO is engaged by the Contractor, it is usually for the duration of the project construction as part of the contract agreement terms.

It is recommended that an Environmental Performance Monitoring committee (EPMC) be established to address issues related to water quality and other environmental aspects at the project site. In this regards, the EHS committee can function as the EPMC.

The EO is responsible to ensure that the control measures and monitoring programme proposed in the Environmental Management Plan (EMP) are properly implemented. With regards to water quality monitoring, the EO will refer to the EIA approval conditions and approved EMP which will have details of the sampling stations, frequency of monitoring and parameters for analysis.

The roles of the EO include:

- Ensure all control and mitigating measures in EMP are implemented in a timely and effective manner
- Conduct regular inspection and audit of all control measures implemented at site
- Conduct in-situ sampling and testing using appropriate quick tests and instruments, particularly on water samples collected after storm events
- Ensure environmental monitoring are carried out according to stipulated schedule
- Supervise environmental monitoring by monitoring team at the selected sites
- Review environmental monitoring reports for compliance to conditions of project EIA, standards and take appropriate corrective actions where necessary
- Ensure corrective actions are implemented on a timely basis
- Ensure timely submission of environmental monitoring reports to the DOE

### **2.1.3 Contractor**

The Contractor is responsible for the implementation of all the appropriate control measures outlined in the EMP during the construction of the project. The control and mitigating measures are to be implemented in a timely and effective manner.

The roles of the Contractor include:

- Comply with the EIA approval conditions and EMP monitoring requirements
- Ensure all control and mitigating measures in the EMP and Erosion and Sediment Control Plan (ESCP) approved by DID are implemented in a timely and effective manner
- Conduct regular inspection of the control measures to ensure their effectiveness
- Take appropriate actions to remediate, improve or repair control measures to ensure their effectiveness

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### 3.1 OVERVIEW

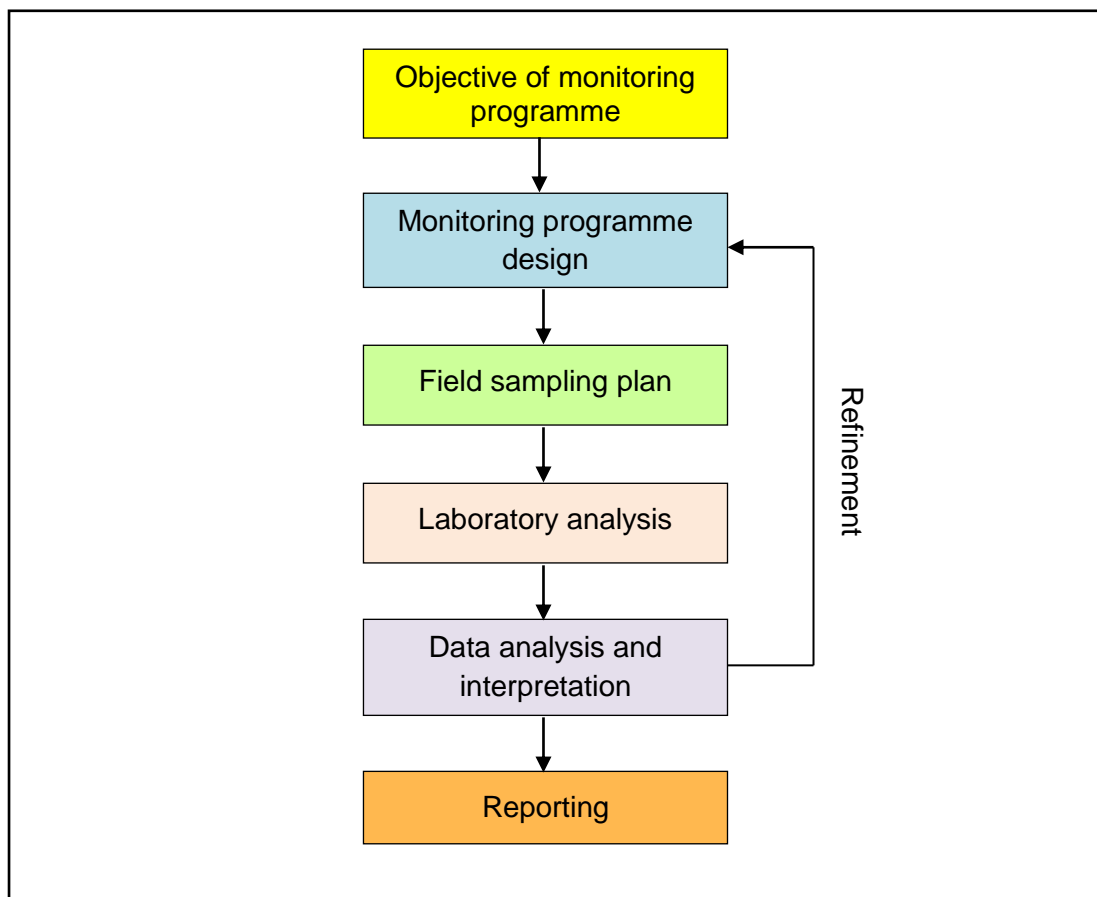
In designing an effective sampling or monitoring programme for the assessment of water quality, the following factors need to be considered:

- Objectives of monitoring – whether it is to establish baseline water quality, water quality assessment (EIA), environmental management during project development and operation stage (post-EIA monitoring);
- Type of water quality assessment, whether it is a new or supplementary report to a previous one;
- Type and characteristics of the water body whether upland river, lowland river, lake and reservoir, estuary or marine; fast flowing or stagnant; shallow or deep water body etc.;
- Use of the water resources, whether for conservation, water supply, recreation, agriculture (irrigation / livestock), aquaculture etc.;
- Site characteristics such as terrain, geology, surrounding land use etc.; and
- Seasonal variation (e.g. diurnal, seasonal, annual)

The basic steps involved in developing a programme for monitoring and assessment of water quality include (illustrated in **Figure 3-1**):

- i. Define objectives of the monitoring programme
- ii. Design of monitoring programme, including type of monitoring (ad-hoc, periodic, regular), scale, duration, frequency, parameters
- iii. Field sampling plan
- iv. Laboratory analysis
- v. Data analysis and interpretation
- vi. Reporting

**Figure 3-1 Framework for developing a water quality monitoring programme**



### 3.2 OBJECTIVES OF MONITORING PROGRAMME

Before planning a water quality sampling and monitoring programme, the objectives must be clearly stated. The goal of an effective monitoring programme is to obtain accurate information and data about an issue or concern, economically and in a timely manner, for decision making.

The common objectives for monitoring of water quality include:

- To measure baseline quality of ambient freshwater or marine water (as in EIA assessments)
- To assess the effectiveness of control or mitigating measures (post EIA monitoring reports);
- To assess the load of pollutants into a receiving water body from an activity(s) within the catchment;
- To compare water quality to appropriate standards for its designated use;
- To identify trends in the quality of the water body;
- To provide information for better management of water resources.

SECTION 3 : FRAMEWORK FOR DESIGNING A MONITORING PROGRAMME

Monitoring objectives should be specific, measurable, attainable, result-oriented, to be achieved within a stipulated time frame. Well defined objectives will make it easy to design a sampling plan to obtain the information required.

### **3.3 AVAILABLE INFORMATION**

At the start of a monitoring programme, available secondary information relating to the water quality of the water body should be collected. The compilation of data may include a review of relevant previous monitoring data collected for the site of interest, of nearby locations or other locations with similar conditions, other studies or reports as well as from third party or agencies. Collation of such information will save time and funds by avoiding unnecessary repeat studies on similar issues or site of interest.

Existing data may comprise of water quality analysis results, stream-flow records and some biological data. Some of these data may have been published; others may be in the records of various agencies or research providers.

The sources of available secondary information include:

- Department of Environment – annual reports
- Alam Sekitar Malaysia Sdn. Bhd. (ASMA) – historical water quality data;
- Department of Irrigation and Drainage (Jabatan Pengairan dan Saluran, JPS) – past records, particularly for streamflow data of rivers
- Other relevant water quality, water resources management and hydrological studies conducted in the project area

### **3.4 NATURAL PROCESSES AFFECTING WATER QUALITY**

Understanding of the natural processes in the ecosystem that affects water quality is essential in designing a water quality monitoring programme. A conceptual process model illustrates the components and linkages in the system to be monitored. It presents the factors that drive changes in the system and the consequences of the changes. For example, nutrients are driving factors that results in chlorophyll or algal cells, and causes eutrophication in lakes.

SECTION 3 : FRAMEWORK FOR DESIGNING A MONITORING PROGRAMME

The process model is useful to outline:

- important components and linkages in the system
- key processes and cause-effect relationships
- spatial boundaries
- parameters for the processes concerned
- sampling site selection
- seasonal considerations

The key processes in the ecosystem that affects water quality falls into three broad categories namely physical, chemical and biological and include:

- flow, turbulence, mixing and stratification
- evaporation, precipitation, deposition
- pollutant transport, sedimentation, resuspension, diffusion
- pollutant dissolution, transformation, degradation, adsorption, precipitation
- nutrient transformation, recycling, nitrification, denitrification, ammonification
- ingestion, absorption, primary productivity

The monitoring programme may need to consider the sources and transport of pollutants, from the sources to streams, rivers, lakes, estuaries and the sea. The transport models for nutrients and metals are shown in **Appendix 2**.

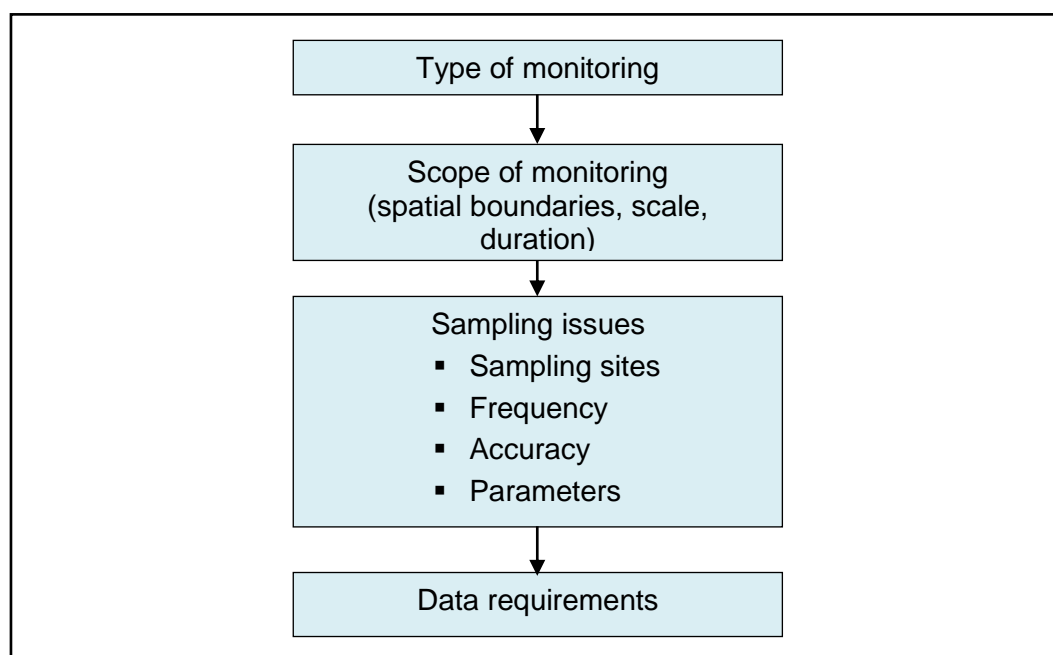
## 4.1 INTRODUCTION

The design stage of the monitoring programme involves a more detailed plan that addresses the specific data required to meet the objectives of the study or assessment. The basic steps for undertaking a monitoring programme design (shown in **Figure 4-1**) involves:

- i. Define the type of monitoring – baseline assessment reports (EIA), monitoring of changes in water quality (post EIA), conformity to water quality standards etc.;
- ii. Determine the scope of monitoring – type of water body (stream, river, lake, estuary, coastal), spatial boundaries (normally defined by catchment) and duration (length of time required to obtain appropriate understanding of the system);
- iii. Consider the sampling issues – field sampling sites, frequency, accuracy and parameters concerned
- iv. Determine the specific data requirements

The most important aspect to be considered in the design of sampling programmes is the variability of the environment, both spatial and temporal, which will dictate the location and number of sampling sites, and the frequency and timing of sample collection. Often data collected are too variable to be representative of ambient conditions or to show a trend or impact due to the high environmental variability coupled with the constraints of logistics.

