# NORTHERN TERRITORY



# Australian River Assessment Scheme

# Sampling and Processing Manual



Jane Lloyd and Samantha Cook

**Natural Resources Division**
**Department of Lands, Planning and Environment**

Further information concerning this document can be obtained in the first instance from:

Peter Dostine
Resource Management Branch
Natural Resources Division
Department of Lands, Planning and Environment
PO BOX 30
PALMERSTON  NT  0831

Phone: (08) 89 994406
Fax:     (08) 89 994403

Information on the AUSRIVAS program, including predictive models, can be attained from the following website:
http://www.ausrivas.canberra.edu.au/

# ACKNOWLEDGMENTS

Cover Photograph: Helimuster Dreaming, Victoria River Downs, mid-dry season 1996

# TABLE OF CONTENTS

# INTRODUCTION

Rivers and streams in Australia are accessed and used by people for a variety of activities, ranging from extraction of drinking and irrigation water, industrial uses, stock watering to recreational pursuits. Recently, concern about the degradation of rivers and streams has prompted the introduction of various systems to assess river health. River health is difficult to define, but can be considered in terms of the degree of similarity between a river and unimpacted rivers of a similar type. Levels of impact on a river can therefore be determined by a comparison of the water quality, biological and physical characteristics of impacted rivers and also of rivers in pristine or untouched condition.

Traditional methods for assessment of riverine conditions have largely relied on sampling and monitoring of physico-chemical parameters (such as pH), which didn't necessarily provide an easily interpretable picture of the biological condition of the waterbody. More recently, an integrated approach has been implemented, whereby characteristics of a waterbody and surrounds, such as depth, width, degree of erosion on banks; flow characteristics; available habitats and their condition; water quality and also biological characteristics are measured and assessed. Impacts and stresses on a river system may arise from a number of different sources, for example through riparian vegetation clearing, changes in water quality through pollution inflow and stock access changing bank characteristics.

An impact on a river system may affect not only the physical characteristics and/or water quality of a river, but also the habitats and environment of the many different organisms making up the fauna and flora associated with that river. Each of these biological groups will respond in different ways to stresses in their environment. To assess the condition of Australian waterways, macroinvertebrates (water bugs) were adopted as biological indicators of water quality.

Macroinvertebrates (animals without backbones) live, for at least some part of their life history, in the aquatic system and are usually large enough to be seen with the naked eye. This group includes dragonflies, caddisflies, biting flies (eg. midges), mites, snails, mussels, prawns and crayfish. Macroinvertebrates were chosen because of their abundance and diversity nationally, their sensitivity to changes in water quality, and relatively good taxonomic knowledge. They are also limited in their ability to move from an area of river that is being adversely impacted, and will recolonise quite slowly after pulse pollution events. These animals have been utilised worldwide as good indicators of river and stream health and are increasingly used for rapid bioassessment.

The Monitoring River Health Initiative (MRHI) was developed in Australia as part of the National River Health Program (NRHP). One of the aims of the MRHI was to develop an ability to assess the biological condition of surface rivers and streams in Australia, based on the British model RIVPACS (River Invertebrate Prediction and Classification Scheme). The MRHI has resulted in the construction of a database containing biological and chemical information collected from reference sites - sites that are 'least impacted' by human activities - over a two year period in all states and territories. Outputs from the MRHI program have included the development of a nationally standardised methodology for biological sampling; standard taxonomic identification with quality assurance/quality control protocols and a replicable process to collect comparable data.

AUSRIVAS (Australian River Assessment Scheme) represents an integrated approach to river assessment combining all facets of the MRHI program and including the generation of mathematical predictive models for individual site assessment. These models enable prediction of macroinvertebrate taxa expected to occur at a site, (in absence of any stress

impacting that site), and therefore a comparison between actual collected taxa (observed taxa) with predicted taxa can be made. This allows the site to be categorised relative to reference condition.

This manual describes the methodology used by the Northern Territory (NT) for bioassessment of rivers and streams in the NT, adopted from standard protocols outlined in the River Bioassessment Manual (Davies, 1994). This approach was used for the NT MRHI/AUSRIVAS programs, and consequent model formulation. The manual is intended as a working guide for groups or individuals wishing to follow the standardised protocol and to collect data that is able to be compared with reference data collected by the MRHI program.

