ACT and Upper Murrumbidgee
Waterwatch Program

DATA CONFIDENCE MANUAL

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June 2007

Preface

Waterwatch is a water quality monitoring program that enables local communities to understand their waterways and catchments, and to contribute to their management and protection. A large number of community members and Waterwatch groups throughout the ACT and the Upper Murrumbidgee undertake a variety of biological and habitat assessments as well as physical and chemical tests, to build up a picture of the health of their waterways and catchments. This monitoring is important, as it provides 'hands-on' community education, as well as knowledge and understanding about environmental protection, managing waterways, and controlling pollution.

This data confidence plan sets out how ACT Waterwatch measures the quality of information that participants collect. This manual contains guidelines for Waterwatch coordinators and participants to ensure a medium to high level of data confidence in regard to salinity, phosphates, pH, temperature, turbidity and dissolved oxygen parameters.

Acknowledgements

Throughout this manual, reference is made to the following documents:

Waterwatch Australia, 2002. Waterwatch Australia National Technical Manual. Module 4 - Physical and Chemical Parameters. Waterwatch Australia Steering Committee. Published by Environment Australia.

Waterwatch Australia, Unpublished. Waterwatch Reference Manual - Field Test Draft. Chapter 4 - Planning to Monitor.

Waterwatch Tasmania, 2001. Waterwatch Tasmania Data Confidence Guidelines. Compiled and written by Michael Cassidy, Department of Primary Industries, Water and Environment (DPIWE), Tasmania.

USA Environment Protection Agency, 1996. The Volunteer Monitor's Guide to Quality Assurance Project Plans.

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1. INTRODUCTION

1.1 WHAT IS DATA CONFIDENCE?

Data confidence refers to the *degree of quality* that can be attributed to a particular set of data.

For Waterwatch groups, data confidence covers all aspects of data collection including sampling, analysis, data management and storage. Data confidence is achieved by applying the principles of Quality Assurance and Quality Control (QA/QC).

***Quality Assurance* (QA)** refers to the overall *management system*, which includes the organisation, planning, data collection, quality control, documentation, evaluation and reporting activities. QA provides the information needed to ascertain the quality of data and whether it meets the requirements of the project. QA ensures that data will meet defined standards of quality with a stated level of confidence.

***Quality Control* (QC)** refers to the routine *technical activities* whose purpose is, essentially, error control. Since errors can occur in either the field, the laboratory or in the office, QC must be part of each of these functions.
(USA Environment Protection Agency, 1996)

By developing a thorough data confidence plan, that keeps track of equipment calibration and maintenance, training records and QC checks, the accuracy and reliability Waterwatch data can be proven.

1.2 ACT WATERWATCH PLANNING FOR DATA CONFIDENCE

Confidence in data is imperative for the success of the ACT Waterwatch program, as it can ensure that data is meaningful, and can be utilised to its full extent.

Planning for data confidence:

- ☑ allows identification of contamination of samples, poor technical practices, faults with training, and failure of equipment;
- ☑ produces data of known integrity, which will increase its value to all users, including the media and natural resource management agencies;
- ☑ saves money and time through reducing the need to resample or discard data; and
- ☑ reassures participants that their time and effort are valued, and that their results are meaningful.

2. DATA CONFIDENCE PLAN

The ACT Waterwatch data confidence plan involves a number of steps that clarify our reasons for monitoring and the way that ACT Waterwatch goes about it. The eleven issues set out in Section 2.1 draw a complete picture of ACT Waterwatch's monitoring program; it's purpose, users, and therefore the quality of data that ACT Waterwatch aim to achieve

2.1 MONITORING PLAN

Monitoring Priorities

Waterwatch groups in the ACT have been created to meet a number of monitoring needs throughout the region. These include:

i) Post-January 2003 Bushfire waterway recovery
ii) M&E of sites where community works have taken place
iii) Effectiveness of storm water management
iv) ACT Government effectiveness in meeting the water quality specifications set out in the Environmental Protection Regulations of 2005

Information users

ACT Waterwatch is constantly seeking to increase the number of individuals and groups who can access and use the information we collect. Current and potential users include:

i) Landcare, Waterwatch and environment-focused community groups and members
ii) Environmental stewardship NGOs such as Greening Australia and the UMCCC
iii) Government bodies such as ACT Territory and Municipal Services and the NSW Bureau of Rural Services
iv) Private industry/businesses/agriculture improve their green credentials, such as Bundy Rum, Bunnings and Dilmah Tea
v) Educational institutions, from primary schools to university level research
vi) Service and special interest community groups such as Rotary, Canberra Ornithologist Group and the Game Fishing Association of Australia.

Information use:

ACT Waterwatch would like to see our data used for numerous and diverse purposes. Current and potential uses include:

i) Focus and promote on-ground works strategies
ii) Demonstrate the efficacy of on-ground work projects
iii) Map water quality 'hot zones'
iv) Identify areas of high environmental significance
v) Determine sustainable levels of environmental flows
vi) Assist industry, business and agriculturalists in assessing their impacts on waterways
vii) Provide raw research data to secondary and tertiary students
viii) Coordinate data with special interest group activities.

Monitoring Parameters

ACT Waterwatch monitors the following physical and chemical parameters:

i) Temperature
ii) Orthophosphates
iii) Electrical conductivity
iv) Dissolve oxygen
v) pH
vi) Turbidity

Further the ACT Waterwatch also conducts macro invertebrate surveys, riparian habitat assessments, and has the capability to seen provide ground water assessments on the above parameters

Data Quality

Waterwatch data used outside of community groups collecting it will meet or exceed a medium level of data confidence

Methods

Waterwatch data will be collected for the above parameters using the following methods and equipment:

a) Temperature
   i) Spirit thermometer –10/110° C according to manufacturer instructions
b) Orthophosphates
   i) Visocolor HE Phosphate Kit 0.01-0.25 mg/L *or* Visocolor HE Phosphate Kit 0.05-1.0 mg/L *or* Hanna Phosphate Colorimeter 0.00-2.5 according to manufacturer instructions
c) Electrical Conductivity
   i) Eutech Conductivity Testers, Lamotte Salt Tracers *or* Hanna DIST 5 Conductivity Testers according to manufacturers instructions
d) Dissolved oxygen
   i) Visocolor Oxygen SA10 kits, *or* Lamotte Dissolved Oxygen kits according to manufacturer's instructions.
e) pH
   i) Eutech pH Testr series and Eutech pHScans according to manufacturer's instructions
f) Turbidity
   i) Turbidity tubes according to standard practices.

