Nile Basin Initiative
Nile Trans boundary Environmental Action Project

Simple Procedures for Water & Waste Water Sampling for Nile Basin Countries for Transboundary Water Quality Monitoring

July 2007

NILE BASIN INITIATI

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FOREWORD

The Basin wide Water Quality Monitoring Component of the NTEAP has developed four Water Quality Operational Manuals which will assist in the transboundary water quality monitoring of the Nile Basin.
The four Manuals that have been developed are:

- **Simple Procedures for Water & Waste Water Sampling for Nile Basin Countries for Transboundary Water Quality Monitoring.**
- **Selected Common Standard Analytical Methods for Nile Basin Countries for Transboundary Water Quality Monitoring.**
- **Guidelines for Data Reporting Forms for Nile Basin Countries for Transboundary Water Quality Monitoring.**
- **Manual for On-Site Tests by Local Communities & Schools for Nile Basin Countries for Transboundary Water Quality Monitoring.**

The Manuals will also:

- *Promote basin wide networking on Water Quality Management, to ensure transboundary water quality assessment;*
- *Promote continued exchange of information on key transboundary parameters;*
- *Enhance continued awareness on water quality issues;*
- *Assist and enhance capacities for Water Quality Monitoring, and improve the understanding of transboundary Water Quality Management issues.*

The Manuals will promote good comparability of the water quality data produced, and also ensure data reporting consistency on a regional and international level, so that the analytical results produced can be compared on a level platform.

The NBI through NTEAP is proud to produce and launch these simply designed and user-friendly series of Manuals which will compliment the already on-going national water quality monitoring initiatives.

On behalf of the NBI, the NTEAP wishes to acknowledge with gratitude the technical and administrative support by the Regional Water Quality Working Group Members, the Consultant, the PMU Staff, the National Project Coordinators and Water Quality Lead Specialist for contributing to the development of these Manuals.

It is our hope that the users of these Manuals will find them beneficial, as a first step towards harmonizing transboundary water quality monitoring practices in the Nile basin countries.

Gedion Asfaw,
Regional Project Manager,
Nile Transboundary Environmental Action Project.

Acknowledgements

The following members and associates of NBI assisted with the production of this Manual:

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In the preparation of these Manuals, other sources of information such the Standard Methods for Water and Waste water Analysis by the American Water Works Association (AWWA) as well as other standard sources were referred to. All these sources are hereby acknowledged.

Our thanks go to all those persons and institutions that played a role in the compilation of this Manual.

CONTENTS

Abbreviations

BOD …………………………...Biochemical Oxygen Demand
COD……………………………Chemical Oxygen Demand),
DEHP…………………………..Di(2-ethylhexyl)phthalate
DO ……………………………..Dissolved Oxygen
EC………………………………Electrical Conductivity
FAO…………………………….Food &Agriculture Organisation
GPS ……………………………Geographical Positioning System)
N……………………………….Nitrogen,
NBI ……………………………Nile Basin Initiative
OS………………………………On site (analysis)
P………………………………...Phosphorous
PAH ……………………………Poly Aromatic Hydrocarbons
PCB……………………………..Polychlorinated Biphenyls
TDS……………………………..Total Dissolved Solids
TSS…………………………….Total Suspended Solids
UNOPS…………………………United Nations Office for Project Services
NTEAP …………………………Nile Trans boundary Environmental Action Project

BACKGROUND

The Nile Trans boundary Environmental Action Project (NTEAP) is one of seven projects under the Nile Basin Initiative Shared Vision Programme and is of five years duration. The main objective of the project is to provide a strategic environmental framework for the management if transboundary waters in the Nile Basin.

The basin wide Water Quality Monitoring Component is one of the five Components of the NTEAP. This Component's objectives include:

i. Initiate basin-wide dialogue on water quality.
ii. Improve capacities for monitoring and management of water quality.
iii. Provide a platform for the exchange and dissemination on information on key parameters.

This Manual is one a series of four manuals, which meets these objectives. This manual is a controlled document and amendments can only be authorised by The NBI Water Quality Manager.

The other Manuals of are:

- Selected Common Standard Analytical Methods for Nile Basin Countries for Transboundary Water Quality Monitoring

- Guidelines for Data Reporting Forms for Nile Basin Countries for Transboundary Water Quality Monitoring

- Manual for On-Site Tests by Local Communities & Schools for Nile Basin Countries for Transboundary Water Quality Monitoring.