**Figure 4-1 Framework for designing a monitoring programme**



## 4.2 SAMPLING PATTERNS

The pattern and timing of sampling is of critical importance in obtaining accurate data. The types of sampling include:

- Simple random sampling – samples may not be representative of the system due to variability within the site and time of collection. Data collected is considered unbiased.
- Stratified random sampling – considered more efficient than random sampling. Samples are collected from various strata within the system, as in lakes, estuaries and coastal waters. Stratification within the system may be spatial (physical) or temporal (seasonal).
- Systematic sampling – samples are collected at regular intervals. Measures needed to ensure unbiased sampling as regular sampling schedules may coincide with certain activities e.g. factory discharges is lowest in the morning compared to end of the day.

## 4.3 SAMPLING SITES

The criteria for selection of suitable sites include:

- Free flowing water, away from hindrances to flow (e.g. bridges, weirs, jetties).
- Well mixed and away from contribution from other sources such discharge outlets, convergence with other streams etc.
- Spatial variation within a site. Stratified sampling for water bodies with different strata (habitats) such as lakes, major rivers and marine waters. Samples to be taken from mid-stream or mid-channel rather than close to the banks in rivers.
- Sampling sites should be representative of the zone of impact. In EIA studies, the zone of impact is generally taken as 5 km radius from the project site. The zone of impact should however extend to the sensitive receptors located further away such as water intake stations, aquaculture/ agriculture activities, fish breeding grounds etc. Samples should be taken from upstream and downstream of the site. Coastal waters are subject to longshore currents and samples should be collected along the coastline.

Hydrological maps, topographical maps, aerial photographs, land use plans and other records of activities within catchment should be consulted in the selection of sampling sites. Reports of other studies conducted for the project area such as hydrological studies should be consulted in the selection of sampling stations.

Other factors to be considered in the selection of sampling sites:

- Sites must be easily and safely accessed under all weather conditions.
- Sites must be easily identifiable so that they can be sampled repeatedly. Global Positioning Systems (GPS) are useful tools especially in marine environment.

The checklist for selection of sampling sites is tabulated in **Table 4-1**.

**Table 4-1 Checklist for selecting sampling sites**

Criteria	Action required	
	Yes	No
i. Is water free flowing, away from hindrances?	-	Select alternative
ii. Is there any contribution from other sources? (e.g. discharge outlets, convergence with other streams etc.)	Select alternative	-
iii. Is water body shallow, deep, stratified? (e.g. major river, large lake)	Stratified sampling	Direct sampling
iv. Are selected sites sufficient and representative of zone of impact? (e.g. upstream and downstream of project site; sensitive users of water)	-	Add sites within zone of impact
v. Are sites safe and easily accessed during all weather conditions?	-	Select alternative
vi. Are sites easily identified for repeated sampling?	-	Use GPS

#### 4.4 SAMPLE TYPES

Two different types of sample can be taken from rivers, lakes and similar surface waters. The simplest is a grab sample, taken at a selected location, depth and time. Composite or integrated samples are samples made up of several different parts. Composite samples may be of the following types:

- *Depth-integrated*: commonly made up of two or more equal parts collected at pre-determined depths between the surface and the bottom.
- *Area-integrated*: made by combining a series of samples taken at various sampling points spatially distributed in the water body (usually all at one depth or at predetermined depths).
- *Time-integrated*: made by mixing equal volumes of water collected at a sampling station at regular time intervals (example morning, evening and night).

SECTION 4 : MONITORING PROGRAMME DESIGN

For baseline studies and post-EIA monitoring, grab sampling is the common practice and accepted. For stratified water bodies such as lakes and large rivers, grab samples are to be collected at different depths for separate analysis and not composited. For large rivers, it is recommended for composite sampling to be carried out and the suggested number of sampling points and depths are presented in **Table 4-2**.

**Table 4-2 Suggested composite sampling in rivers**

Average flowrate (m <sup>3</sup> /s)	Type of stream/river	Number of sampling points	Number of sampling depths
<5	Small stream	1-2	1
5 – 140	Stream	3-4	2
150 – 1,000	River	5-6	3
>1,000	Large river	>6	4

(Source: UNEP/WHO 1996)

#### 4.5 SAMPLING FREQUENCY

The frequency of sampling is determined by the objectives of the monitoring programme and ultimately the amount of information or data required for the assessment report. The main criterion in selecting the sampling frequency is the temporal variation at the site including

- Drought or rainy (monsoon) seasons;
- Tidal patterns in major rivers, estuaries and marine waters;
- Diurnal consideration for certain activities e.g. factory operations in the morning and evening may differ;
- Non periodic events e.g. storms, flooding;
- Annual variation (e.g. shutdown periods, holiday seasons).

The limiting factor that determines the sampling frequency is the duration of the assessment. Baseline studies are often required to be completed within a short time span of months and seldom long enough to capture the annual variation. In this regards, samples collected after a rain event may be taken in lieu of rainy season.

Nonetheless, as a general guide the following are recommended below:

- Rivers (include drains, channelized waterways, streams and rivers) – morning and afternoon; dry and rainy season
- Lakes – dry and monsoon season
- Estuary and marine – low and high tides

#### 4.6 SAMPLE NUMBERS

The number of samples to be collected depends on the nature of the assessment. The sample number or replicates also depends on the frequency of sampling, with more samples collected in repeated sampling events. The sample size should be able to provide adequate data for accurate assessment of an environmental condition or to detect changes in the environment.

The following sample numbers are recommended:

- a. Baseline (EIA) studies – minimum of two (2) sets of data for Schedule 1 activities, and minimum 3 sets for Schedule 2 activities. In the event that secondary data is available for the project area, the number of samples may be reduced to 1 for Schedule 1 activities. For Schedule 2 activities, the sample numbers are also stipulated in the Terms of Reference for the report.
- b. Post EIA monitoring studies – monthly for rivers and lakes directly affected by the activity; bi-monthly for waters indirectly affected such as marine waters for activities that are located inland within the same catchment.

The recommendation of sampling sites, sampling frequency and sample numbers for baseline (EIA) assessment and post-EIA monitoring for compliance purposes are summarised in **Tables 4-3** and **4-4** respectively. Schematic diagrams showing the selection of sampling sites location with river and coastal waters are given in **Appendix 3**.

**Table 4-3 Recommendation of sampling sites, sampling frequency and sample numbers for baseline assessments**

Issues	River	Lake	Estuary / Marine
Sampling sites location	<ul style="list-style-type: none"> <li>• At mid-stream of river</li> <li>• Shallow rivers<sup>1</sup>: surface sampling</li> <li>• Deep rivers<sup>1</sup>: surface; mid depth and bottom (depending on depth of river)</li> </ul>	<ul style="list-style-type: none"> <li>• Top (1 m below); middle and bottom strata (1 m above)</li> </ul>	<ul style="list-style-type: none"> <li>• At least 100 m from coastline</li> <li>• Surface (1 m below); mid depth and bottom (1 m above)</li> </ul>
	<ul style="list-style-type: none"> <li>• Upstream, at project site and downstream of project site (up to sensitive receptors)</li> <li>• Minimum 3 locations (project site, upstream, downstream)</li> </ul>	<ul style="list-style-type: none"> <li>• Upstream, within lake and downstream</li> <li>• Minimum 4 locations (upstream, inlet, middle, outlet, downstream)</li> </ul>	<ul style="list-style-type: none"> <li>• At project site, estuary and along coastline</li> <li>• Minimum 5 locations (to cater for longshore current patterns)</li> </ul>
Sampling frequency	<ul style="list-style-type: none"> <li>• Tidal influence: high and low tides</li> <li>• Non-tidal: dry and rainy season/day</li> </ul>	<ul style="list-style-type: none"> <li>• Dry and rainy season/day</li> </ul>	<ul style="list-style-type: none"> <li>• Tidal influence: high and low tides; spring and neap tides</li> </ul>
Sample numbers	<ul style="list-style-type: none"> <li>• Schedule<sup>3</sup> 1 projects: minimum 2 numbers<sup>4</sup></li> <li>• Schedule 2 projects: minimum 3 numbers<sup>5</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Schedule<sup>3</sup> 1 projects: minimum 2 numbers<sup>4</sup></li> <li>• Schedule 2 projects: minimum 3 numbers<sup>5</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Schedule<sup>3</sup> 1 projects: minimum 2 numbers<sup>4</sup></li> <li>• Schedule 2 projects: minimum 3 numbers<sup>5</sup></li> </ul>

*Notes:*

1. *Shallow rivers are generally those with depths of below 1 meter, whilst deep rivers generally have depths of more than 1 meter.*
2. *Or according to frequency stipulated in EIA approval conditions.*
3. *Schedule 1 and Schedule 2 are prescribed activities listed in the Environmental Quality (Environmental Impact Assessment) Order 2015.*
4. *Number of samples may be reduced to 1 for Schedule 1 activities provided secondary data is available for the project site.*
5. *Number of samples for Schedule 2 activities is also subject to the Terms of Reference.*

**Table 4-4 Recommendation of sampling sites, sampling frequency and sample numbers for post-EIA monitoring**

Issues	River	Lake	Estuary / Marine
Sampling sites location	<ul style="list-style-type: none"> <li>• At mid-stream of river</li> <li>• Shallow rivers<sup>1</sup>: surface sampling</li> <li>• Deep rivers<sup>1</sup>: surface; mid depth and bottom (depending on depth of river)</li> </ul>	<ul style="list-style-type: none"> <li>• Top (1 m below); middle and bottom strata (1 m above)</li> </ul>	<ul style="list-style-type: none"> <li>• At least 100 m from coastline</li> <li>• Surface (1 m below); mid depth and bottom (1 m above)</li> </ul>
	<ul style="list-style-type: none"> <li>• 3 locations (project site, upstream and downstream)</li> </ul>	<ul style="list-style-type: none"> <li>• 3 locations (inlet, middle and outlet)</li> </ul>	<ul style="list-style-type: none"> <li>• 3 locations (project site and both sides of coastline)</li> </ul>
Sampling frequency	<ul style="list-style-type: none"> <li>• Monthly<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Monthly<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Bi-monthly<sup>2</sup></li> </ul>
Sample numbers	<ul style="list-style-type: none"> <li>• Schedule<sup>3</sup> 1 projects: minimum 2 numbers<sup>4</sup></li> <li>• Schedule 2 projects: minimum 3 numbers<sup>5</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Schedule<sup>3</sup> 1 projects: minimum 2 numbers<sup>4</sup></li> <li>• Schedule 2 projects: minimum 3 numbers<sup>5</sup></li> </ul>	<ul style="list-style-type: none"> <li>• Schedule<sup>3</sup> 1 projects: minimum 2 numbers<sup>4</sup></li> <li>• Schedule 2 projects: minimum 3 numbers<sup>5</sup></li> </ul>

*Notes:*

1. *Shallow rivers are generally those with depths of below 1 meter, whilst deep rivers generally have depths of more than 1 meter.*
2. *Or according to frequency stipulated in EIA approval conditions.*
3. *Schedule 1 and Schedule 2 are prescribed activities listed in the Environmental Quality (Environmental Impact Assessment) Order 2015.*
4. *Number of samples may be reduced to 1 for Schedule 1 activities provided secondary data is available for the project site.*
5. *Number of samples for Schedule 2 activities is also subject to the Terms of Reference.*

#### 4.7 MEASUREMENT PARAMETERS

The selection of measurement parameters is dependent on the environmental value or beneficial use of the water body (drinking, recreation, agriculture, industrial etc.) and the objectives of the investigation. The common parameters used to assess water quality encompass physical, chemical and biological stressors as listed in **Table 4-5**.