Monitoring Sites

Sites are selected based on accessibility and proximity to:

ii) Physical landforms of interest
   (1) tributaries
   (2) changes to surface hydrology
   (3) geological outcrops
   (4) soil type
   (5) active erosion sites
   (6) low or high slope
iii) Land uses of interest
   (1) varying agricultural and silviculture uses
   (2) fire-affected areas
   (3) areas of high biological significance
iv) Sites of strong human impact
   (1) urban areas
   (2) industrial areas
   (3) construction sites
   (4) recreational areas
   (5) wastewater treatment facilities
   (6) stormwater outflow points and settling ponds
v) Remediation projects
   (1) fenced areas
   (2) revegetated areas
   (3) sites of intensive weed removal
   (4) erosion control
   (5) constructed wetlands
   (6) other habitat enrichment (snagging projects, etc.)
vi) Areas of Community Group Interest
   (1) School grounds
   (2) Parkland

Monitoring Frequency

Sites are monitored on a monthly basis.

Volunteers

Waterwatch volunteers carry out surveys and/or test water samples, they will arrange transport to sites and back. At least one volunteer in each group will have had QA/QC training within the previous six months to assure proper procedures are carried out during sampling and testing.

The Waterwatch coordinators are be responsible for the repair/replacement of all malfunctioning equipment and the resupply of regents and testing kits.

Photographs of sites will be taken by volunteers, coordinators and occasionally by the ACT Waterwatch Facilitator from preferability pre-determined marked points.

2) **Data Management and Presentation:**
   Original data is owned by the groups or individuals who collect it. Groups are encouraged to pass on copies or originals of their results to their waterwatch coordinators for professional storage and entry into their catchment's waterwatch databases. Originals and copies as well databases are stored with the waterwatch coordinators at the catchment group offices. A copy of waterwatch data is also stored off-site over night and on weekends to further protect the continuity of data from theft, and physical disasters.

   While Waterwatch coordinators are free to present data in any number of ways, all have reporting requirements attached to their grant funding, though this is expressed differently in each catchment. All waterwatch coordinators present and analyse their data in public publications at regular intervals.

   At the regional level, quality controlled and assured waterwatch data is fed into the INCP water quality database, which is managed and presented by the ACT government.

3) **Ensuring Data Credibility:**
   Waterwatch data credibility is ensured through a process of quality assessment and control procedures. Set quality control (QC) procedures are in place to ensure that sample collection, handling, and testing meets manufacturer's requirements for the test kits that volunteers use. Quality Assurance (QA) is the set of procedures intended to ensure that water quality testing meets specified accuracy requirements. These QA/QC procedural requirements are laid out in the Waterwatch National Technical Manual.

2.2 LEVEL OF DATA CONFIDENCE

Based on the goals of the ACT Waterwatch monitoring program and the resources available, Waterwatch data is expected to meet a medium level of confidence. This includes using accepted procedures for collecting data, with calibrated equipment that is kept clean and in good working order. Further internal QC checks that accepted procedures for collecting data are used, along with a minimum of two QC checks yearly will be performed. These internal QC checks will indicate data points within the designated tolerable error range are used to infer that the whole data set should be viewed with a medium level of data confidence. This data will then data qualify for entry in the Waterwatch database.

It is our goal within the next five years to additionally submit 10% of samples as duplicates to be tested by independent external agencies or labs. These external QC checks will indicate data points within the designated tolerable error range are used to infer that the whole data set can be viewed with a high level of data confidence.

2.3 CONCEPTS FOR DATA CONFIDENCE

2.3.1 Collecting Complete, Representative and Comparable Data

Water bodies are not uniform, and vary over distance and time. In order to collect meaningful data, ensuring that it is complete and representative of the water body is crucial.

- ✓ **Completeness** is the amount of data required to accurately reflect the true environmental conditions in the waterway. It is generally expressed as the percentage of the amount of valid data obtained compared to the amount of data planned.

- ✓ **Representativeness** is the extent to which data accurately reflect the conditions in the waterway. Monitoring at critical times will ensure the data is representative. Site selection and sampling techniques are also important to ensure that data is representative of the waterway.
- ✓ **Comparability** is the degree to which different methods, data sets and / or decisions agree or are similar. Sample results are comparable if they have been collected under the same conditions and analysed in the same way.

(Waterwatch Tasmania, 2001)

2.3.2 Error

Error is defined as "how far recorded measurement could be from the truth for that specific sample, either as percentage of the value (e.g. plus or minus 10%, or ± 10%) or as an increment of the value (e.g. ± 0.3 pH units), depending on the method. Error encompasses the concepts of accuracy, precision and resolution".

Data quality is related to the degree of accuracy and precision (the more accurate and precise, the higher the quality of the data).

- ✓ **Accuracy** is how close the sampling results are to the true value. Accuracy is most affected by the equipment and the procedures used.
- ✓ **Precision**, on the other hand, is how repeatable the result is. Precision can be determined by repeated analyses of the same sample at different times. Human error in sampling and analytical technique is a major cause of imprecision.
- ✓ **Resolution** is the smallest change in a parameter that the method will discern with confidence.
- ✓ **Detection Limit**, a related term, is the lowest concentration that the method will report as positive. Note that sensitivity is a term often used to describe both resolution and detection limit and can therefore be confusing.

2.3.3 Tolerable Error Range

ACT Waterwatch's monitoring goals determine the acceptable tolerable error range (TER) for each parameter monitored in the table below.

TABLE 1: Tolerable Error Ranges Of Common Parameters

Parameter	Tolerable Error Range	Comments
Dissolved Oxygen	Error of ± 1 mg/L in the ranges of 0-3 and 8-10 mg/L. Error of ± 0.4 mg/L in the range of 5-7 mg/L.	The amount of DO required varies according to species and stage of life. Values in the range of 0-4 mg/L are inadequate for most aquatic organisms and values in the range of 7-11 mg/L are generally required for normal growth and activity. The range of 5-7 mg/L is the critical zone for warm and cold water fisheries. The difference between 4 mg/L and 6 mg/L may mean life or death.
pH	Error of ± 0.5 pH units in the range 5-9.	It is generally accepted that in fresh waters a range of 5 - 9 is not acutely lethal to fish (ANZECC 1992). Below 5, most fish eggs will not hatch.
Electrical Conductivity	Error up to ± 30% of the true value	Drastic changes in conductivity, which could indicate illicit discharges to the creek, may cause osmotic stress to fish.
Turbidity	Error up to ±	Atypical dry weather values may be encountered

	50% of the true value	during the weekends (more garden, street activities in residential catchments, and more human and dog access to the creek). The main turbidity questions relevant to fisheries are: how often does the creek become turbid, and for how long?
Temperature	Error of ± 0.5 °C	Most aquatic organisms can tolerate gradual changes in temperature. However, changes of more than 2 °C in 1-24 hours can cause thermal stress. More rapid changes can cause thermal shock.