Simple Procedures for Water & Waste Water Sampling for Nile Basin Countries for Transboundary Water Quality Monitoring

1.0 INTRODUCTION

The objective of this manual is to provide simple standard guidance on the procedures required in taking representative water samples from raw water locations such as rivers & lakes for monitoring transboundary water along the River Nile for the nine member countries. The analytical results are dependent on the correct sampling and though each country has its own national sampling schemes these need to be internationally consistent. By the application of these guidelines the results can be then be compared on a level platform.

2.0 .MONITORING SCHEMES

The location of sampling points and the frequency of sampling depends on the type of monitoring. There are three types of river basin monitoring schemes, which include:

2.1 Surveillance Monitoring

The objectives of surveillance monitoring are to provide:

i. An initial baseline assessment of the water basin.
ii. Monitor the impacts of natural conditions and anthropogenic activities.
iii. Highlight water quality trends.

The more frequently samples are taken, the better the assessment of the river basin. As the resources are limited for NBI Transboundary Water Quality monitoring, samples should be taken at least after every 3 months. Similarly, the more sampling points applied, then the better the surveillance. Owing to the limitations of the resources of the project, the number of sampling points has to be set to a minimum of 2 to 4 for each member country. Each country has recommended these sampling points on the basis that they will be indicative of the water quality as it arrives, travels, and exits the country. These sites should be at Hydrological Stations, so that flows and levels can be recorded at the same time of sampling. Ideally, the sampling should be sequentially between countries, so that the parameters are monitored and tracked as they flow down the Nile.

2.2 Operational Monitoring

Each country should have a national river basin management scheme to monitor water bodies that are at risk. The location of the sampling points for operational monitoring ideally should be at every point where there is a change in the river's conditions e.g. after a major a tributary or a major effluent producer such as an urban sewage works. These points should be listed and prioritised and the sampling scheme developed based on the logistics and available resources. It is important for the member states to exchange the results of their operational monitoring with neighbouring states and the NBI, to provide further data for the international surveillance of the whole river basin.

2.3 Investigative Monitoring

When a problem indicated from the above monitoring schemes, it may be necessary to concentrate on monitoring a specific river sub-basin. This entails taking extra samples from additional locations and analysing specific parameters to obtain more detailed information.

An important aspect of investigative monitoring is to list the procedures for responding to pollution incidents.

When a major pollution incident occurs the monitoring of the pollutant is critical in order to:

i. Minimise the damage,
ii. Operate control procedures,
iii. Initiate remediation procedures, &
iv. Provide accurate information to communities and countries downstream so that they can initiate damage limitation procedures.

One of the priority issues for this project is to establish clear procedures to deal with major pollution incidences, formally agreed between all countries. These procedures should include the following:

1) Contact details of all the senior stakeholders.
2) Prioritised action plan.
3) A rota drawn up to ensure that at least the main senior stakeholders are available 24 hours a day.

2.3.1 Emergency Monitoring Procedures:

When the pollution incident occurs, the pollutant must be sampled and analysed as quickly as possible. Therefore, the following procedures should be followed:

1) Obtain the undiluted effluent with the full list of all its components. This information may be available from the polluter and/or by undertaking a full analysis of the concentrate.

2) By using the recorded river flow from the closest hydrological station, calculate the location of the pollutant and then to monitor its concentration as it flows downstream.

3) The pollution site should also be continually monitoring during this period to check for additional leaching and the control of the effluent.

4) Combine the resources from other departments and organisations, especially in taking samples from remote inaccessible locations.

5) If the most harmful component is difficult or time consuming to analyse, it is expedient to monitor other components of the effluent, rather than just monitor only the dangerous constituents. Preserved samples should be taken for further in-depth analysis later, e.g. electrical transformer oils can contain very harmful PCB’s but the major constituent is mineral oil, which is easier to analyse.

6) When the pollution has disappeared, a report should be submitted by each affected country. This should be discussed technically by the senior stakeholders, including the appropriate NBI members in an enquiry held in private.

7) The objective of the investigation should be to establish ways to improve the procedures, and to prevent such an incident from happening again. It should not be used to apportion blame, as this will only encourage countries to hide such incidences, resulting in the deterioration of the Nile for all countries.

3.0 PARAMETERS

The parameters that have been considered important in the developed countries for river basin management have been highlighted in appendix 3.