**Table 4-5 General categories of parameters for water quality assessment**

Category	Parameter
Physical	pH, Temperature, Conductivity, Turbidity, Flow rate, Dissolved Oxygen, Suspended solids
Chemical	Biological oxygen demand, Chemical oxygen demand, Phosphorus, Nitrogen, Metals, Ammonia, Inorganic compounds, Organic compounds
Biological	Faecal contaminants, <i>Chlorophyll a</i> , phytoplankton, algae

**i. Water Quality Standards**

The Department of Environment (DOE) has established standards for the water quality of freshwater (river and lakes) and marine water as listed in **Appendix 4** and described below:

- Interim National Water Quality Standards (INWQS) for surface water. There are a total of 72 parameters with limits set for six (6) classes depending on the intended use of the surface water. The comprehensive standard includes physical and chemical stressors, toxic organic compounds, biocides and radioactivity.
- Marine Water Quality Standards (MWQS) for marine water. This standard has twenty (20) parameters with values set for four (4) classes depending on the beneficial use of the marine water.

The existing Malaysian standards for water quality do not include biological indicators such as *Chlorophyll a* which is a measure of the phytoplankton biomass, an indication of the biodiversity of the aquatic ecosystem in the water body. It is recommended that biological indicators *Chlorophyll a* and phytoplankton be measured for sensitive ecosystems and waters intended for use in recreation and aquaculture.

For marine waters, it is recommended to include analysis for *Enterococci*, although it is not listed in the MWQS. Enterococci are distinguished by their ability to survive in salt water and are typically more human specific than the larger faecal streptococcus group. USEPA recommends enterococci as the best indicator of health risk in salt water used for recreation. In May 2014, DOE issued a notice (Notice 3/2014) requiring both E. Coli and Enterococci to be included for baseline marine water quality sampling for projects located at recreational and tourist beach areas.

**ii. Activity Specific Parameters**

It is often not necessary and not cost-effective to conduct analysis for the full suite of parameters specified under the Malaysian standards for surface and marine waters. Conversely it is recommended that selected critical parameters be analysed according to the type of activity or development proposed, and the types of discharges anticipated.

For streams and rivers, it is recommended that the minimum parameters for analysis are pH, DO, BOD, COD, TSS, AN, O&G and E.Coli. However, additional parameters as appropriate and relevant to the project or development in question need to be included, as outlined in **Table 4-6**. Similarly for projects discharging into lakes, it is recommended that Chlorophyll a and nutrients of total nitrogen (in soluble nitrite and nitrate forms) and phosphorous (in soluble ortho-phosphate form) be included as these water bodies are prone to eutrophication and algal growth (**Table 4-7**). For projects located in estuary and coastal areas, the minimum parameters proposed for analysis are temperature, DO, TSS, TOC, O&G, AN and Enterococci, with additional parameters to be included as appropriate (outlined in **Table 4-8**).

In many instances, alternative parameters may be analysed due to the nature of the water body that interferes with the test methods. A classic example is the analysis of TOC in place of COD in water that has high concentration of Chloride such as in marine and coastal waters.

**Table 4-6 Activity Specific Parameters for Water Quality of Rivers**

Types of Activities <sup>1</sup>	Parameters
Coastal & Hill area, Dam, Drainage & Irrigation, Fisheries, Housing, Road, Slope area, Township, Transportation, Water Supply	pH, DO, BOD, COD, TSS, O&G, AN, Nitrite N, Nitrate N, Phosphate, E.Coli
Aerodrome, Dredging, Industry, Industrial estate, Land reclamation, Mining, Petroleum, Port, Power, Quarry, Waste treatment & disposal, Radioactive industry	pH, DO, BOD, COD, TSS, O&G, AN, E.Coli, heavy metals, other relevant* parameters listed in INWQS
Agricultural, Forestry	pH, DO, AN, BOD, COD, TSS, O&G, E.Coli , relevant organic compounds and pesticides

Source: *Interim Water Quality Standard (INWQS)*

<sup>1</sup> *Prescribed activities listed in Schedule 1 and Schedule 2 of the Environmental Quality (Environmental Impact Assessment) Order 2015.*

\* *Determined by the types of processes, chemicals used and discharge characteristics*

SECTION 4 : MONITORING PROGRAMME DESIGN

**Table 4-7 Activity Specific Parameters for Water Quality of Lakes**

Types of Activities <sup>1</sup>	Parameters
Coastal & Hill area, Dam, Drainage & Irrigation, Fisheries, Housing, Road, Slope area, Township, Transportation, Water Supply	pH, DO, AN, BOD, COD, TSS, O&G, E.Coli, Chlorophyll a, Nitrite N, Nitrate N, Phosphate
Aerodrome, Dredging, Industry, Industrial estate, Land reclamation, Mining, Petroleum, Port, Power, Quarry, Waste treatment & disposal, Radioactive industry	pH, DO, AN, BOD, COD, TSS, O&G, E.Coli, Chlorophyll a, Nitrite N, Nitrate N, Phosphate heavy metals, other relevant* parameters listed in INWQS
Agricultural, Forestry	pH, DO, AN, BOD, COD, TSS, O&G, E.Coli , Chlorophyll a, Nitrite N, Nitrate N, Phosphate, relevant organic compounds and pesticides

Source: Interim Water Quality Standard (INWQS)

<sup>1</sup> Prescribed activities listed in Schedule 1 and Schedule 2 of the Environmental Quality (Environmental Impact Assessment) Order 2015.

\* Determined by the types of processes, chemicals used and discharge characteristics

**Table 4-8 Activity Specific Parameters for Water Quality of Marine and Coastal Waters**

Types of Activity <sup>1</sup>	Parameters
Coastal & Hill area, Dam, Drainage & Irrigation, Fisheries, Housing, Road, Slope area, Township, Transportation, Water Supply	Temp., DO, TSS, TOC, O&G, AN, E. Coli, Enterococci
Aerodrome, Dredging, Industry, Industrial estate, Land reclamation, Mining, Petroleum, Port, Power, Quarry, Waste treatment & disposal, Radioactive industry	Temp., DO, TSS, TOC, O&G, AN, E. Coli, Enterococci, metals, other relevant* parameters listed in MWQS
Agricultural, Forestry	Temp., DO, TSS, TOC, O&G, AN, E. Coli, Enterococci, PAH

Source: Marine Water Quality Standard (MWQS)

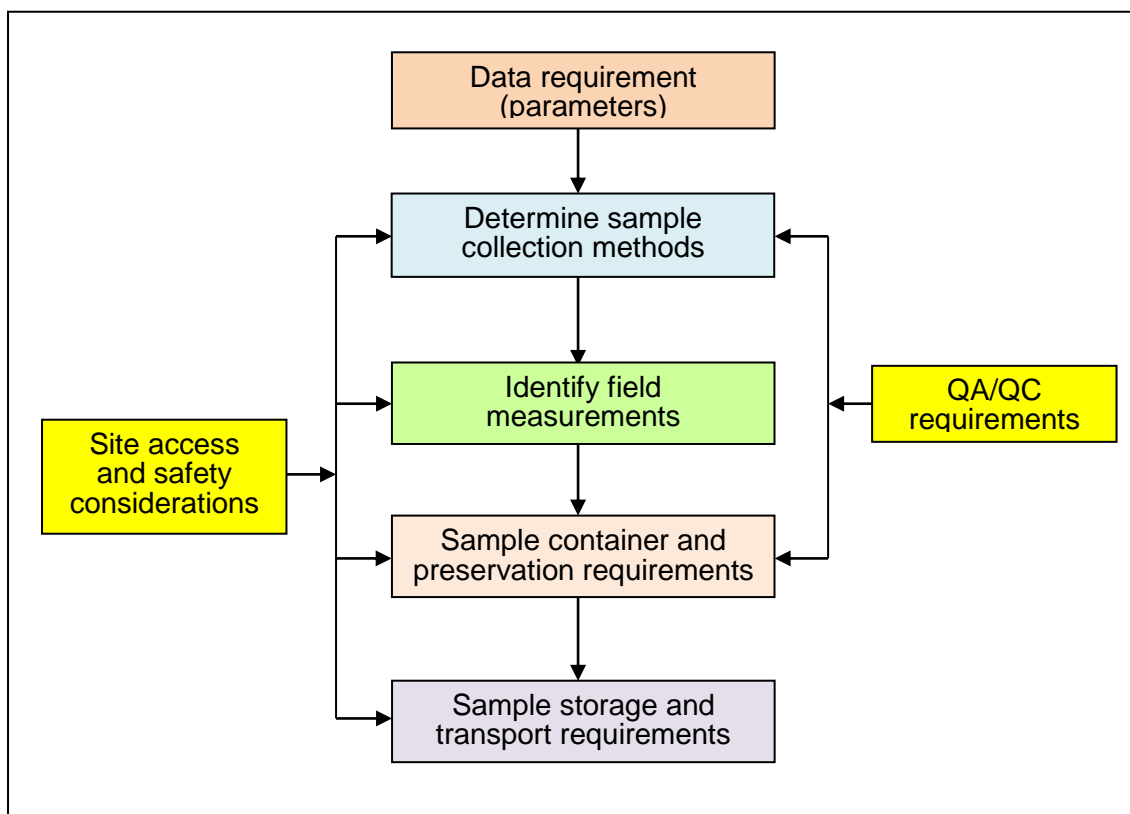
<sup>1</sup> Prescribed activities listed in Schedule 1 and Schedule 2 of the Environmental Quality (Environmental Impact Assessment) Order 2015.

\* Determined by the types of processes, chemicals used and discharge characteristics

## 5.1 SAMPLING FRAMEWORK

Once the monitoring programme has been outlined, the next stage is the execution of the programme in the field. This stage involves the sampling team to prepare for the actual sample collection at the selected sites. The framework for preparing a field sampling plan is presented in **Figure 5-1**.

**Figure 5-1 Framework for field sampling plan**



The sampling procedure and protocols involved in a field sampling programme include:

- equipment and personnel inventory;
- field (in-situ) measurements;
- sample collection;
- sample preservation;
- sample labelling, preparation and storage;
- QA / QC requirement;
- chain of custody documentation; and
- transportation to the laboratory

The checklist for field sampling plan is tabulated in **Table 5-1**.

**Table 5-1 Checklist of a field sampling plan**

Considerations	Action required
i. Are sites easily accessed or require vessel/boat to access?	Arrange for boat if required
ii. How are the samples to be collected and the equipment required?	Sampling equipment (bails, depth sampler etc.)
iii. What are the field measurements to be taken? In-situ parameters, flow rate, depth etc.	Instruments required
iv. What are the parameters to be analysed?	Sample preservation and type of containers
v. What are the QA/QC requirements?	Sample blanks, duplicates as required
vi. How many sampling sites are involved and number of samples to be collected at each site?	Number of sample containers
vii. What are the field observations to be recorded?	Field data sheet to be completed
viii. What is the chain of custody document required?	Field register to be completed
ix. How many sampling personnel required? Are they trained?	Trained personnel to be involved
x. Time lapse between sample collection and delivery to laboratory for analysis	Sample storage required

The sampling team should comprise of personnel who are trained and familiar with proper sampling procedures and protocol including sample collection, preservation, storage and field reporting. This is a requirement under the Malaysian laboratory accreditation scheme (Skim Akreditasi Makmal Malaysia, SAMM). In the absence of a formal competency course, most laboratories conduct in-house training for their field sampling personnel which covers types of sampling requirements (baseline or compliance monitoring), sampling techniques, sample preservation, field reporting, storage and transportation.

## 5.2 SAMPLE CONTAINERS

Sample containers are best provided by the laboratory. This ensures that large enough samples are obtained for analyses and that sample bottles have been properly prepared, including the addition of preservatives as necessary. It is essential to have enough containers to hold the samples collected. Glass containers are commonly used and are appropriate for samples for many analyses, but plastic containers are preferred for samples intended for certain chemical analyses. Plastic has the obvious advantage that it is less likely to break than glass.