2.4 QUALITY CONTROL PROCEDURES

Quality control (QC) procedures are specific steps taken during sample collection and analysis. They provide a means of showing whether procedures and equipment produce data values that fall within the acceptable tolerable error range. QC results also allow data users to ascribe a level of confidence to the data.

2.4.1 Internal QC Checks

These are internal to Waterwatch and can be performed by members of the group. Data satisfying internal QC checks have an associated *medium level of data confidence* from the perspective of data users who are not involved in the monitoring program.

TABLE 2: Internal Quality Control Checks

Type of QC Check	Description	Expected Result
Calibration standard	A calibration standard (or calibration solution) is a solution of a known concentration or value for a particular parameter. They are used to calibrate a meter before running a test, or to periodically check the instrument for 'drift'.	The meter should read the known concentration of the standard solution.
Calibration blank	A calibration blank is deionised water, which is treated like any of the samples. It is the first sample analysed and used to set the meter to zero. Calibration blanks are also used to periodically check the measuring instrument for 'drift.' It can help pinpoint where contamination has occurred by comparing the result with the field blank.	The meter should always read "0".
Field Blank	A field blank (also known as a trip blank) is deionised water poured into the sample bottle, which is used to gather samples from the waterway, and analysed as normal. Field blanks indicate errors in technique and dirty sample collecting equipment.	Result should be "0"
Field Replicate	This is where two or more samples are taken from the same site at the same time using the same method and independently analysed in the same manner. Replicate samples are used to measure natural variability of the stream as well as the precision of sampling and analytical method.	Two samples are compared as relative percent difference. Results for three or more samples are compared using standard deviation. If a result is

		more than ± 2 standard deviations from the mean, then there is less than a 5% chance that the result is true and it should be investigated.
Mystery Samples	Mystery (unknown) samples at concentrations similar to the levels being measured in the waterway are made up by a quality control lab under the direction of the Waterwatch coordinator. The concentrations of particular parameters e.g. pH, conductivity, and phosphate, are unknown to participants who test them using normal methods. Results are reported back, discrepancies noted and problems fixed with the Waterwatch coordinator.	Compare results of sample testing and the known value as relative percent difference.
Macro-invertebrate Reference Collection	A reference collection is a standard set of macro-invertebrates that is used to verify identification. Macro-invertebrates may be preserved with alcohol in glass vials and labelled correctly and used as a reference collection.	Not Applicable

2.4.2 External Quality Control Checks

These checks are performed by an external lab ("quality control lab") or water quality officer in the field. Waterwatch data which satisfies external QC checks will have *a high level of data confidence* from the perspective of data users who are not involved in the monitoring program.

TABLE 3: External Quality Control Checks

Type of External QC Check	Description	Expected Result
External lab analysis of mystery samples	Mystery (unknown) samples which are made up for Waterwatch by a quality control lab are tested by a second lab. The concentration of these is unknown to the second lab. Sample results are reported to the quality control lab and Waterwatch coordinators. Any problems indicated by discrepancies in the results are solved. This ensures that mystery samples used by Waterwatch groups are accurate.	Compare results of two samples as relative percent difference. Results should be within the error range of field-testing equipment used by Waterwatch groups.
External field replicate	An external field replicate is where a second sample is collected at the same place and time as a Waterwatch group sample and processed by a water quality professional using calibrated equipment. It is used to determine whether the measurement falls within the tolerable error range. Field replicates are also influenced by natural variability of the waterway.	Calculate the results of two replicate samples as relative percent difference and/or compare with tolerable error range.

External duplicate samples	A duplicate sample is where one sample is divided equally into two or more sub-samples. One sub-sample is analysed by samplers and the other s analysed by an independent lab or water quality officer. Duplicate samples are used to determine whether the measurement falls within the tolerable error range. Thoroughly mix samples before dividing them or large variations in results can occur. Recycled calibration standards or actual samples that have already been tested by a lab are a useful source of duplicate samples.	Calculate the results of two or more duplicate samples as relative percent difference and / or compare with tolerable error range.
Macro-invertebrate checks	A portion of the macro-invertebrate sample identified by the Waterwatch group should be preserved. A professional biologist should identify the samples to the same classification level, e.g. order level. This may detect that one or two macro-invertebrates give consistent problems. Samplers may be considered proficient once the error rate for identification drops to less than 10% for each habitat sampled.	Compare the two sets of identifications and calculate the percentage of incorrect identifications.

2.5 EVALUATING THE SUCCESS MONITORING

By carrying out appropriate QC procedures for each parameter, ACT Waterwatch is able to gain a good idea about whether monitoring efforts are fulfilling the objectives of the monitoring plan.

Results from QC procedures can be used to:

- Identify any faulty equipment that may need servicing or replacement;
- Identify any shortfalls in the training program, related to sample collection, analysis and data management; and
- Show data users the extent to which results are reliable, as a reflection of the true state of the waterway tested.

Data from groups is only accepted for inclusion into the ACT government Integrated Nature Conservation Plan Database if it:

- ✓ ***is collected using accepted methods, as set out in the Waterwatch Australia National Technical Manual; AND***
- ✓ ***uses the QC checks described in Chapter 3; AND***
- ✓ ***falls within the tolerable error range,***

If data consistently fails to meet the above criteria, QA/QC activities will be used to identify the reasons. This will lead to a re-evaluation of those aspects of the program that are not working. For example:

- monitoring goals may need to be revised;
- changes in acceptable procedures may need to be made;
- re-training or refresher courses for participants and coordinators may be necessary;
- the suitability of monitoring sites may need to be re-evaluated, to suit the goals of the ACT Waterwatch program.

3. GUIDELINES FOR COLLECTING QUALITY DATA

This chapter describes the recommended procedures for collecting water quality data that can be assigned a medium level of data confidence. The collection of quality data requires:

- ✓ ***the use of correct sampling techniques***
- ✓ ***selection of appropriate monitoring and analytical equipment consistent and thorough maintenance of equipment procedures for measuring and documenting the quality of the data collection process (QC checks)***

Section 3.1 describes procedures to collect quality water samples. Section 3.2 provides checklists for a number of common water quality parameters. And Section 3.3 provides details for some suppliers of water quality monitoring equipment.

3.1 GUIDELINES FOR COLLECTING QUALITY WATER SAMPLES

There are a number of guidelines that should be taken into consideration when taking water quality samples. Following these guidelines will ensure that water samples are representative of the water body sampled and free from contamination. These guidelines should form an integral part of any monitoring regime, and should also be emphasised during relevant training sessions.