The predictive models are formed from physical, biological and chemistry data collected from surface waters (freshwater). It should be stressed that the sampling and processing protocols specified in this document are not to be used for the bioassessment of wetland, saltwater or estuarine systems.

# SAMPLING PROGRAM

## Site Selection

Selection of reference and test sites in the Northern Territory follows the protocols outlined in the River Bioassessment Manual (Davies, 1994).

In the NT two additional considerations had an important bearing on site selection:
- availability of permanent pools in long dry stretches of ephemeral creeks and rivers,
- accessibility to these remote waterholes.

## Sampling Period

The climate in the "Top End" of the NT is characterised by two distinct seasons; the wet (November-April) and the dry (May-October). The monsoonal weather patterns (producing deluges of rain) experienced during the wet season make field sampling impractical and potentially unsafe. Additionally, sampling sites are generally inaccessible during this season.

In consequence, the sampling program for the NT MRHI was conducted over two sampling events during each year. The first sampling event occurred in the early stages of the dry season and the second during the late dry season.

Sampling should not be carried out if the river/stream is discoloured from recent rain events. Discolouration may occur from localised storms with resultant run-off events and high flows potentially leading to changes in the macroinvertebrate community, due to animals being washed downstream. Attempts to sample such sites should be postponed for at least four weeks, or until the water flow has stabilised and the macroinvertebrate community has recolonised.

## Habitats Sampled

At the outset of the MRHI, five potential riverine habitats were defined for biological sampling. These were the edge, sand bed, macrophyte (water plants) bed, rock/gravel bed, and the riffle area.

Predictive models have been developed for both the edge and sand bed habitats in Top End waterways, as these were the two dominant habitats sampled during 1995-96. Macrophyte, riffle and rock/gravel beds were not modelled as these habitats are less common than edge and sand bed habitats.

Once a site is selected, suitable areas of edge and sand habitat are identified. A sampling area from each habitat is selected which is representative of the reach (100m in length around the water collection point).

A primary consideration for habitat selection is personal safety. Assume all rivers are potentially inhabited by saltwater crocodiles and avoid steep and/or slippery banks beside rivers. Also consider accessibility to habitats after changes in water levels for future sampling events. Avoid attempts to access habitats by wading or crossing submerged rocks and sandbars.

Edge habitat

A sampling locality for this habitat was chosen where the edge was as close to vertical as possible. The edge should ideally contain abundant root material, and is usually associated with a pool (varying from 0.3m to several metres in depth). Ideally, this habitat should be selected from areas where adjacent water velocity is minimal.

Areas to avoid when sampling edge habitats are pandanus roots and large undercut banks, both of which are difficult to sample effectively. Macrophytes growing within 0.5m from the edge provide an additional and separate habitat for macroinvertebrates, and edge habitats with macrophytes within this range should not be sampled.



Edge Habitat

<u>Sand habitat</u>
Sand beds containing a covering of thick detritus (organic matter, eg. leaves) and/or algae are avoided. Areas of high flow should be avoided, due to rapid turnover of the available habitat and removal of macroinvertebrate assemblages. Caution should be exercised when sampling this habitat in rivers and streams inhabited by saltwater crocodiles, and sites where the bed is located close to a steep drop-off should be avoided.



Sand Habitat

# FIELD TRIP PREPARATION

When preparing for a field trip, several considerations need to be made.

Ensure that sufficient safety equipment is packed and always carry navigation equipment, together with the site access instructions.  Always take a first aid kit along.  Include adequate clothing for climatic conditions experienced in the Top End, and don't forget to slip, slop, slap!  Most importantly, take plenty of drinking water (2-5L per person per day).

*Permits*

Be aware of Aboriginal sacred sites and interests in the region of the trip, and be sure to attain proper authority for entry to Aboriginal lands.

Similarly, sites may be located on pastoral/agricultural leases and arrangements should be made with station managers for access to the property, as required.

If intending to sample in national parks, permission should be obtained from the park managers.

*Equipment*

Water Quality Sampling
Bottles used for laboratory analysis of water samples must be prepared with particular care, depending on the analysis required.  Appendix 1 details the preparation required for each parameter sampled by the NT MRHI.