SECTION 5 : FIELD SAMPLING PLAN

For microbiological analysis, strong, thick-walled, glass sample bottles with a minimum capacity of 300 ml should be used. They should have screw caps of a type that will maintain an effective seal, even after they have been sterilised many times in an autoclave.

### 5.3 SAMPLE PRESERVATION

It is essential that samples collected be preserved in the field and stored without deterioration. Sample bottles should be resealed and stored in a clean, cool, dark environment and protected from contamination. Storage may vary according to the method employed for analyses as stated in the standard methods. Suggested chemical preservatives and recommended maximum storage times for samples for various analyses are summarised in **Table 5-2**.

**Table 5-2 Suggested preservative treatments and permissible storage times**

Parameter	Recommended container	Preservative	Max. permissible storage time
Aluminium, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Nickel, Zinc	Polyethylene	2 ml conc. HNO <sub>3</sub>	6 months
Arsenic	Polyethylene	Cool 4 °C	6 months
BOD	Polyethylene	Cool 4 °C	4 hours
Boron	Polyethylene	Cool 4 °C	6 months
Carbamate pesticides	Glass	H <sub>2</sub> SO <sub>4</sub> to pH <4	Extract immediately
Carbon, inorganic/organic	Polyethylene	Cool 4 °C	24 hours
Chloride	Polyethylene	Cool 4 °C	7 days
Chlorinated hydrocarbon	Glass	Cool 4 °C	Extract immediately
Chlorophyll	Plastic petri dish	Freeze -20 °C	7 days
COD	Polyethylene	Cool 4 °C	24 hours
Electrical conductivity	Polyethylene	Cool 4 °C	24 hours
Flouride	Polyethylene	Cool 4 °C	7 days
Mercury	Glass or Teflon	1 ml H <sub>2</sub> SO <sub>4</sub> + 1 ml 5% Cr <sub>2</sub> O <sub>7</sub>	1 month
Nitrogen (Ammonia, Kjeldahl, Nitrate, Nitrite, organic)	Polyethylene	Cool 4°C	24 hours
Organophosphorus pesticides	Glass	Cool, 4 °C, 10% HCl to pH 4.4	No holding, extraction on site

SECTION 5 : FIELD SAMPLING PLAN

Parameter	Recommended container	Preservative	Max. permissible storage time
Pentachlorophenol	Glass	Cool 4 °C	24 hour
pH	Polyethylene	None	6 hours
Phenolics	Glass	Cool 4 °C	24 hour
Phenoxy acid herbicides	Glass	Cool 4 °C	Extract immediately
Phosphorus (total)	Glass	Cool 4 °C	1 month
Selenium	Polyethylene	1.5 ml conc. HNO <sub>3</sub>	6 months
Silica	Polyethylene	Cool 4 °C	7 days
Sulphate	Polyethylene	Cool 4 °C	7 days

Source: American Public Health Association (APHA)

#### 5.4 FIELD MEASUREMENTS

It is recommended that measurements are to be made in the field (in-situ) for parameters that are sensitive to ambient conditions and tend to change due to storage and transport when analysed later in the laboratory. Field instruments are required to be pre-calibrated in the laboratory before being used in the field. This is also a requirement under the SAMM accreditation scheme.

The in-situ field measurements include:

- i. Temperature
- ii. pH value
- iii. Dissolved oxygen
- iv. Salinity / conductivity
- v. Turbidity
- vi. Flowrate

Handheld multi parameter instruments are available for measurements of the several parameters commonly pH, temperature, salinity and conductivity, whilst DO meters also record temperature. Measurement of stream flowrates involves measurement of the stream width, depth and velocity at a cross section of the river. The details of measuring stream flowrates are given in **Appendix 5**. Examples of field equipment for water sampling and in-situ measurements are listed in **Appendix 6**.

The use of portable test kits may be applied under certain circumstances, example in far flung or isolated sites that takes several days to reach. Such quick or rapid on-field tests are also useful where the results are required on-the-spot such as Turbidity after storm events. It has to be noted that test kits are less accurate and have higher detection limits compared to laboratory analysis.

SECTION 5 : FIELD SAMPLING PLAN

The list of parameters suitable for quick tests includes the following:

- i. Ammonia
- ii. Chlorine, Chloride
- iii. Copper
- iv. Iron
- v. Phosphorous, phosphate
- vi. Sulphite
- vii. Silica
- viii. Nitrogen, nitrite
- ix. Hardness

The common test strips and test kits available and their detection limits are given in **Appendix 7**.

It is to be noted that in-situ test results using quick test methods are only meant for rapid assessment of the water quality for the purpose of self-regulation by the EO and Project Proponent. For baseline assessments and post-EIA compliance monitoring, the analysis must be carried out by laboratories with SAMM accreditation. This is because the quick test methods do not adhere to established test methods.

## 5.5 FIELD OBSERVATIONS

A field report should be included as part of the documentation during the sampling exercise (refer to example in **Appendix 8**). This information would be useful as reference and proper interpretation of the analysis data that will be provided.

Information to be recorded includes the following:

- Site location (on the site location (coordinates),
- Weather condition during the sampling and significant events on the previous day (e.g. storm or flooding)
- Physical observations of stream (e.g. colour of water, debris, oil slicks etc.)
- Appearance of sample (clear, coloured, etc.)
- Field measurements

## 5.6 SAFETY CONSIDERATIONS

Field personnel may encounter a wide range of hazards in the course of their work. Hazards may include water-courses that are highly contaminated with sewage or chemicals, access to sampling stations may involve crossing dangerous terrain, and wading in streams with the possibility of slipping and personal injury. Where there is a risk of infection from contact with water, suitable protective clothing, such as rubber gloves should be provided and its use by staff strongly encouraged. Where physical hazards may be encountered as in accessing a site by boat and other sea vessels, life-jackets and hard hats are recommended to be worn (**Appendix 9**).

SECTION 5 : FIELD SAMPLING PLAN

The list of safety equipment for field sampling includes the following:

- Protective clothing (long sleeves and long pants)
- Rubber gloves (protection against contamination and infection)
- Rubber boots (for wading in streams)
- Safety vests (for visibility)
- Life jackets (on boats and other vessels)
- Hats (protection against sun and overhanging branches)

Field personnel should be trained to recognise and deal with as many as possible of the hazards they may encounter. Training should include water safety and first-aid. A basic first-aid kit should be carried at all times.

### **5.7 TRANSPORTATION AND STORAGE OF SAMPLES**

The sample collection process should be coordinated with the laboratory. The laboratory should be informed of the how many samples will be arriving, the approximate time of arrival and the analyses that are to be carried out, so that appropriate resources (chemist, chemicals and analytical instruments) can be prepared.

Each sample bottle must be provided with an identification label with the following information clearly and indelibly written:

- Name of the assessment (EIA or post-EIA)
- Date and time of sampling
- Name of water body (river, lake, coast)
- Sample station identification or number
- GPS coordinates
- Sampling depth

Sample bottles should be placed in a cool box for transport to the laboratory that will protect samples from sunlight, prevent the breakage of sample bottles, and allow a temperature of 4 °C to be attained and maintained during transport. Samples should be delivered to the laboratory as soon as possible preferably within 24 hours.

## 6.1 RECEPTION OF SAMPLES BY LABORATORY

The laboratory staff should sign for the receipt of samples and record the time and date of delivery and check for the following at the same time:

- Necessary details are recorded on the labels of sample bottles
- Samples are contained in appropriate bottles that are in good condition
- Samples have arrived in time for subsequent analysis to provide reliable results
- Samples have been treated with any necessary preservatives
- Samples have been stored at appropriate temperatures, maintained throughout transport

Samples should be logged into the laboratory system as soon as they arrive and transferred to a refrigerator (at about 4 °C).

## 6.2 LABORATORY ANALYSIS

Sample analyses are to be conducted according to standard or rigorously tested methods by accredited laboratories. Analyses are to be carried out using properly calibrated laboratory instruments, with QA/QC procedures observed.

The selection of an analytical method for water quality assessment depends on the information needs, and on the parameters themselves. Other factors include the laboratory resources, speed of analyses required and accuracy required. Two main considerations for selecting the appropriate analytical method are:

- The range of concentrations of the parameter; detection limits are method specific and the lowest concentration need to be stated.
- The accuracy and precision required. Generally, the greater the accuracy and precision required the greater the analytical complexity.

A summary of the analytical methods for common parameters is presented in **Table 6-1** below.

**Table 6-1 Summary of analytical methods for common parameters**

Parameter	Methodology	Reference*
<b>Physical</b>		
Temperature	Thermometer, electronic data logger, thermistor	APHA
Flow rates	Acoustic Doppler current profiler, depth sounder	USEPA
Colour	Colorimetry	APHA, USEPA
Dissolved Solids	Gravimetry	APHA, USEPA
Suspended solids	Gravimetry	APHA, USEPA
Turbidity	Nephelometry, light scattering	APHA, USEPA
Conductivity	Instrumental	APHA
<b>Chemical</b>		
pH	Electrometry	APHA, USEPA
Alkalinity, Acidity	Titration	APHA, USEPA
Salinity	Electrical conductivity, density, sensors	APHA
Dissolved Oxygen	Oxygen probe, iodometry, Winkler method	APHA, USEPA
Biological Oxygen Demand (BOD)	Incubation	APHA, USEPA
Chemical Oxygen Demand (COD)	Reflux, titrimetry, colorimetry	APHA, USEPA
Total Organic Carbon (TOC)	Combustion IR, persulfate UV oxidation	APHA, USEPA
Metals (Ag, Al, As, Ba, Ca, Cd, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb, Se, Sn, Zn)	AAS, ICPAES, ICPMS etc.	APHA, USEPA (Hg), USEPA (As)
Tributyltin (TBT)	Solvent extraction, HPLC	USEPA
Ammonia, Ammoniacal Nitrogen	Electrode, titrimetry, colorimetry	APHA
Nitrate, Nitrite	Colorimetry, ion chromatography	APHA, USEPA
Total Kjeldahl Nitrogen	Colorimetry, potentiometry	APHA, USEPA
Carbonate bicarbonate, CO <sub>2</sub>	Titrimetry	APHA
Hardness	Titrimetry	APHA
Silica	AAS, Colorimetry, ICPAES	APHA, USEPA
Phosphorous, Phosphate	Colorimetry	APHA, USEPA
Cyanide	Titrimetry, colorimetry, cyanide-selective electrode	APHA, USEPA
Boron	Colorimetry	APHA

SECTION 6 : SAMPLE PROCESSING AND ANALYSIS

Parameter	Methodology	Reference*
Chlorine	Iodometry, amperometry	APHA, USEPA
Chloride	Colorimetry, titrimetry, IC potentiometry	APHA, USEPA
Fluoride	Colorimetry	APHA
Sulphide, Sulphur compounds	Titrimetry	APHA, USEPA
Oil & Grease	Extraction/FTIR spectrophotometry	APHA, USEPA
Surfactants	Extraction/gravimetric method	APHA, USEPA
Phenols	Extraction/UV spectrophotometry	APHA , USEPA
Organochlorine compounds	Extraction/gravimetric method	APHA 2005, USEPA 2014
Organophosphate pesticides	GC	APHA, USEPA
Carbamate pesticides	HPLC	USEPA
Chlorinated phenoxyacid herbicides	GC	APHA, USEPA
Polycyclic Aromatic Hydrocarbons (PAHs)	HPLC, GC, GC-MS	APHA, USEPA
Radioactivity	Counting	APHA
<b>Biological</b>		
Chlorophyll	Extraction, fluorimetry, spectrophotometry	APHA
Coliform bacteria	Enumeration, enzyme assays	APHA

*\*To refer to latest editions of APHA, USEPA*

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## 7.1 REPORTING

Data obtained from laboratory and field analysis need to be presented in a format that amenable for processing and evaluation. The results from the laboratory first need to be examined on their integrity before detailed analysis can be made. This includes missing data, values that need to be rounded off to the appropriate figures, values below detection limits and suspicious data. The latter is based on past experience or available information of the ecosystem at the sampling site.