3.1.1 Collecting water samples

The collection and treatment of samples can have a huge effect on results. For accuracy and precision:

- ✓ sample from the exact same location, and at the same time of day, each time;
- ✓ handle, test and analyse in the same way, and
- ✓ ensure sample container and collection methods are appropriate for the characteristic tested.

3.1.2 Where to sample

Generally sample:

- ✓ in the middle of the stream, or as far away from either edge as possible;
- ✓ about 20 cm below the surface;
- ✓ in the main current; and
- ✓ upstream from where sampler is standing.

Avoid sampling surface water or stagnant water, non-flowing water near the stream edge or surface, or water near the stream bottom, unless specifically intending to examine these situations.

3.1.3 Sampling equipment

An extension (long-handled) sampling pole enables collection of water from wide or deep streams or pools. Rubber boots or waders will give access to small and shallow streams or pools. Other equipment will vary depending on the parameters being tested, and the methods used.

3.1.4 Sampling containers

For most basic water quality tests a plastic or glass bottle will suffice. The most important consideration is to make sure the container, whether new or reused, is clean. When testing most common parameters, rinsing the sample container thoroughly with the water that will be sampled is sufficient. However, in some cases extra care is necessary (e.g. when sampling for orthophosphates) - refer to section 3.1.6.

Directions for taking water samples:

1. Approach the sampling spot from downstream. Try not to disturb the bottom sediment. Collect the water sample on upstream side of the sampler.
2. Remove the cap from the sample bottle just before sampling. Do not touch the inside of the bottle or the cap as this may contaminate the sample.
3. Hold the bottle near its base and plunge it (opening downward) below the water surface. If using an extension pole, remove the cap, turn the bottle upside down and plunge it into the water. Air pressure within the bottle will stop surface scum and water entering the bottle. Hold it about 20 cm beneath the surface or, if the water is shallow, mid-way between the surface and the bottom.
4. Turn the bottle underwater into the current and away from the sampler. In a slow-moving river, push the bottle underneath the surface and away in an upstream direction.
5. Empty the bottle downstream, and then repeat steps 4 and 5.
6. Fill the bottle completely and recap the bottle carefully.
7. If transporting the bottle to a laboratory, write details of the sample on the water quality result sheet and on the bottle label. Be sure to label each sample bottle clearly and distinctively.
8. Be aware of the standard methods and times for preserving the quality of the samples collected. (See Table 4)

TABLE 4. Requirements for Preservation of Water Quality Samples

Parameter	Preservation Method	Maximum Holding Time	Comments
pH	Refrigeration	24 hours	Fill sample bottle completely to exclude air. Preferably tested in the field.
Conductivity	None Required Refrigeration	24 hours 1 month	Fill sample bottle completely to exclude air. Preferably tested in the field if samples have low EC <20 µS/cm
Turbidity	None Required	24 hours	Preferably tested in the field
Phosphate, dissolved	Filter on site and refrigerate Filter on site and freeze	24 hours 1 month	
Dissolved Oxygen	None required. Fix oxygen in the field and store in the dark	24 hours	Determine on site. Avoid excessive turbulence to sample. Fix as described in chosen method
Temperature	Not applicable	Not applicable	Must be analysed on site

3.1.5 Avoiding Contamination

- ✓ To avoid contamination and contact with possibly toxic chemicals, never use a thumb as a cap over test tubes when mixing.
- ✓ Do not empty excess reagents back into their original containers. Instead, put them into a special waste container to dispose of safely.
- ✓ Do not wet dispensing spoons or allow them to touch the inside of a test bottle or tube. Dry the spoons thoroughly if they do become wet. After a spoon has been used, tap the spoon on the rim of the test bottle or tube to dislodge any remaining particles and, if necessary, wipe the spoon with a paper towel. Immediately place the paper into the solid waste container.
- ✓ Do not allow droppers to touch the test bottles or tubes - this will contaminate the droppers.

3.1.6 Reagents.

A reagent is a substance, which, on account of the reactions it causes, is used, in chemical analysis. For accurate results, reagents need to be kept in good condition and used before their expiry date.

- ✓ Check the appearance of reagents and look for any changes such as colour, cloudiness and formation of solids. If in doubt over the condition of the reagents, test a water sample with reagents and compare results from a test carried out with another kit or with fresh reagents, or with a meter. Replace any reagents that have been degraded.
- ✓ Reagents degrade more quickly at high temperatures, so store and transport them away from heat and sunlight.
- ✓ Many reagents react with oxygen or carbon dioxide in the air so keep bottles tightly capped when not in use.
- ✓ Contamination of reagents with foreign matter or other chemicals will cause degradation. Use dedicated spoons and droppers for each reagent to avoid cross contamination.

3.2 DATA COLLECTION GUIDELINES FOR EACH PARAMETER

The following section provides detailed guidelines for selection of equipment, maintenance of equipment, calibration requirements and recommended quality control checks for some commonly tested water quality parameters. To attain a medium level of data confidence, all quality control results should fall within the designated tolerable error range chosen for each parameter (see Chapter 2).

Supplier details and prices listed in this manual were updated on June 2003. Prices are approximate, do not necessarily include GST or freight, and prices may change without notice.

TABLE 5: WATER TEMPERATURE

Recommended Equipment	✓ Water temperature can be measured with a glass thermometer or a digital meter. Thermometers filled with alcohol are preferred over those filled with mercury because they are less hazardous if broken. ✓ Meters designed for other tests such as pH or dissolved oxygen, may also measure temperature and can therefore be used instead of a thermometer.
Calibration	✓ Before first use and every 6 months, check the calibration of field thermometers against a precision thermometer that reads in 0.1 °C increments. Compare the readings at two points, 0 °C and 25 °C. ✓ Field thermometers should be repaired or discarded if they do

	not read within 1.0 °C of the precision thermometer.
Methods and Maintenance	✓ Maintain servicing and calibration records ✓ Field thermometers should be checked for defects, e.g. cracks in glass or breaks in the liquid, before each use. ✓ Place the thermometer a few centimetres into the waterway or immediately into the water sample as soon as it has been collected. Read the thermometer whilst the bulb is still in the water sample. ✓ Allow sufficient time for the thermometer to reach equilibrium temperature with the water, 2 - 3 minutes. ✓ Take the reading as close as possible to eye level. ✓ After use, rinse the thermometer with clean water, dry it, and return to its protective container.
QC Checks	✓ Inspect thermometer for breaks in the liquid filled column before each use. ✓ For large groups, test a field replicate every 10 samples. Results should fall within the designated tolerable error range.
Suggested TER	✓ Error of ± 0.5 °C
Additional QC Checks	✓ The precision thermometer should be checked against a certified thermometer or a calibrated professional every 6 months before each quality control workshop. ✓ The difference between the external and Waterwatch results should be within the designated tolerable error range.