The members of the NBI have listed the following twelve priority parameters for the transboundary objective:

- Heavy Metals,
- Toxic substances,
- Pesticide residues,
- Biochemical Oxygen Demand (BOD),
- Chemical Oxygen Demand (COD),
- Total Suspended Solids (TSS),
- Total Dissolved Solids (TDS),
- Conductivity,
- Nutrients (P, N),
- Faecal Coliforms,
- Oil and Grease,
- Conductivity.

3.1 Organic Parameters

One of the main groups of organic compounds that can pollute the Nile are pesticides. As there are such a large number of different pesticides, it is expedient to monitor only the most likely ones. Therefore a desktop study should be undertaken by the members, for the agricultural areas in their countries within the Nile Basin recording:

1) A list and locations of crops;
2) Pesticides associated with these crops;
3) Quantities of pesticides imported and purchased by the farmers;
4) Frequency of applications, and
5) Times and the locations where the pesticides are applied.

This information could be collated from data obtained from: the FAO, Farmers, Farmers Union, Ministry of Agriculture, and Pesticide Manufacturers & Suppliers. From this data, a sampling and an analytical scheme should be drafted and implemented.

Similarly, member countries should make an inventory of each effluent producer along the Nile Basin, to highlight the other possible toxic pollutants and to set up the appropriate sampling and analytical programmes.

The main analytical methods have been detailed in the manual for “Selected Standard Methods for Water & Waste Water Quality Analysis for Transboundary Samples.”

3.2 Biological Parameters

It is recommended that simple biotic indices are also considered measured, though external training maybe required for this specialised sampling and analysis, possibly by experts from the LVEMP. The biological assessment of river water, especially when applied to locations both up and down stream from effluent producers, can provide a valuable insight into the condition of the ecosystem, indicating its current state and its ability to tolerate further pollution. Some water invertebrates are very sensitive to pollution, whereas others thrive in nutrient rich polluted water. A simple guide is shown in appendix 4. When the NBI Water Quality Team are confident in this simple analysis, it should progress to undertake more comprehensive ecological surveys at each point, called the Biological Quality Element (BQE), which focuses on the abundance & species composition of:

- Phytoplancton,
- Phytobentos,
- Macrophytes,
- Benthic Macro-invertebrates, &
- Fish.

4.0 EQUIPMENT

To enable samples to be taken correctly, the recommended sampling equipment, bottles, and field equipment are listed in Appendix 1.

4.1 Chain of Custody

When a sample is taken, the sampling details should be recorded on the bottles and on a Chain of Custody form. This is fully explained in the “Manual for Transboundary Water Monitoring Data Forms”. The form should be signed by the laboratory staff, such that there is a traceable record of the sample.

4.2 Transport & Storage

The preservation of samples is detailed for all inorganic parameters is shown in Appendix 2. A number of parameters should be analysed on-site including: pH, Electrical Conductivity (EC), & Dissolved Oxygen (DO). Organic parameters have different methods of preparation, extraction and these are often linked to the preservative. Many organics, inorganic compounds & microbiological parameters can be preserved by refrigeration, so cooler boxes with frozen blocks are essential for the transportation of the samples. The internal temperatures should be monitored and logged during the transportation.

An abbreviated list of bottles is also shown in Table 1 appendix 1.

4.3 Location Definition

In order to define the exact location of the sampling point the equipment should include: detailed maps, a tape measure, a compass and, ideally, a Geographical Positioning System (GPS). A camera can also be helpful in recording the surrounding environment, and the changing level and morphology of the river.

5.0 SAMPLING TECHNIQUES

There are a number of sampling techniques, which depend on the objectives of the monitoring scheme. These methods include:

5.1 Grab Sampling

When a sample is collected at one location, at one time, it is called a grab sample. This is the most common type of sampling performed on river waters and are recommended for the normal transboundary monitoring. There are two types of grab samples:

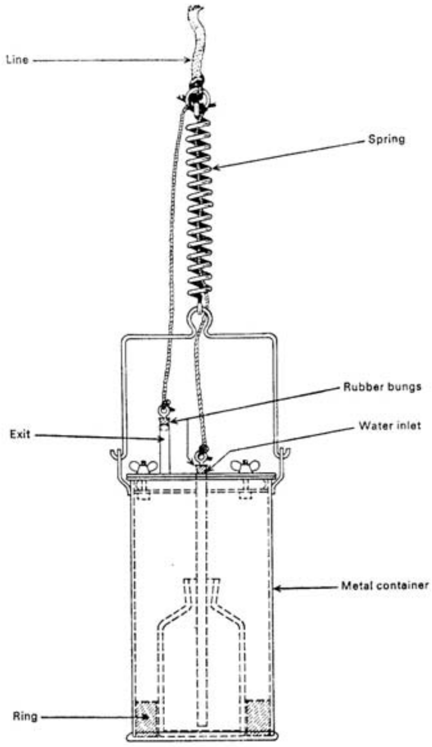
5.1.1 Dip Samples

Dip sampling is a technique where a collector vessel, e.g. 500 ml plastic beaker is clamped on to a pole and the water sample is taken at a depth of about 1m below the surface and away from the bottom. The water is then transferred to the sampling bottle. This is essential for parameters that require bottles previously prepared with preservatives, e.g. heavy metals and some organic compounds.

5.1.2 Depth samplers

Depth samplers or sometimes-called grab samplers are designed to retrieve a sample from any predetermined depth.
An example of this is shown below which is designed specifically for the sampling of DO samples such that the water enters without splashing, however it can also be used for other types of samples.

Figure 1 Depth sampler for DO



When the sampler is at the require depth, a sharp tug on the line will release the inlet and outlet bungs to allow the water to be sampled.

5.1.3 Submersible Pump

If there are a large number samples or a large quantity of sample required, then a submersible pump maybe used. This is usually used from a boat or a bridge. The pump is lowered using a weighted rope to retain the pump at a fixed location, and for retrieval.

5.1.4 MICROBIOLOGICAL SAMPLES

For microbiological samples, it is essential that the sampling bottles and equipment are sterile to avoid contamination. The sample should be taken from below the surface. Specialised samplers that have been pre-sterilised are used for these samples. The following procedures should be applied:

i. Ensure the sampling bottles and equipment are kept sterile.
ii. Do not handle the bottle by the neck or touch the inside of the bottle or lid.
iii. Ensure the bottle is not opened before the time of sampling.
iv. Do not rinse the bottle before sampling.
v. Hold the bottle by the base and remove the lid with the other hand.
vi. Retain the lid in the hand whilst the bottle is filled and replace immediately.
vii. Place the sample in the cool box as soon as the sample has been taken.
viii. Ideally the sample should be analysed within 6 hours, but in exceptional circumstances it can be stored in a refrigerator for up to 24 hours at 2-4ºC.

5.1.5 HEAVY METALS

The samples should be acidified with 10ml of 50% v/v Nitric acid to 1000ml of sample or the plastic sampling bottles are pre acidified and are filled to a defined volume with the sample.

5.1.6 Direct Samples

For some parameters it is best to take samples directly using the storage bottles themselves, ensuring they are rinsed thoroughly with the sample, filled smoothly without splashing, e.g. dissolved oxygen. The open bottle can be clamped at the end of a pole or suspended in a weighted cage by a strong cable. The sample should be taken as far as possible from the river bank. Direct samples are preferable for most parameters, as there is a less chance of cross-contamination, but cannot be used for samples where the bottles have been pre-dosed with preservatives.

The bottles without preservatives should be rinsed three times with the sample before filling the bottle.

5.2 Composite Sampling

A composite sample is a mixture of individual grab samples mixed into one bottle, they are unsuitable for DO, pH or temperature analysis.

Composite samples are used for specialised purposes when the mathematical prediction of the average water is inaccurate or even impossible. There are two main types of these samples:

5.2.1 Time Composite Samples

Composite samples maybe required for litigious purposes, for pollution control, or the calculation of effluent tariffs. These samples are usually taken from the same location, at different times and called time composite samples. Automatic sampling devices are often used for these types of samples, especially if the samples are taken over a long time-period.

5.2.2 Integrated Samples

Another type of composite sample is taken where grab samples are collected from different locations and mixed together into one bottle; this is called an integrated sample. These samples are used for specialised studies such as evaluating the river with differing compositions at different depths or widths, to determine the loading of a water treatment works.

6 SEDIMENT SAMPLING

There are a number of methods for sampling sediment samples and their associated analysis. The main ones include:

1) Sediment Grab Samples

1) The simplest is to use a sediment grab sampler to take a grab sample from the riverbed.

Analysis

i. The sample is then oven dried and passed through a range of calibrated filter trays.
ii. Each mass of material retained by specific sieves is then weighed using calibrated laboratory balances.
iii. From these results, the size distribution curve for the bed material is obtained.
iv. This data can then be used in models to specify bed roughness.