Laboratory data should be tabulated for analysis and comparison to appropriate water quality standards. Statistical tools can be used for data analysis, including numerical measures (e.g. means, medians, percentiles), tables (e.g. frequency distribution) and graphs (e.g. histograms, scatter-plots). These statistics helps to present the essential information in a concise and clear manner. Statistical treatment can only be applied where significantly large data set is available which is determined by the number of samples or level of replication. Examples of data treatment and presentation are given in **Appendix 10**.

The report format on the water quality monitoring may include the following:

- Objective of the report
- Sampling sites location. A map showing location of sampling sites and photographs of the sites and sample collection to be included. Brief description of the sampling sites and GPS coordinates are to be included.
- Presentation of the data, including statistical treatment of the data (e.g. tabular form, histogram, trend plots, dependent on number of data obtained);
- Evaluation against prescribed water quality standards or criteria;
- Discussion and interpretation of data; and
- Recommendations for further improvement as appropriate
- Laboratory reports or certificates of analysis are to be included as appendices.

For post EIA compliance monitoring, the water quality monitoring is usually required to be carried out over the duration of project construction and operation. The data collected should be presented in a graph to show the trend of the parameters measured over the period of monitoring. Trend analysis for the past year(s) should be included for comparison, besides the current results obtained. For certain parameters (e.g. DO and pH) upper and lower control limits may be included in the trend plots to indicate warning levels for corrective actions to be taken.

SECTION 7 : REPORTING

A sample format for water quality monitoring report is given in **Appendix 11**. This report may be prepared by the EO to demonstrate the project's environmental performance for self-regulation. For submission to the DOE for post-EIA compliance monitoring, the report is to be prepared by a registered environmental consultant.

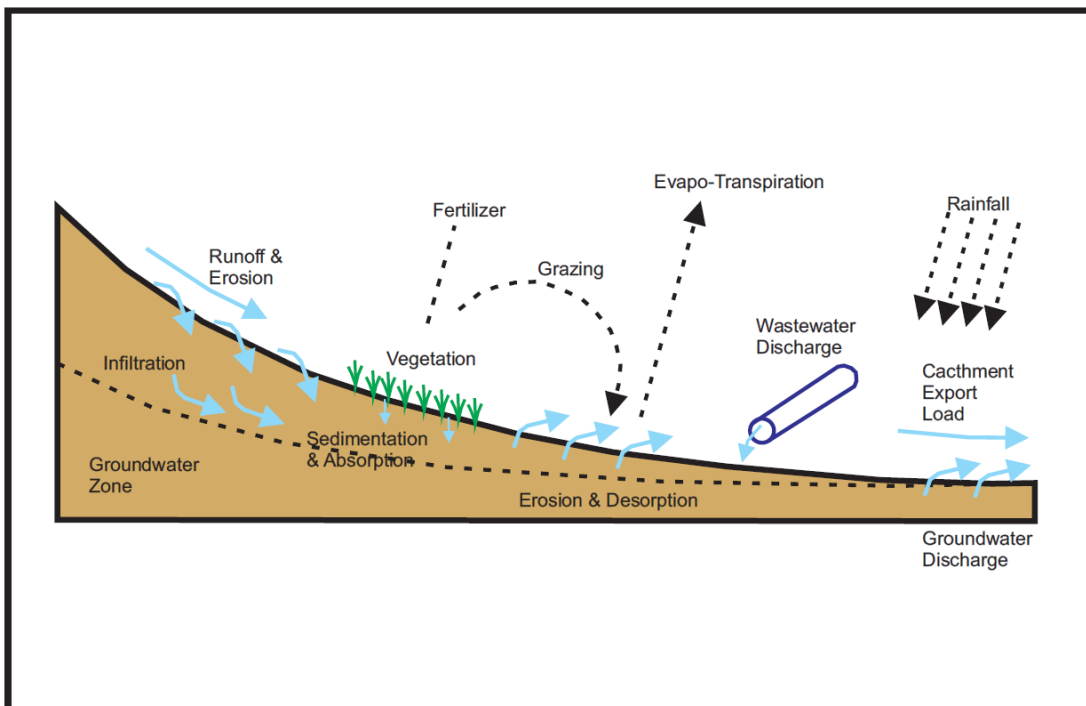
Records of water quality monitoring are required by the DOE to be kept for a period of five (5) years after project completion. This includes both the internal or unofficial records kept by the EO as part of self-regulatory performance monitoring, as well as monitoring reports submitted to the DOE.

## REFERENCES

1. Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), October 2000. National Water Quality Management Strategy: Australian Guidelines for Water Quality Monitoring and Reporting.
2. Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), October 2000. National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
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4. United Nations Environment Programme and World Health Organization (UNEP/WHO) 1996. Water Quality Monitoring - A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes. Edited by Jamie Bartram and Richard Balance.
5. United States Environmental Protection Agency (US EPA), 2015. Water Monitoring & Assessment, 5.11 Fecal Bacteria Monitoring & Assessment.
6. United States Environmental Protection Agency (US EPA), 2004. 40 CFR Ch.1, Part 131 - Water Quality Standards.
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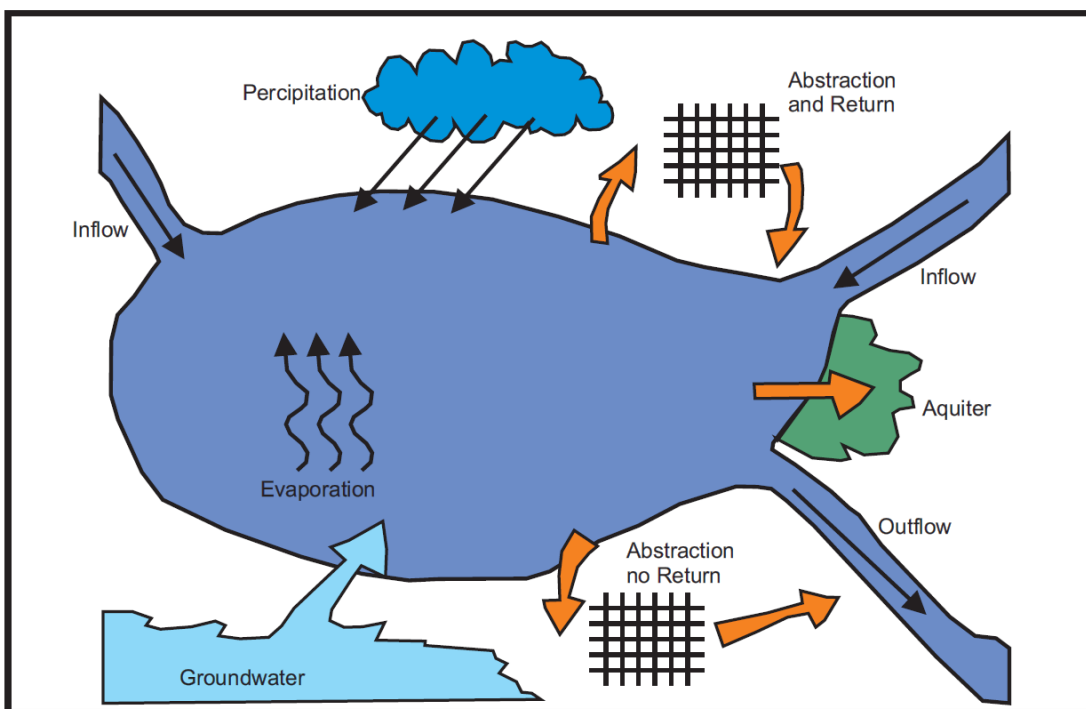
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**Figure 1: Processes of nutrient sources and transport**



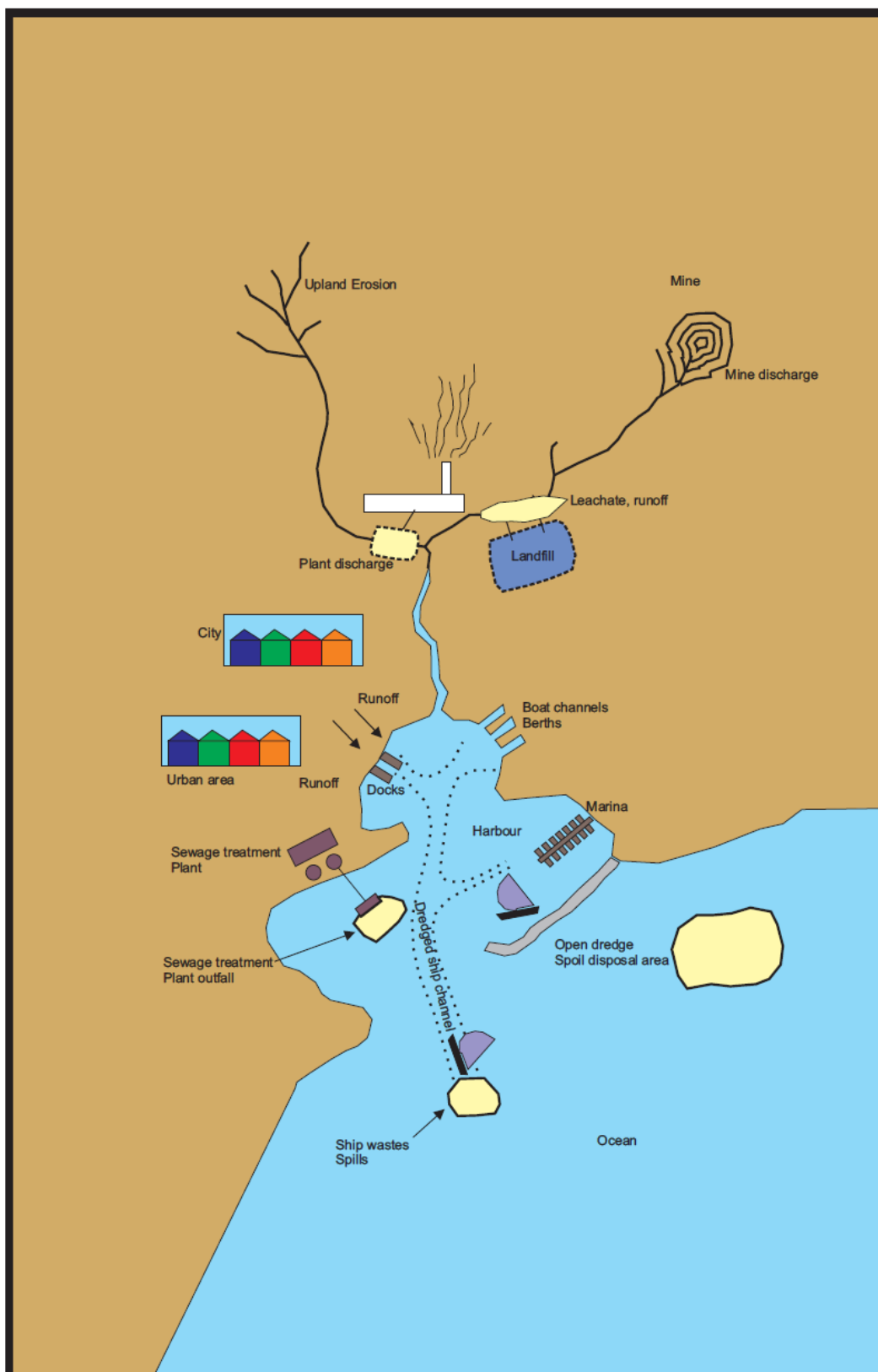
(Source: Australia and New Zealand Environment and Conservation Council, 2000)

**Figure 2: Processes affecting water balance in lakes**



(Source: UNEP/WHO, 1996)

**Figure 3: Processes of pollutants release to the aquatic environment**



(Source: Australia and New Zealand Environment and Conservation Council, 2000)