TABLE 6: ELECTRICAL CONDUCTIVITY

Most data quality problems are related to electrode fouling, inadequate stirring of the meter in the sample, and lack of calibration.

Recommended Equipment	Electrical Conductivity Meter
Calibration	✓ Calibrate meter at 25 °C solutions before each use and every fifth sample during a testing session. ✓ Calibrate to the low range calibration standard of 1413 µS/cm ✓ Keep calibration solutions in a cool, dark place. ✓ Ensure that calibration solutions are within their expiry date ✓ Assess the temperature compensation facility of meter every 6 months by testing calibration solutions at 5°C. If outside the specified range (± 40 µS/cm) contact the Waterwatch coordinator.
Methods and Maintenance	✓ Maintain equipment servicing and calibration records ✓ During testing, move the electrode slowly in a circle for one minute until the digital read-out stabilises or continually jumps between two numbers. ✓ Wash electrodes thoroughly after each use with deionised water, then wipe dry with a tissue. ✓ To clean electrodes, periodically wipe the electrodes with a

	tissue and soak for 10 - 15 minutes in alcohol, then rinse with deionised water. It is recommended that cleaning is undertaken after every 3 to 6 sampling events. ✓ Be sure to record the units of measurement that the meter uses. Most meters will give readings in EC units (µS/cm - micro Seimens per centimetre), but some (e.g. TDScan10) will give the conductivity in ppm - parts per million. (See section 5.1.1 to convert between these two units of measurement.)
QC Checks	✓ Test a mystery sample every 6 months. Results should fall within the designated tolerable error range. ✓ For large groups, test a field replicate every 10 samples. Results should fall within the designated tolerable error range.
Suggested TER	✓ Error of up to ± 30% of the true value.
Additional QC Checks	✓ Have a duplicate sample or field replicate tested by lab to identify any problems, and periodically after that (e.g. 12 months). ✓ The difference between the external and Waterwatch results should be within the designated tolerable error range.

TABLE 7: pH

Recommended Equipment	✓ The pH meter should have a resolution of at least ± 0.2 pH units; have automatic temperature compensation and one point or two point calibration.
Calibration	✓ A pH meter should be calibrated with one or two standard buffer solutions before each set of readings and every fifth sample during a testing session. This recheck should be within ± 0.1 - 0.2 units of the true value of the pH buffer. ✓ Check that pH buffers are within their expiry range
Methods and Maintenance	✓ Maintain servicing and calibration records ✓ If using a Hanna meter, wait until the clock symbol disappears before confirming the reading. ✓ After each use, rinse the electrode well with deionised water, and replace cap when finished. ✓ To maximise electrode life and prevent the probe from drying out, place a small piece of clean cloth or sponge in the cap, moisten with tap water or pH 7 buffer solution (not deionised water), and replace cap. ✓ Clean and maintain the electrode once a month or less often if the meter is used infrequently. Carefully wipe the glass probe using a soft tissue with methylated spirits to remove greases, then rinse thoroughly with deionised water.
QC Checks	✓ Maintain calibration procedures as above. ✓ For large groups, measure a field replicate every 10 samples. ✓ Test a Waterwatch mystery sample every six months. Results should fall within the tolerable error range.
Suggested TER	✓ Error of up to ± 0.5 pH units (in the range of 5 - 9 pH units).
Additional QC Checks	✓ Have a duplicate sample or field replicate tested by lab to identify any problems, and periodically after that (e.g. 12

	months). ✓ Results should fall within the designated tolerable error range.

TABLE 8: TURBIDITY

Recommended Equipment	✓ Turbidity tube
Calibration	Not Applicable
Methods and Maintenance	✓ Regularly clean and check the tube for scratches or defects ✓ When collecting sample, ensure that bottom sediments are not disturbed, and that any surface scum is not collected. ✓ Ensure water sample is thoroughly mixed before pouring into tube. ✓ Carry out the test in the shade, preferably looking over a white surface. ✓ Make sure sampler has removed sunglasses and are wearing any prescription eyewear required to normally read. ✓ When the water level is between two numbers, record the value as less than the last number (e.g. < 30 NTU if the water level is between 30 and 20 marks). ✓ If the sampler can see the wavy lines when the water is at the top, record the result as '< 10 NTU' (i.e. 'less than 10 NTU'). ✓ Confirm the results with a second person. ✓ Note the presence of highly coloured water that will result in overstating the turbidity level. ✓ The turbidity tube tends to overestimate turbidity in samples that are highly coloured, and underestimates turbidity in samples that contain very fine particles, such as clay.
QC Checks	✓ For large groups, test a field replicate every 10 samples. Results should fall within the designated tolerable error range.
Suggested TER	✓ Error of up to ± 50% of the true value
Additional QC Checks	✓ Have a duplicate sample or field replicate tested by a professional water quality officer or lab. ✓ The difference between the external and Waterwatch results should be within the designated tolerable error range.

TABLE 9: DISSOLVED OXYGEN

Colorimeter Method

Recommended Equipment	✓ DC1600 Colorimeter, for use with the Winkler Colormetric Method.
Calibration	✓ Calibrate before each use, using an untreated water sample to set the colorimeter to 100%T, as per the manufacturer's instructions.
Methods and Maintenance	✓ Maintain service and calibration records ✓ It is important to record the water temperature, conductivity (if saline) and time of day on the results sheet to help interpret

	dissolved oxygen results. ✓ Avoid air bubbles in the sample bottle. These elevate the reading, particularly if DO is low. ✓ Ensure that test tubes used in the colorimeter are clean and free of smudges or water droplets, by wiping with a lint-free cloth. ✓ Place a cover over the test tube cell while taking colorimeter readings, to prevent light penetration. ✓ Ensure that reagents are within the expiry date and are not contaminated. Replace sodium thiosulfate every 12 months. This is the most critical reagent in the kit. ✓ Clean glassware after each test by rinsing with deionised water and drying before storage.
QC Checks	✓ For large groups, test a replicate every 10 samples. Results should fall within the designated tolerable error range. ✓ Carry out twice yearly tests on the quality of the reagents and technique by measuring the DO reading of a fully saturated sample of known temperature. The reading should be within ± 5% of the DO value. This test will reveal any deterioration of the reagents, with time. ✓ Test a saturated dissolved oxygen sample anytime a reagent has been replaced. Compare results with a calibrated DO meter or with the expected DO value.
Suggested TER	✓ Error of up to ± 1 mg/L in the ranges of 0-3 and 8-10 mg/L. ✓ Error of up to ± 0.4 mg/L in the range of 4-7 mg/L.
Additional QC Checks	✓ Have a duplicate sample tested by a professional water quality officer. ✓ The difference between external and Waterwatch results should be within the designated tolerable error range.