2) Water Sample

The second method, is to obtain a known volume of water (2-3litres) containing uniformly mixed sediment.

Analysis

i. Use a settling column (Owen Tube) to extract equal volumes of water over BSI specified time increments to analyse the concentration/sample.
ii. From this data the settling velocity of a particular sediment type can be calculated

3) Bed Sediment Frame Sampler

The most comprehensive method sediment samples are taken at discreet levels using a bed –sediment frame. This a an adjustable Bowden flex cable operating a sampling arm close to the river bed nominally 0.05, 0.1, 0.15, 0.3, 0.6 and 1m above the bed. Using a boat-based pumped system, filtering a known volume of water; normally 10L, although this depends on the sediment concentration encountered, through a 63-micron glass fibre filter in a filter frame.
At each level, the velocity of the water is measured using an impellor type current meter (i.e. Braystoke 002 type).
The rest of the water column (bed + 1m to surface) is sampled using a 'roving unit' from a davit on board the survey vessel. The rover incorporates a pumped sampler system and separate filter again measuring the velocity at each level sampled.
The sediment retained on each filter, uniquely labelled, is then retained in filter trays or sealable plastic bags for laboratory analysis of weight/sample. This will establish a sediment curve throughout the water profile, obviously the highest concentration closest to the bed and 'tailing-off' further away from the bed.

Analysis

i. From this sampling and analysis, the data is used to calculate sediment transport.
ii. This data is then inserted into numerical / physical models to calculate the sediment flux of a river system, i.e.: to correlate the amount of sediment being transported by the river at differing current speeds.
iii. These calculations can then be used to assess the amount of sediment being transported along a river course at different flows which is very significant to the countries on the Nile.

Appendix 1

Sampling Equipment

Appendix 1- Sampling Equipment

Equipment Required when Water Sampling

I. Dip sampler
II. Bacteriological Dip Sampler
III. Cables/ cages to attach to bottles for direct samples
IV. Sample bottles/preservatives
V. Cooler boxes with freezer blocks
VI. Chain of Custody records, custody seals
VII. Field data record sheets-x
VIII. Maps/plans
IX. Safety equipment
X. Compass
XI. Tape measure
XII. Digital Camera
XIII. Permanent marker pen
XIV. Logbook/waterproof pen
XV. Sample bottle labels
XVI. Geographical Positioning System (GPS) to identify exact location of sampling point

Field equipment:

I. DO meter
II. pH Meter
III. Electrical Conductivity Meter
IV. Turbidity Tube or meter
V. Photometer and reagent tablets for Nitrate, Ammonia and phosphate analysis
VI. Distilled water

Table 1 Sampling Bottles

Bottles Types	Parameters
1 litre polypropylene bottle with 10ml 50% Nitric acid	Heavy metals
2.5l Clear glass bottle	pH , BOD,, EC, PO4, NO3, TDS, TSS, Turbidity,
2.5l Amber glass bottle	Organic analysis e.g. pesticides
250 ml Sterile glass bottle	Faecal coliforms
Glass DO bottle	DO

Appendix 2

Sampling, & Preservation Methods

&

Storage Times

Appendix 2 Sample Preservation

Appendix 3

Parameters required for Full Water Basin Assessment

Appendix 3- Parameters

<u>Recommended Parameters for Full Baseline Survey</u>

1) **Ammonia-Nitrogen (OS)**
2) *Arsenic
3) **Alkalinity (OS)**
4) BOD
5) *Cadmium
6) Calcium
7) Chloride
8) *Chromium (VI)
9) COD
10) Colour
11) *Copper
12) *Cyanide (Total)
13) Detergents
14) **Dissolved Oxygen (OS)**
15) **Electrical Conductivity (OS)**
16) Fluoride
17) Kjeldahl Nitrogen
18) *Iron
19) *Lead
20) Magnesium
21) *Manganese
22) *Mercury
23) **Nitrate-Nitrogen (OS)**
24) **Nitrite – Nitrogen (OS)**
25) *Oil & Grease
26) Pesticides- from Desktop Survey
27) *Phosphate (Total)
28) Phosphate (Soluble)
29) **.pH (OS)**
30) Silicate (Dissolved)
31) Sodium
32) Sulphate
33) TDS
34) Turbidity (OS)
35) Temperature
36) TSS
37) Turbidity
38) *Zinc
39) Faecal Streptococci
40) Faecal Coliform
41) Total Coliform
42) Chlorophyll- a

(* = Analysis carried out on the wet-sieved 63 µm fraction)

<u>Key:</u>

***** = Parameters should be analysed also in sediments. Sediments should always be taken from both left and right profile when sampling at the main river bed. Only *<u>wet-sieved 63 µm fraction</u>* of sediments should be analysed in order to be able to compare data from different sampling sites.