Figure 4: River Monitoring

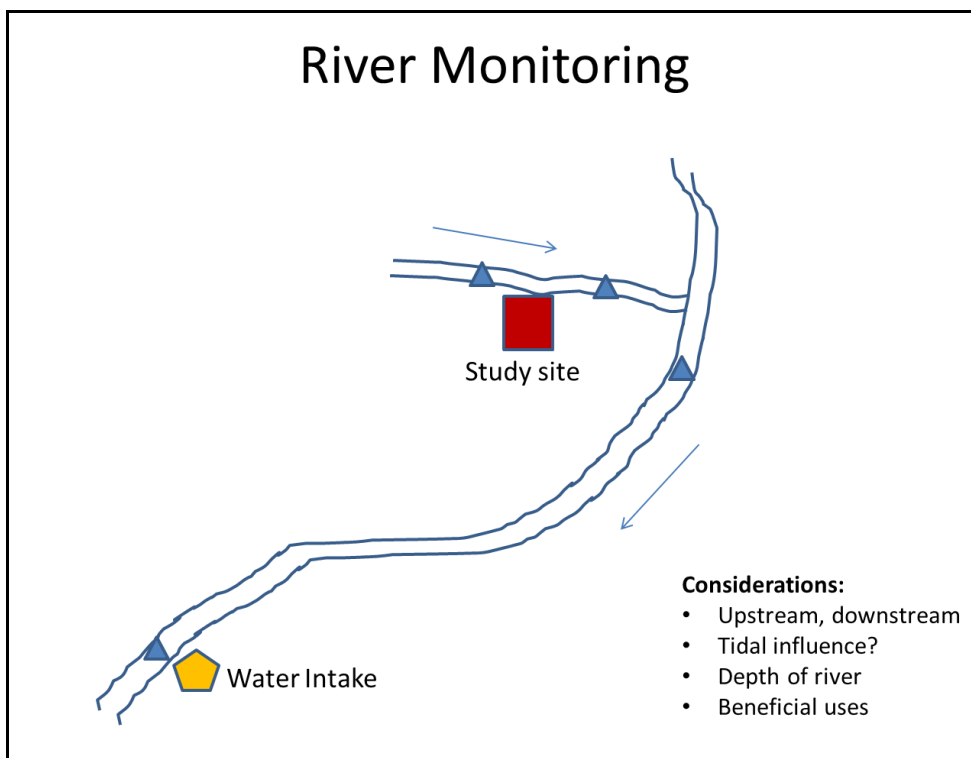
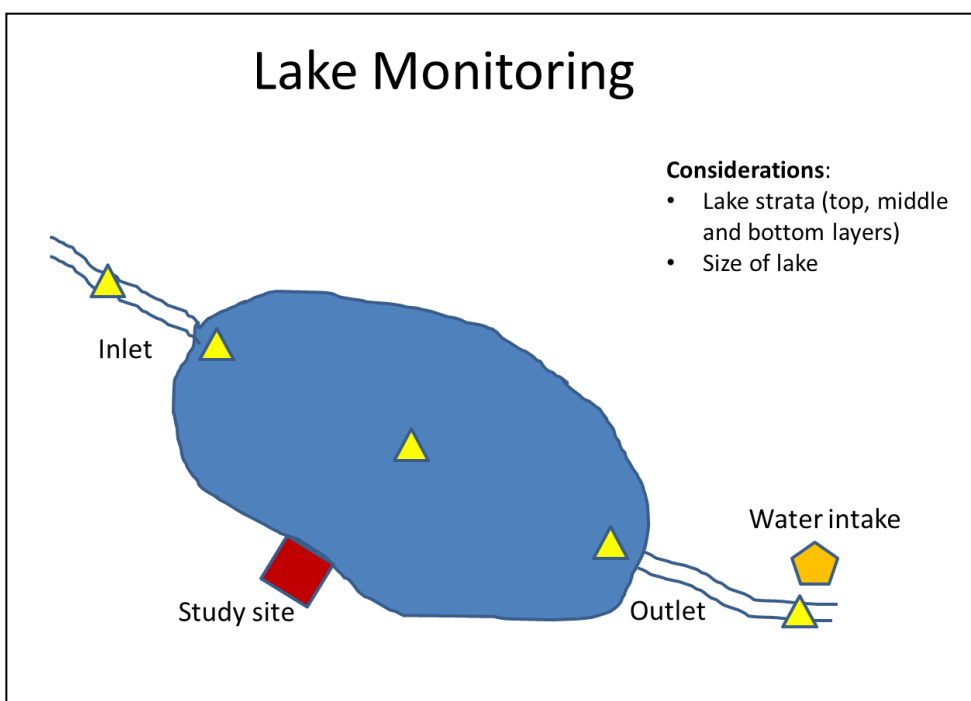
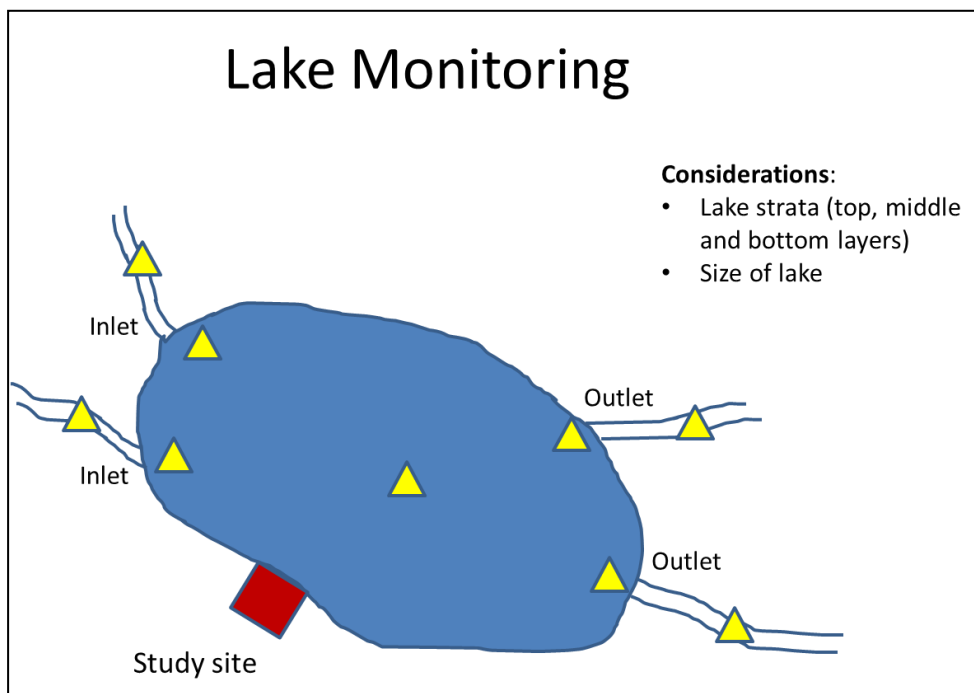


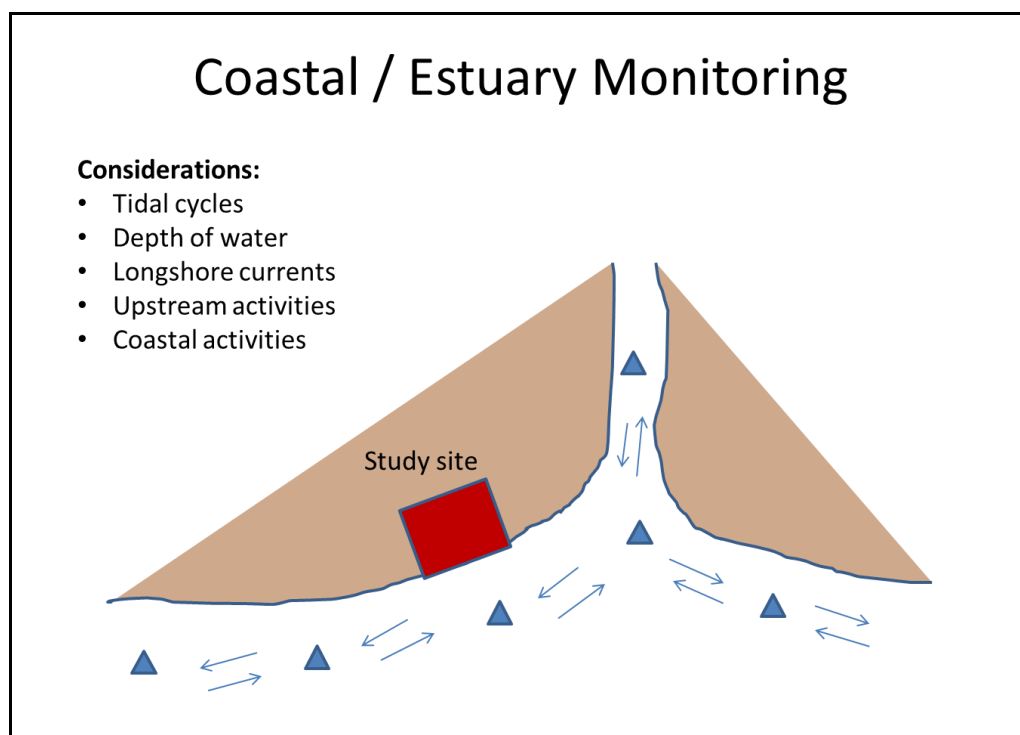
Figure 5: Lake Monitoring (Scenario 1)



**Figure 6: Lake Monitoring (Scenario 2)**



**Figure 7: Coastal / Estuary Monitoring**



**a) Interim National Water Quality Standards (INWQS)**

Parameters	(Units)	Classes					
		I	IIA	IIB	III	IV	V
1. pH		6.5-8.5	6-9	6-9	5-9	5-9	-
2. DO	mg/l	7	5-7	5-7	3-5	< 3	< 1
3. Elect. Cond.*	µmhos/cm	1000	1000	-	-	6000	-
4. Salinity*	‰	0.5	1	-	-	2	-
5. Odour		N	N	N	-	-	-
6. Taste		N	N	N	-	-	-
7. Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
8. BOD	mg/l	1	3	3	6	12	> 12
9. COD	mg/l	10	25	25	50	100	> 100
10. Colour	TCU	15	150	150	-	-	-
11. Floatables		N	N	N	-	-	-
12. Total Diss. Solid*	mg/l	500	1000	-	-	4000	-
13. Total Suspended Solids	mg/l	25	50	50	150	300	> 300
14. Temperature	°C	-	Normal±2	-	Normal±2	-	-
15. Turbidity	NTU	5	50	50	-	-	-
16. E. Coliform**	counts/100ml	10	100	400	5000 (20000) <sup>ε</sup>	5000 (20000) <sup>ε</sup>	
17. Total Coliform	counts/100ml	100	5000	5000	50000	50000	> 50000

N = No visible floatable materials/debris,  
or No objectionable odour,  
or No objectionable taste.