Titration Method

Recommended Equipment	✓ LaMotte Dissolved Oxygen Titration Kit ✓ Visocolor ECO Oxygen Kit
Calibration	✓ Not Applicable
Methods and Maintenance	✓ It is important to record the water temperature, conductivity (if saline) and time of day on the results sheet to help interpret dissolved oxygen results. ✓ Ensure that reagents are within the expiry date and are not contaminated. ✓ Replace sodium thiosulfate every 12 months. This is the most critical reagent in the kit. ✓ Ensure that air bubbles are not introduced into the sample, while collecting the sample, or when adding reagents. ✓ Clean glassware after each test by rinsing with deionised water and drying before storage.
QC Checks	✓ For large groups, test a replicate every 10 samples. Results should fall within the designated tolerable error range. ✓ Carry out twice yearly tests on the quality of reagents and technique by measuring the DO reading of a fully saturated sample of known temperature.

Suggested TER	✓ Error of up to ± 1 mg/L in the ranges of 0-3 and 8-10 mg/L. ✓ Error of up to ± 0.4 mg/L in the range of 4-7 mg/L.
Additional QC Checks	✓ Have a duplicate sample tested by a professional water quality officer. ✓ . The difference between external and Waterwatch results should be within the designated tolerable error range.

PHOSPHATE

When testing for orthophosphates, cleanliness of all sampling and analysis equipment is essential.

The following procedure will ensure the cleanliness of sampling containers and glassware:

1. Wash each bottle with a brush and phosphate-free detergent
2. Rinse 3 times with tap water
3. Rinse with 1M or 2M hydrochloric acid (HCl)
4. Rinse 3 times with deionised water
5. When clean and dry, cover the bottle opening with aluminium foil or plastic film to avoid contamination.

TABLE 10: Phosphate
Colorimeter Method

Recommended Equipment	✓ DC1600 Colorimeter ✓ Note that existing methods and equipment are unable to detect phosphate concentrations below about 0.02 mg/L.
Calibration	✓ Calibrate colorimeter before each sample is measured, as per manufacturer's instructions. Untreated sample water should be used to set the colorimeter to 100%T.
Maintenance and Methods	✓ Maintain test kit service and calibration records ✓ All containers and equipment that will hold water samples or come into contact with reagents used in this test, must be dedicated. ✓ Avoid using common kitchen detergents, dish wiping cloths, sponges, towels and other materials used for wiping around the house that may be contaminated with phosphate. ✓ Always wear plastic disposable gloves when analysing samples. ✓ Ensure that test tubes used in the colorimeter are clean and free of smudges or water droplets, by wiping with a lint-free cloth. ✓ Place a cover over the test tube cell while taking colorimeter readings, to prevent light penetration. ✓ Ensure that reagents are within their expiry date, and are not contaminated.
QC Checks	✓ Every 6 months, test a mystery solution to check accuracy and precision of the method. Results should fall within the designated tolerable error range. ✓ For large groups, test a field replicate every 10 samples. Results should fall within the designated tolerable error range that is determined by experiment for the equipment and method used.

	✓ Carry out twice yearly calibrations against a set of standard solutions to allow a check of the accuracy of the meter over the full range of concentrations normally found and to report the accuracy to data users.
Suggested TER	✓ Error of up to ± 30% of the true value.
Additional QC Checks	✓ Have a duplicate sample or field replicate tested by a lab early in the monitoring program to identify any problems and periodically after that (e.g. 12 months). ✓ The difference between the results from the lab and Waterwatch should be within the designated tolerable error range.

Colour Comparator Method

Recommended Equipment	Kits that are appropriate for the expected range of phosphate levels at the particular site. ✓ Visocolor Color Comparator Kit - Low Range (0.01 - 0.25 mg/L P) ✓ Visocolor Colour Comparator Kit - High Range (0.05 - 1.0 mg/L P)
Calibration	Not Applicable
Maintenance and Methods	✓ The temperature of the water sample should be between 18 and 30 degrees Celsius. Outside this range, the rate of the reaction decreases by finding less phosphate than actually is present. ✓ Always wear plastic disposable gloves when analysing samples. ✓ All containers and equipment that will hold water samples or come into contact with reagents used in this test, must be dedicated. ✓ Avoid using common kitchen detergents, dish wiping cloths, sponges, towels and other materials used for wiping around the house that may be contaminated with phosphate. ✓ Ensure that reagents are within their expiry date, and are not contaminated.
QC Checks	✓ Every 6 months, test a mystery solution to check accuracy and precision of the method. ✓ For large groups, test a field replicate every 10 samples ✓ Results should fall within the designated tolerable error range that is determined by experiment for the equipment and method used.
Suggested TER	✓ Error of up to ± 30% of the true value.
Additional QC Checks	✓ Have a duplicate sample or field replicate tested by a lab ✓ The difference between the results from the lab and Waterwatch should be within the designated tolerable error range.

TABLE 11: MACRO-INVERTEBRATES

The main challenge is to make sure that the sample collected is representative of the macro-invertebrate community living at the site and those animals are correctly identified at the level appropriate for the needs of the group. Some groups may require identification to family level for reporting purposes, but most will identify only to order level.

Recommended Equipment	✓ Macro-invertebrate sampling net
Calibration	✓ Not Applicable
Maintenance and Methods	✓ Nets used for the collection of macro-invertebrate samples need to be regularly checked for holes or tears, and repaired or replaced if necessary. ✓ Pick a minimum of 100 animals from the sample for identification or pick for 30 minutes, whichever comes first. ✓ Ensure that the same habitats are sampled each time in the same manner e.g. edge waters, riffles. This eliminates the possibility that variation over time at a site is due to solely to sampling different types of habitat. ✓ All equipment used for the collection, storage, sorting and analysis of macro-invertebrate samples needs to be clean and free of organic debris or leftovers from previous sampling sites.
QC Checks	✓ For large groups: divide the group into two or more sampling teams to collect replicate samples at 10% of sites to check that the method and identification skills of sampling teams are satisfactory. ✓ For each habitat sampled, at least 90% of macro-invertebrates should be identified correctly for the classification level chosen, e.g. order level.
Additional QC Checks	✓ Early on in the monitoring program, compare sample data with that collected within a few days by a professional aquatic biologist from the same site (external field replicate). ✓ Alternatively, check the identification of macro-invertebrates preserved from a sample with an aquatic biologist. ✓ Waterwatchers should aim for correct identification of 90% of macro-invertebrates for the chosen classification level (e.g. order) for each type of habitat sampled (e.g. riffle or edge).