*In situ* water physico-chemical variables are measured using a multi-parameter probe, such as an Horiba U10 Water Quality Checker (Horiba Pty Ltd, Kiyoto).  All multi-probe devices require calibration before using in the field.  Refer to the manufacture's instructions, and calibrate for the range of conditions expected in the waterbodies where sites are located.

Biological Sampling Equipment
Equipment used by the NT MRHI is listed in Appendix 2.

*Field sheets*

Complete information on the field sheets for the following categories, for each site being assessed on the field trip, prior to departure.  Field data sheets are included in Appendix 3.

- Basin
- River
- Tributary
- Site Name
- Site Code
- Maps and Map Datum
- Altitude (m): contours from 1:250 000 topographic maps
- Distance From Source (km): calculated using CAD mapping programs

# SITE ASSESSMENT AND SAMPLE COLLECTION

Historically, the NT MRHI selected a site along a river or stream because it contained two or more of the afore mentioned habitats within a defined 100m reach. As predictive models were generated for two habitats only, an attempt should be made to select a site with both habitats. This may involve some exploration along the river/stream before final site selection.

## Water Quality Sampling

To minimise impact on water quality, water samples and basic water measurements are collected before disturbing sediments during biological sample collection.

### Water sample collection

Water samples are collected from the edge of the waterway for safety reasons, and preferably in flowing water. In still or very slow-flowing waters, move the surface scum away from the collection bottle. When sampling along the edge of the waterbody, select a spot that is representative of the reach, and ensure that sediments are not disturbed when sampling to prevent contamination. If the area has been disturbed, sample upstream instead.

- Label the water sample bottles with the date and site code, using a permanent, waterproof marker.
- Face the bottle mouth upstream and submerge the bottle to partially fill. Cap, shake vigorously and empty. Rinse the water bottle at least three times in this manner, ensuring the lid is rinsed. Take care not to touch the insides of the bottle or lid.
- Fully submerge the bottle (to a depth of about 10cm) and fill.
- When filling the small nutrient and general chemistry bottles, ensure no air is left inside the bottle. On capping gently squeeze the bottle so that the water is level with the top of the bottle and cap. Leave a small air gap in the large nutrient bottle to allow for shaking before laboratory processing.
- Store samples on ice.

Details of the analyses performed for each sample are displayed in Appendix 1.

### *In situ* WQ sampling

Place an Horiba, or similar multi-parameter water quality device in flowing water, if possible. To prevent disturbance of the sediment, do not stand upstream of the device. The oxygen probe consumes oxygen whilst in use, therefore, when assessing dissolved oxygen ensure that the probe is moved gently to maintain a continual supply of oxygenated water over the probe.

Record the following water quality parameters after allowing sufficient time for probe equilibration (usually several minutes):

| | |
|---|---|
| Water Temperature | $^\circ$C |
| Conductivity | ✦S/cm |
| pH | pH units |
| Dissolved Oxygen | mg/L |
| Turbidity | NTU |

## Biological Sampling

In Australia all macroinvertebrate sampling for the AUSRIVAS program is conducted using a long-handled 250µm mesh net. Generally the net opening is a triangular frame, 350mm wide at the base. A single operator uses this net to 'sweep' the separate habitats for a distance of 10 metres to collect macroinvertebrates.

Two types of sampling methods have been employed for AUSRIVAS, live picking and laboratory sorting. Live picking is conducted for a set time on site, with a percentage of the residues preserved and resorted in the laboratory for quality control. The protocol for live picking is included in Davies (1994). Laboratory sorting requires the entire sample to be preserved in the field and then sorted in the laboratory upon return. In the NT, laboratory sorting has been adopted as the preferred technique for a number of reasons, not least the extreme environmental conditions experienced in the field. Additionally, the travelling time required to access sites and the time spent at each site were important considerations.

Sampling for macroinvertebrates in the NT is undertaken using the above-described net, and a 3-pronged cultivator rake for disturbing the sediment. Two operators are required for this procedure, which also increases safety in crocodile inhabited waters.