\* = Related parameters, only one recommended for use

\*\* = Geometric mean

ε = Maximum not to be exceeded

APPENDIX 4 : MALAYSIAN WATER QUALITY STANDARDS

Parameters	(Units)	Classes					
		I	IIA/IIB	III@	III	IV	V
18. Al	mg/l	↑	-	-	(0.06)	0.5	↑
19. As	mg/l	↑	0.05	0.4	(0.05)	0.1	↑
20. Ba	mg/l	↑	1	-	-	-	↑
21. Cd	mg/l	↑	0.01	0.01*	(0.001)	0.01	↑
22. Cr (VI)	mg/l	↑	0.05	1.4	(0.05)	0.1	↑
23. Cr (III)	mg/l	↑	-	2.5	-	-	↑
24. Cu	mg/l	↑	1	-	-	0.2	↑
25. Hardness	mg/l	↑	250	-	-	-	↑
26. Ca	mg/l	↑	-	-	-	-	↑
27. Mg	mg/l	↑	-	-	-	-	↑
28. Na	mg/l	↑	-	-	-	3 SAR	↑
29. K	mg/l	↑	-	-	-	-	↑
30. Fe	mg/l	↑	0.3	1	-	1 (leaf) 5 (others)	↑
31. Pb	mg/l	N A	0.05	0.02*	(0.01)	5	L E V E L S
32. Mn	mg/l	T	0.1	0.1	-	0.2	V E L S
33. Hg	mg/l	U	0.001	0.004	(0.0001)	0.002	E L S
34. Ni	mg/l	R	0.05	0.9*	-	0.2	L S
35. Se	mg/l	A	0.01	0.25	(0.04)	0.02	S
36. Ag	mg/l	L	0.05	0.0002	-	-	A B O V E
37. Sn	mg/l	-	-	0.004	-	-	A B O V E
38. U	mg/l	L	-	-	-	-	A B O V E
39. Zn	mg/l	E V	5	0.4*	-	2	A B O V E
40. B	mg/l	E	1	-	(3.4)	0.8	E
41. Cl	mg/l	L	200	-	-	80	I V
42. Cl <sub>2</sub>	mg/l	↑	-	-	(0.02)	-	I V
43. CN	mg/l	↑	0.02	0.06	(0.02)	-	I V
44. F	mg/l	↑	1.5	10	-	1	I V
45. NO <sub>2</sub>	mg/l	↑	0.4	0.4	(0.03)	-	I V
46. NO <sub>3</sub>	mg/l	↑	7	-	-	5	I V
47. P	mg/l	↑	0.2	0.1	-	-	I V
48. Si	mg/l	↑	-50	-	-	-	I V
49. SO <sub>4</sub>	mg/l	↑	250	-	-	-	I V
50. S	mg/l	↑	0.05	-	(0.001)	-	I V
51. CO <sub>2</sub>	mg/l	↑	-	-	-	-	I V
52. Gross-α	Bq/l	↑	0.1	-	-	-	I V
53. Gross-β	Bq/l	↑	1	-	-	-	I V
54. Ra-226	Bq/l	↑	< 0.1	-	-	-	I V
55. Sr-90	Bq/l	↓	< 1	-	-	-	I V

\* = At hardness 50 mg/l CaCO<sub>3</sub>

@ = Maximum (unbracketed) and 24-hr average (bracketed) concentrations

APPENDIX 4 : MALAYSIAN WATER QUALITY STANDARDS

Parameters	(Units)	Classes					
		I	IIA/IIB	III@	III	IV	V
56.CCE	µg/l	↑	500	-		-	-
57.MBAS/BAS	µg/l	N	500	5000	(200)	-	-
58.O&G (mineral)	µg/l	A	40;N	N		-	-
59.O&G (emulsified edible)	µg/l	T.	7000;N	N		-	-
60.PCB	µg/l	L	0.1	6	(0.05)	-	-
61.Phenol	µg/l	E	10	-		-	-
62.Aldrin/ Dieldrin	µg/l	V					
		E	0.02	0.2	(0.01)	-	-
63.BHC	µg/l	L					
		S	2	9	(0.1)	-	-
64.Chlordane	µg/l		0.08	2	(0.02)	-	-
65.t-DDT	µg/l	O	0.1	1	(0.01)	-	-
66.Endosulfan	µg/l	R	10	-		-	-
67.Heptachlor/ Epoxide	µg/l		0.05	0.9	(0.06)	-	-
		A					
68.Lindane	µg/l	B	2	3	(0.4)	-	-
		S					
69.2, 4-D	µg/l	E	70	450		-	-
70.2, 4, 5-T	µg/l	N	10	160		-	-
71.2, 4, 5-TP	µg/l	T	4	850		-	-
72.Paraquat	µg/l	↓	10	1800		-	-

N = Free from visible film, sheen, discoloration and deposits

@ = Maximum (unbracketed) and 24-hr average (bracketed) concentration

**Class**

**Uses**

- I Conservation of natural environment  
Water supply I - practically no treatment necessary (except by disinfection or boiling only)  
Fishery I - very sensitive aquatic species
- IIA Water supply II - conventional treatment required  
Fishery II - sensitive aquatic species
- IIB Recreational use with body contact
- III Water supply III - extensive treatment required  
Fishery III - common, of economic value, and tolerant species
- IV Irrigation
- V None of the above

**b) Malaysia Marine Water Quality Criteria and Standard**

Parameter	Class 1	Class 2	Class 3	Class 4
Beneficial uses	Preservation, Marine Protected areas, Marine Parks	Marine Life, Fisheries, Coral Reefs, Recreational and Marine culture	Ports, Oil & Gas Fields	Mangroves Estuarine & River-mouth Water
1. Temperature (°C)	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient	≤ 2°C increase over maximum ambient
2. Dissolved oxygen (mg/L)	>80% saturation	5	3	4
3. Total suspended solid (mg/L)	25 mg/L or ≤ 10% increase in seasonal average, whichever is lower	50mg/L (25 mg/L) or ≤ 10% increase in seasonal average, whichever is lower	100 mg/L or ≤ 10% increase in seasonal average, whichever is lower	100 mg/L or ≤ 30 % increase in seasonal average, whichever is lower
4. Oil and grease (mg/L)	0.01	0.14	5	0.14
5. Mercury* (µg/L)	0.04	0.16 (0.04)	50	0.5
6. Cadmium (µg/L)	0.5	2 (3)	10	2
7. Chromium (VI) (µg/L)	5	10	48	10
8. Copper (µg/L)	1.3	2.9	10	2.9
9. Arsenic (III)* (µg/L)	3	20(3)	50	20 (3)
10. Lead (µg/L)	4.4	8.5	50	8.5
11. Zinc (µg/L)	15	50	100	50
12. Cyanide (µg/L)	2	7	20	7
13. Ammonia (unionized) (µg/L)	35	70	320	70
14. Nitrite (NO <sub>2</sub> ) (µg/L)	10	55	1,000	55
15. Nitrate (NO <sub>3</sub> ) (µg/L)	10	60	1,000	60
16. Phosphate (µg/L)	5	75	670	75
17. Phenol (µg/L)	1	10	100	10
18. Tributyltin (TBT) (µg/L)	0.001	0.01	0.05	0.01

APPENDIX 4 : MALAYSIAN WATER QUALITY STANDARDS

<b>Parameter</b>	<b>Class 1</b>	<b>Class 2</b>	<b>Class 3</b>	<b>Class 4</b>
19. Faecal coliform (Human health protection for seafood consumption) - most Probable Number (MPN)	70 faecal coliform 100mL-1	100 faecal coliform 100mL-1 & (70 faecal coliform 100mL-1 )	200 faecal coliform 100mL-1	100 faecal coliform 100mL-1 & (70 faecal coliform 100mL-1 )
20. Polycyclic Aromatic Hydrocarbon (PAHs) ng/g	100	200	1000	1000

*\*MWQS in parentheses are for coastal and marine water areas where seafood for human consumption is applicable.*

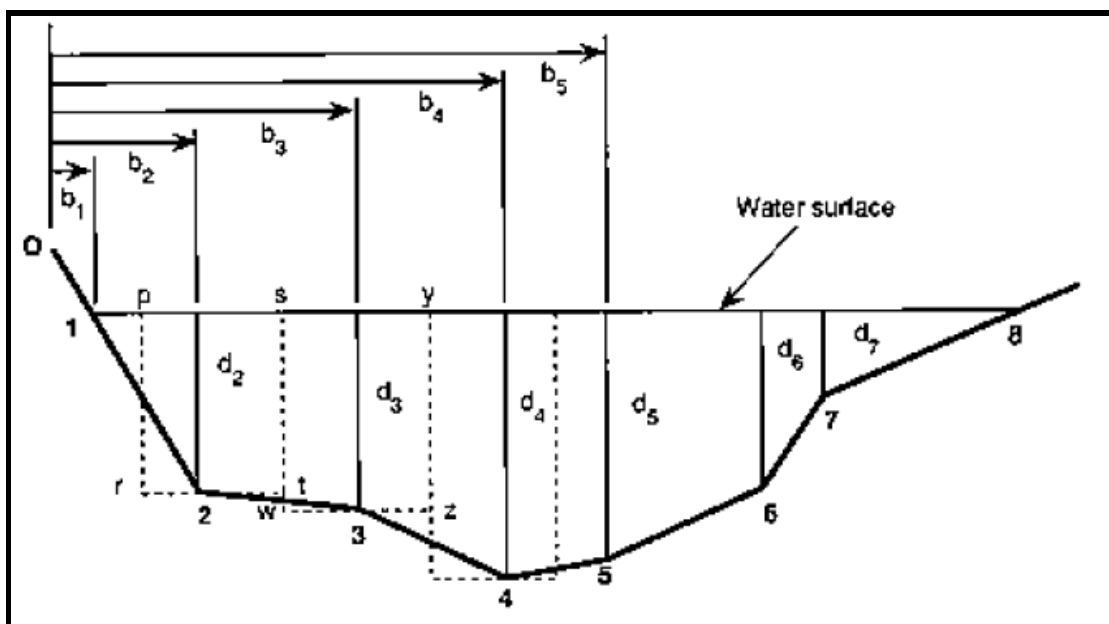
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## Measuring Stream Flow

Procedure for measuring flowrate:

1. All measurements of distance should be made to the nearest centimetre.
2. Measure the horizontal distance  $b_1$ , from reference point 0 on shore to the point where the water meets the shore, point 1 in **Figure 8**.
3. Measure the horizontal distance  $b_2$  from reference point 0 to vertical line 2.
4. Measure the channel depth  $d_2$  at vertical line 2.
5. With the current meter make the measurements necessary to determine the mean velocity  $v_2$  at vertical line 2.
6. Repeat steps 3, 4 and 5 at all the vertical lines across the width of the stream.

**Figure 8: Cross-section of a stream divided into vertical sections for measurement of flow rate**



(Source: UNEP/WHO 1996)

The computation for discharge is based on the assumption that the average velocity measured at a vertical line is valid for a rectangle that extends half of the distance to the verticals on each side of it, as well as throughout the depth at the vertical. Thus, the mean velocity  $v_2$  would apply to a rectangle bounded by the dashed line p, r, s, t.

The area of this rectangle is:

$$a_2 = \frac{b_3 - b_1}{2} \times d_2$$

and the discharge through it will be:

$$Q_2 = a_2 \times \bar{v}_2$$

Similarly, the velocity  $v_3$  applies to the rectangle s, w, z, y and the discharge through it will be:




$$Q_3 = \frac{b_4 - b_2}{2} \times d_3 \times \bar{v}_3$$



The discharge across the whole cross-section will be:

$$Q_T = Q_1 + Q_2 + Q_3 \dots Q_{(n-r)} + Q_n$$

In the example,  $n = 8$ . The discharges in the small triangles at each end of the cross-section,  $Q_1$  and  $Q_n$ , will be zero since the depths at points 1 and 8 are zero.

If the water is shallow, the operator may wade into the stream holding the current meter in place while measurements are being made. Where the water is too deep for wading (more than 1 meter) the current meter must be lowered from a bridge, an overhead cableway or a boat.