TABLE 12: LIST OF SUPPLIERS

TABLE 6: Some Suppliers of Water Quality Monitoring Equipment

NAME	PHONE	FAX	EMAIL	MAIL	WEB
Australian Entomological Supplies	6684 7650	6684 7188	austento@nor.com.au	PO Box 250 Bangalow NSW 2479	www.entosupplies.com.au
Hanna Instruments Pty Ltd.	(03)9769 0666	(03)9769 0699	hannains@hannainst.com.au	18 Fiveways Boulevard Keysborough VIC 3173	www.hannainst.com.au
Friends of Waterwatch	-	-	friendsofwaterwatch@hotmail.com	PO Box 7087 Geelong West, VIC 3218	www.waterwatch.org.au
Westlab	1800 358 101 OR (03) 5333 2941	03-5333-4144		PO Box 1680 Ballarat VIC 3354	

4. TRAINING GUIDELINES

Good training is a vital component of a monitoring program's data confidence measures. Training will of course, need to cover the basics of how to use water quality monitoring equipment. However, training sessions also build essential relationships between participants and with Waterwatch trainers.

A successful training session will provide participants with:

- ✓ ***an understanding of the objectives of the Act Waterwatch monitoring program;***
- ✓ ***a sense of personal responsibility for the reliability and usefulness of data they generate;***
- ✓ ***a sense of ownership in an important process; and***
- ✓ ***quality social opportunities.***

This section is aimed at providing Waterwatch trainers and coordinators with some ideas and guidelines for planning, organising and implementing the training component of their monitoring and data confidence program.

Seven components in planning effective training and follow up have been identified:

- ✓ **Understanding the learners**
- ✓ **Defining training program goals**
- ✓ **Planning training program**
- ✓ **Coordinating all the details of the training program**
- ✓ **Evaluating he training program**
- ✓ **Following up after the training program to maintain motivation**
- ✓ **Maintaining a training log**

4.1 LEARNERS

Identify the demographic of the participants that will be trained, and tailoring the program to cater for their specific needs. Four components are key for working with adult learners such as Waterwatch volunteers.

- ✓ **Control over their learning.**
  - Allow participants to help define the objectives and agenda for training sessions
  - Make sure that all participants are aware of what to expect from the session.
  - Keep focus on practical and hands-on
- ✓ **Collaborative, respectful and informal environment to learn in.**
  - Provide opportunities for participants to perform monitoring
  - Allow time for participants to reflect on learning by asking and answering questions.
  - Encourage more experienced members to assist newer participants
- ✓ **Provide for variety of learning styles to assist people with a range of abilities.**
  - Enhance lectures and presentations with visual aids
  - Introduce content through discussion or problem-solving activities
  - Explore issues through small group discussion
  - Assign practical hands-on activities
  - Provide first-hand experience
- ✓ **A clear link between knowledge and how they will be applying it.**
  - Discuss how uses of new knowledge
  - Developing an action plans for using data

4.2 TRAINING OBJECTIVESPLANNING

When preparing for a training session, prepare a clear brief statement describing:
- ✓ what the participant should be able to do;
- ✓ the standard or quality required; and
- ✓ the circumstances in which the learner will perform.

Often training programs are interested in teaching more than just skills. Goals may include participants to be able to trouble-shoot equipment problems, assessment of habitat components, analyse results and develop a sense of stewardship towards their waterway..

4.3 PLANNING

For each training session, carefully plan exactly what will be done within the time allocated. These should include

- ✓ **Introduction of material to be learned**
- ✓ **Demonstration of material**
- ✓ **Participant shows-and-tell response to check for understanding**
- ✓ **Practice and Troubleshooting**
- ✓ **Conclusion with review and final questions**

4.4 ORGANIZATION

The following list provides a reminder of things to check to conduct the training.

Before the training	✓ Inform participants of the time, place, directions and duration of the training. ✓ Tell them what to bring (pen, paper, lunch), how to dress, what to do in case of rain. ✓ Provide contact details. ✓ Outline the training content and provide pre-training readings. ✓ Arrange guest speakers. ✓ Prepare materials, e.g. sampling kits, manuals, data sheets, overheads, food, hand-outs.
During the training	✓ Arrive early to set up and prepare. Participants will often arrive early, and need to be greeted. ✓ Try to have a key person in the organisation open the program. ✓ Cover basic housekeeping matters. ✓ Ask participants to jot down personal objectives for the training and for participation in the program. Take time to listen to these and, adapt the training plan to achieve the participants' objectives.
Guest speakers	✓ Just before the training day, make sure they are still available. ✓ Personally introduce them.
Closing training	✓ Review objectives and ask participants if those objectives have been met. ✓ Briefly review each major session held during the day. ✓ Ask participants to complete an evaluation form and thank participants for their attendance and interest.
After the training	✓ Clean up the training room and return materials. ✓ Store all hand-outs and materials. Retain a master copy. ✓ Pay bills and write thank-you letters. ✓ Note and file suggestions for improvement.

4.5 EVALUATE THE TRAINING PROGRAM

Evaluation of participants' progress during training is essential. Coordinators need to be able to verify that Waterwatchers can collect data to a standard required by the program.

At the end of every training session encourage participants to fill out a training evaluation form. Good trainers are always revising and improving their training sessions in response to feedback during the session and from written comments. This is a vital step in the *observe-plan-act-reflect* cycle of continuous improvement.

The trainer cannot assume that information learned at the end of a training session will be retained by the participants for a long time. Most of our members are busy with other activities and may forget or become confused about information presented at the training. Quality assurance plans should provide for regular evaluation and retraining of participants. These sessions are often conducted one-on-one in the field at the monitor's sampling site.

Evaluation of training should be part of the annual evaluation of the whole Waterwatch program.

4.6 FOLLOW UP TO MAINTAIN MOTIVATION

Success of the program is highly dependent on maintaining motivation of participants. Here are some ideas of how to successfully follow-up the training:

- ✓ Send regular newsletters informing participants about their data and how it is being used;
- ✓ Be available to answer questions and requests;
- ✓ Provide opportunities to learn more advanced techniques and take up more demanding responsibilities;
- ✓ Recognise participants' efforts e.g. through awards;
- ✓ Keep the local media abreast of the goals and group findings, if appropriate;
- ✓ Support group members in the field;
- ✓ Keep participants up to date with new information.

4.7 MAINTAIN A TRAINING LOG

Training records for each group should be kept regularly updated to assess a monitoring group's progress and future training needs. The training log is an easy reference system for monitoring group requirements and demonstrates professional development. Appendix 2.3 provides a template for this. Advanced training or refresher training needed by the group depends on success in mastering competencies.