OS= Parameters analysed on-site confirmed in laboratory

Recommended Extra Parameters to be analysed in Future Baseline Studies with Limits

Name of substance	Maximum Acceptable Concentrations in µg/l
Alachlor	0.7
Aluminum	
Anthracene	0.4
Atrazine	2.9
Benzene	49
Barium	
Boron	
Brominated diphenylether	
deca BDE	--
octa BDE	--
penta BDE	1.4
Chloroalkanes, C10-13	1.4
Chlorfenvinphos	0.3
Chlorpyrifos	0.1
*Chromium Total	
1,2-dichloroethane	1180
Dichloromethane	1900
Di(2-ethylhexyl)phthalate (DEHP)	--
Diuron	1.8
Endosulfan	0.01
(alpha-endosulfan)	
Fluoranthene	0.9
Hexachlorobenzene	0.05
Hexachlorobutadiene	0.6

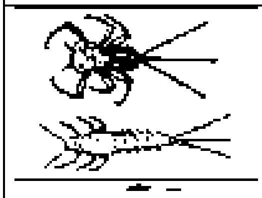
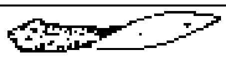
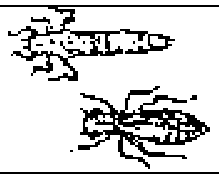
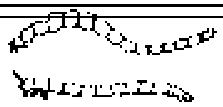
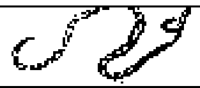
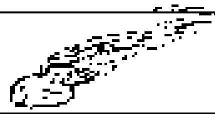
Name of substance	**Maximum Acceptable Concentrations in µg/l**
Hexachlorocyclohexane HCH gamma-isomer, Lindane)	0.04
Isoproturon	1.3
Naphthalene	80
Nickel	
Nonylphenol(4-(para)nonylphenol	2.1
Octylphenol(para-tert-octylphenol	0.13
PCB’s	
*PAH’s: (benzo(a)pyrene),(benzo (b)flouranthene), (benzo(k)flouranthene	
Pentachlorobenzene	1
Pentachlorophenol	1
*Selenium	
Simazine	3.4
TOC	
Tributyltin compounds	0.002
Trichlorobenzenes (all isomers)	50
Trichloromethane	270
Trifluralin	1
DDT total	0,025
para-para-DDT	0,010
Aldrin	0,010
Dieldrin	0,010
Endrin	0,005
Isodrin	0,005
Carbontetrachloride	12
Tetrachloroethylene	10
Trichloroethylene	10

Extra Microbiological Parameters
Chlostridia Perfingens
Giardia
Cryptosporidia

Appendix 4

A Simple key for Biological Assessment of River Water

Biological Assessment of Water Quality Table

Organism	Name	Sensitivity to Pollution	
	mayfly nymphs	extremely sensitive	If this is the most organism present then the water quality is probably good
	stonefly nymphs	Extremely sensitive	If this is the most organism present then the water quality is probably good
	caddisfly larvae	sensitive	Extremely sensitive organisms missing indicates some pollution or turbidity and possibly low oxygen content.
	flatworms	sensitive	Extremely sensitive organisms missing indicates some pollution or turbidity and possibly low oxygen content.
	dragonfly nymphs	moderately sensitive	Sensitive organisms missing indicates pollution by silt or nutrients.
	whirligig beetles	moderately sensitive	Sensitive organisms missing indicates pollution by silt or nutrients.
	water snails	moderately sensitive	Sensitive organisms missing indicates pollution by silt or nutrients.
	blood worms	moderately sensitive	Sensitive organisms missing indicates pollution by silt or nutrients.
	rat tailed maggots	pollution tolerant	Pollution tolerant organism, so highly polluted water as only these organisms can survive.
	sludge worms	pollution tolerant	Pollution tolerant organism, so highly polluted water as only these organisms can survive.
	water algae	pollution tolerant	No life except algae means very serious pollution.