Sampling Equipment	Description
	<ul style="list-style-type: none"> <li>• Multiparameter meters (pH, Temperature, Salinity, Conductivity, DO)</li> </ul>
	<ul style="list-style-type: none"> <li>• Sample bottles (labelled), storage container (cooler box), ice packs, gloves, field report</li> </ul>
	<ul style="list-style-type: none"> <li>• Closed water sampler (depth sampler)</li> </ul>

Sampling Equipment	Description
	<ul style="list-style-type: none"> <li>• Dippers (open sampler) for sampling from shallow rivers</li> </ul>
Accessibility to Sampling Locations	Description
	<ul style="list-style-type: none"> <li>• By boat or other vessels for large rivers</li> </ul>
	<ul style="list-style-type: none"> <li>• By wading in (only for shallow streams, below 1 meter deep)</li> </ul>



**Test Kits Equipment**

### Test Kits and Detection Range

No.	Parameter	Type of Kit	Range
1.	Turbidity	Turbidimeter	0 – 1000 NTU
2.	Ammonia	Color disc, reagents	0 – 3.0 mg/l
3.	Chlorine (free and total)	Color disc, reagents	0 – 3.4 mg/l
4.	Chloride	Titration, reagents	500 – 10,000 mg/l
5.	Nitrate	Color disc, reagents	0 – 40 mg/l
6.	Phosphate (PO <sub>4</sub> )	Color disc, reagents	0.1 – 4.0 ; 1 – 40 mg/l
7.	Sulphate (SO <sub>4</sub> )	Turbidimetric	50 – 200 mg/l
8.	Sulphite (SO <sub>3</sub> )	Titration, reagents	10 – 200; 4 – 800 mg/l
9.	Arsenic	Test strip, reagents	0 – 500 ppb
10.	Iron (Ferrous)	Color disc, reagents	0.2 – 7 mg/l
11.	Copper	Color disc, reagents	0 – 4 mg/l
12.	Chromium (Cr <sup>6+</sup> )	Color disc, reagents	0 – 1.3 mg/l
13.	Manganese	Color disc, reagents	0 – 0.7 mg/l
14.	Silica	Color disc, reagents	0 – 30 ; 0 – 600 mg/l
15.	Cyanide	Color disc, reagents	0 – 0.3 mg/l
16.	Phenol	Color disc, reagents	0 – 4.0 mg/l

Source: HACH ([www.sea.hach.com](http://www.sea.hach.com))

### Test Strips and Detection Range

No.	Parameter	Range
1.	pH	0 – 11; 4 -9
2.	Chloride, Cl	30 – 600 mg/l
3.	Phosphorous, orthophosphate	0 - 50 mg/l
4.	Free and total Chlorine	0 – 10 mg/l; 0 – 600 mg/l
5.	Iron, Fe	0 – 5 mg/l
6.	Nitrite and Nitrate	0 – 50 mg/l
7.	Ammonia (Nitrogen)	0 – 6 mg/l
8.	Copper	0 – 3 mg/l
9.	Total Hardness (CaCO <sub>3</sub> )	0 – 425 mg/l
10.	Total Alkalinity	0 – 240 mg/l

Source: HACH ([www.sea.hach.com](http://www.sea.hach.com))

APPENDIX 8 : WATER QUALITY SAMPLING FIELD DATA SHEET

<b>WATER QUALITY SAMPLING FIELD DATA SHEET</b>			
<b>GENERAL INFORMATION</b>		<b>SAMPLING INFORMATION</b>	
Stream name		<b>Sample No.</b>	
Watershed name		<b>Parameter</b>	
Location (State)		<b>Field Measurement</b>	
Site (description)			
Coordinates			
Sampled by	(name)	Deliberly to lab	
Date		Date:	
Time		Time:	
Weather now	Weather in past 24 hours	Comments	
<input type="checkbox"/> Clear/sunny	<input type="checkbox"/> Clear/sunny		
<input type="checkbox"/> Overcast	<input type="checkbox"/> Overcast		
<input type="checkbox"/> Rain	<input type="checkbox"/> Rain		
<input type="checkbox"/> Storm	<input type="checkbox"/> Storm		
Client name	(company)		
Study type			

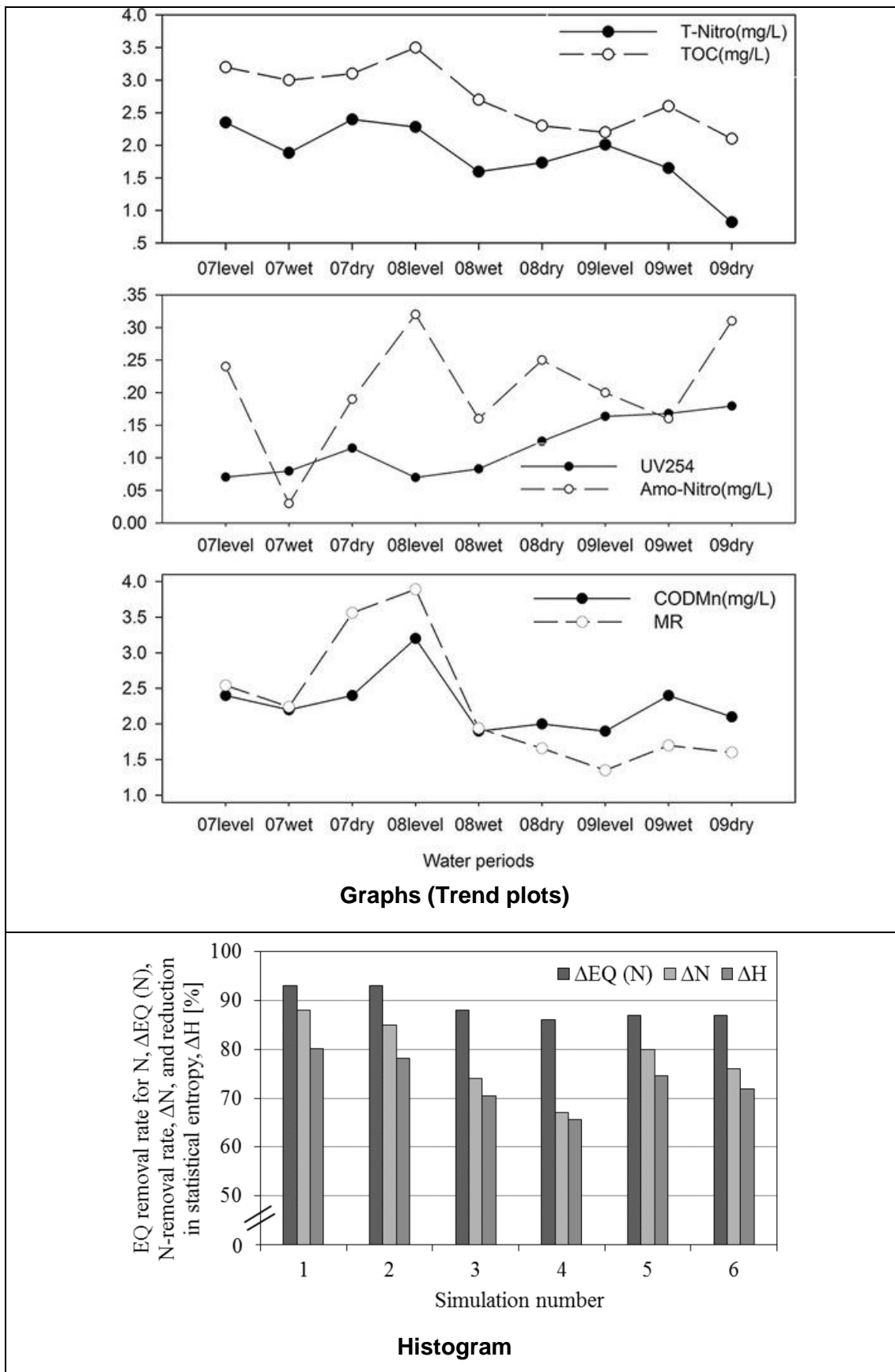
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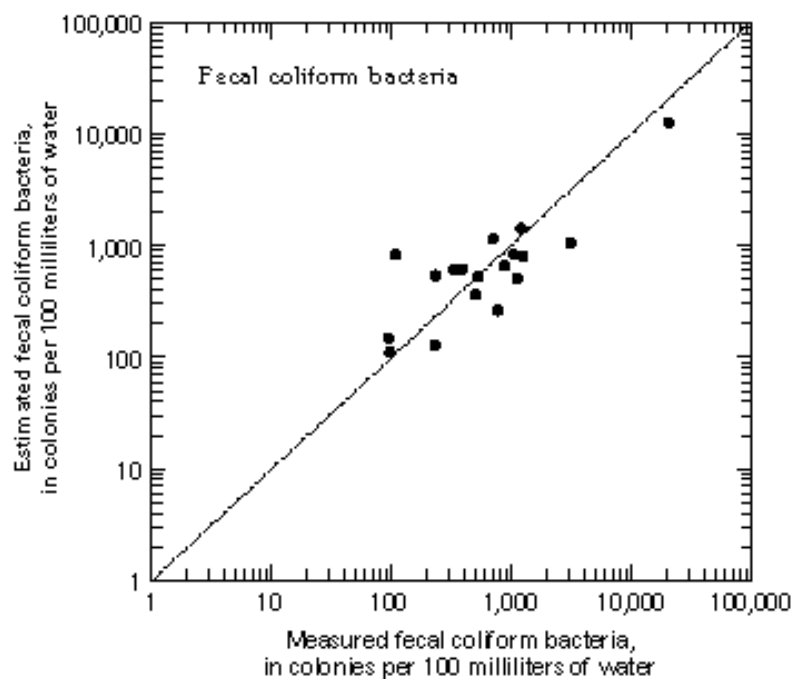
APPENDIX 9 : FIELD SAFETY GEAR



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APPENDIX 10 : STATISTICAL PRESENTATION OF DATA





**Table 3.** Spearman rank correlation coefficients between fecal coliform and water-quality field measurements for selected Wyoming streams

[*Italicized numbers indicate a significant relation where p-values were less than 0.05*]

Site no. (fig. 1)	USGS station no.	Discharge	Specific conductance	pH	Water temperature	Dissolved oxygen
4	06274300	<i>0.495</i>	<i>-0.545</i>	<i>-0.498</i>	<i>0.713</i>	<i>-0.776</i>
6	06284500	<i>0.775</i>	<i>-0.843</i>	<i>-0.556</i>	<i>0.549</i>	<i>-0.634</i>
8	06304500	<i>0.266</i>	<i>-0.079</i>	<i>-0.237</i>	<i>0.605</i>	<i>-0.735</i>
9	06305500	0.021	0.012	-0.066	0.019	-0.214
11	06426500	<i>0.309</i>	<i>-0.123</i>	<i>-0.166</i>	<i>0.551</i>	<i>-0.581</i>
12	06428050	<i>0.331</i>	<i>-0.350</i>	<i>-0.249</i>	<i>0.420</i>	<i>-0.692</i>
14	06756060	<i>0.287</i>	<i>-0.397</i>	0.034	<i>0.425</i>	<i>-0.342</i>
15	09222000	<i>0.696</i>	<i>-0.494</i>	<i>-0.403</i>	<i>0.572</i>	<i>-0.684</i>

**Correlation coefficients treatment**

## **SECTION 1: INTRODUCTION**

- 1.1 General
- 1.2 Project Approval and Compliance Requirement

*The objectives of the monitoring should be described i.e. for compliance to EIA and EMP approval conditions. Any major restrictions (personnel, access, weather/site conditions, etc.) which hindered the programme should be identified.*

## **SECTION 2: PROJECT DESCRIPTION**

- 2.1 Project Description
- 2.2 Environmental Management Measures

*A location map should be included to show project site, hydrological system and surrounding land use. The erosion and sediment control measures adopted are to be described in this section.*

## **SECTION 3: WORK PROGRESS**

- 3.1 Work Progress

*Project development schedule should be included with actual work progress completed shown in percentage.*

## **SECTION 4: ENVIRONMENTAL MONITORING**

- 4.1 Environmental Monitoring Programme
- 4.2 Water Quality Monitoring Programme

*The methods of sampling and analysis should be described. A map showing the location of the monitoring stations together with a brief description of the stations and GPS coordinates should be included.*

## **SECTION 5: RESULTS OF ENVIRONMENTAL MONITORING**

- 5.1 Water quality of Discharge from Silt Traps/Sediment Ponds
- 5.2 Water quality of Receiving Water Body

*Results should be presented in tabular and graphical form. Past monitoring results should be included for comparison with trend analysis as far as possible. Statistical analysis of results should be described with the reliability of the statistics, and its implication given.*

## **SECTION 6 : CONCLUSION**

- 6.1 Compliance Status
- 6.2 Recommendations (Corrective Actions)

*The significance of the results obtained and compliance to the stipulated limits should be discussed. This section should include recommendations for improvement or corrective actions to be taken.*

## **APPENDICES**

- Appendix A EIA and EMP Approval Conditions
- Appendix B Field Inspection Notes
- Appendix C EIA 1-08 and EIA 2-08 Forms
- Appendix E Environmental Monitoring Result (Laboratory)

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