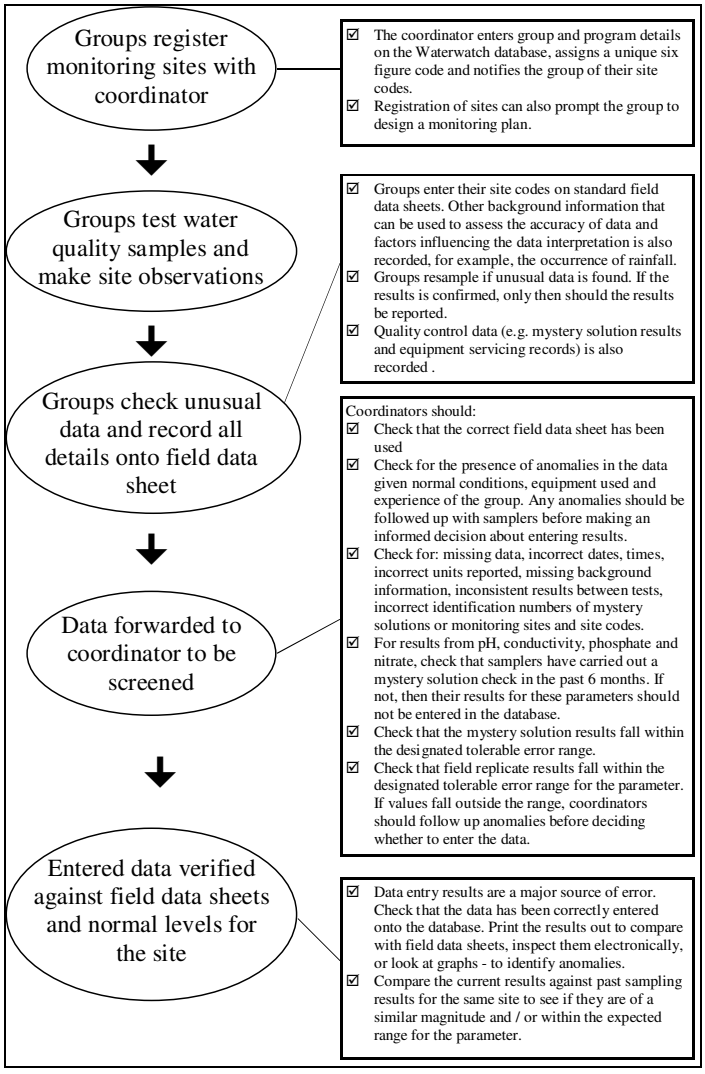
5. DATA MANAGEMENT GUIDELINES

The Waterwatch data is recorded, managed and stored is also an important part of data confidence plan. Errors can occur at any point in the chain from measuring the sample to recording the result on the field data sheet and finally, entering the data on the database. A clear system for data management and interpretation, and a series of guidelines for data validation will ensure that errors are minimised.

Only results which meet the group's data confidence standards (i.e. minimum quality control checks) should be added to the data set. It is better to rely on quality controlled data for interpretation of results, and to use other data for support only.

This section explains some of the common errors that are encountered when recording, managing and interpreting data, and how to incorporate quality control strategies that will minimise these errors. Figure 2 provides an example of a data validation system, with a checklist of things to keep in mind.

FIGURE 2. Quality Control Checks in a Data Validation System



5.1 GUIDELINES FOR DATA MANAGEMENT

5.1.1 Collecting And Recording Data On Site

- ✓ Waterwatch samplers should know how to check their own data before sending it to the regional coordinator. For example, samplers should know, 'what are reasonable values?', 'does the data look correct?' If the results are unusual, the test should be repeated for confirmation. Confirmed results can then be entered on the field sheet and a copy forward to the Waterwatch coordinator.
- ✓ Data that indicates a pollution event should be immediately reported to the local government body.
- ✓ Many errors are made in transcribing data from meters to record sheets. Group members should verify the recorded result from the meter.
- ✓ Unusual data can be true of the conditions at the site and should be explained by recording supporting observations in the comments section of the field data sheets, and / or with photographs.
- ✓ When reporting phosphate results, it is usually best to use 'mg P/L' as the units. If using the titration method, the result is already given in the correct units. However, if using the colorimeter method, the value provided by using the conversion table provided by the manufacturers will need to be multiplied by 0.326, in order to give mg P/L.
- ✓ Waterwatch samplers who take electrical conductivity measurements should be careful to note the units that their measurements are taken in (i.e. µS/cm or ppm). These units can be easily converted to each other, as shown below:

if meter gives result in **µS/cm**	→	**multiply by 0.64**	→	**gives ppm**
if meter gives result in **ppm**	→	**divide by 0.64**	→	**gives µS/cm**

5.1.2 Errors in Data Sheets

Regional coordinators are to check field data sheets sent in by groups for errors and follow up on anomalities before they are entered. Some things to look for include:

- ✓ Are the results similar to past data from the site or, if not, are they still possible?
- ✓ Does the sampler provide an explanation to validate unusual results? (For example, "Dead fish were seen near the site when we measured the low dissolved oxygen levels.")
- ✓ Is there consistency between tests?
- ✓ Is the decimal point in the right place? Look for values that are 10 or 100 times larger or smaller than expected.
- ✓ Look for zeros. The sampler should report low results as less than the detection limit, rather than as zero.
- ✓ Can the test kit used by the group produce the results reported?
- ✓ Is the difference between the mystery sample and reported value acceptable?

5.1.3 Errors in Entering the Data

Data that have been entered on a computerised database acquire an authority that is rarely challenged. Although the prompts on the Waterwatch database provide some safeguards against data entry errors it is vital to check for keyboard mistakes by comparing the original field data sheets with the computer printout. A second check will be done of the field data sheets against the corrected computer printout.

5.1.4 Documentation

Having purposeful monitoring projects implies that the data is to be used. Whether the user is the group who collected the data or some other party, it is important the end users be able to

check the accuracy of the data by referring to any step of the data collection process. To this end, accurate records of all stages of a monitoring project and all QC checks should be carefully documented. Documentation is part of the data confidence planning of the project.

Records ensure that data results are traceable and errors in equipment can be detected and addressed early on. The following checklist shows what records should be kept for regional programs and monitoring groups:

- ✓ Monitoring Plan - The details of the monitoring plan need to be documented and readily available to all group members and data users.
- ✓ Data Confidence Plan - The details of all required QC checks for each parameter, and all QA guidelines need to be documented and readily available to all group members and data users.
- ✓ Instructions for sampling and measuring techniques - Participants will need clear and specific instruction sheets for:
    - collecting water samples
    - measuring each parameter
- ✓ Other Documentation. Templates for these are included in Appendix 1.
    - Equipment calibration records
    - Equipment servicing records
    - Field Data Sheets
    - Training Log