Net and 3-pronged cultivator rake used in biological sampling

Macroinvertebrate sampling equipment

## Habitat sampling

Edge

The cultivator rake is used to agitate submerged root matter, using an upward scratching motion, to a water depth of 30cm from the surface. The net is swept back and forth through the water column attempting to collect all dislodged material. The net operator should stand downstream of the rake operator in flowing water.

In still waters the net is kept mobile to ensure a water current is generated through the net and the collected macroinvertebrates do not swim out. Both operators move upstream for a distance of 10 metres. Separate lengths of edge habitat may be sampled if a continuous 10 metres is not available.

Note the length of edge sampled, and also the sampling depth on the field sheets.

Sand

Sampling this habitat generally requires that both operators stand in the water. It is therefore recommended, for safety reasons, that both operators face the direction of the pool.

The cultivator rake is used to disturb the sediment, by 'scratching' the surface of the bed, to the depth of the rake tines (about 5-10cm). Again, the width of area agitated should be 30cm. The net operator employs a 'figure of eight' sweeping motion, and attempts to collect the dislodged material. The net operator should endeavour to keep the net continually sweeping the habitat surface, without collecting large amounts of sediment.

Both operators move upstream for a distance of 10 metres. Separate lengths of the habitat may be sampled if a continuous 10 metres is not present.

Note the length of the sand bed sampled, and the average sampling depth on the field sheets.

## Sample preparation for storing

Set a 10mm mesh sieve on top of a 250μm mesh sieve, making sure they are firmly attached. Label a widemouth screwtop jar using an alcohol and waterproof permanent marker pen (paintmarker) with the following:

- Site code
- Date
- Habitat
- No. of containers – eg 1/1, 1/3.

Empty the net contents into a bucket of water. Wash the net thoroughly in another bucket of water, to remove any remaining macroinvertebrates. Separate the organic fraction from the inorganic sediments by stirring the bucket contents and pouring the mixture from the bucket into the nested sieves. Take care not to tip too much of the sediment (eg. sand) into the sieves.

The coarse sieve will catch the large detrital material and the remainder is caught on the 250μm sieve below. Continue washing organic material from the bucket using clean water in the manner described above, until no further material is separated from the sediments. Check the sediments for molluscs before discarding. Inspect the contents of the coarse sieve for large macroinvertebrates before discarding. Place any macroinvertebrates into the labelled jar.

If there are large quantities of detritus, a mesh chip-basket can be employed to check for macroinvertebrates. Place a small portion of the detritus in the chip bucket and shake thoroughly to dislodge macroinvertebrates from the leaves and twigs in a separate bucket with clean water. Empty the chip-bucket contents into a plastic sorting tray, and inspect leaves and twigs for macroinvertebrates before rinsing and discarding. Put all macroinvertebrates in the labelled jar(s).

All material from the 250μm sieve is rinsed with a small amount of water into the labelled widemouth jar. Add 90% alcohol to a volume of at least twice that of the organic material, cap and invert to mix thoroughly.

Before sampling the next habitat, wash the net and two sieves carefully to avoid cross-contamination.

Note the number of jars used for each habitat for the site in the field sheets.

## Macroinvertebrate habitat information

Visual estimates about the physical attributes of each habitat are recorded to characterise the sampling areas. Information about the stream substratum assists site assessment, as the substratum is essential for providing habitat for macroinvertebrates. The following information is required for each habitat, from the 10m sampling area:

- Fine organics - Percent cover of fine organics in the habitat sampled
- Coarse organics - Percent cover of sticks, wood, leaves along the habitat sampled
  (The addition of fine and coarse organics may not necessarily total 100%)

- Substrate composition - Record individual percentages of each category, as it is represented in the habitat substratum. The combination of percentages for each category in the substrate must total 100%.

- Percentage coverage - note the percent of each habitat covered by:
  Algae (microfloral growth on river substratum)
  Macrophytes
  Overhanging vegetation
  Trailing root vegetation

- Habitat description - note which category best describes the habitat sampled. More than one category can be chosen to describe the sand habitat.

*Habitat depths and water velocities*

A Pygmy Fan Set (Hydrological Services Pty Ltd, Sydney) and electronic counter are used to measure habitat flow and depths. Record the flow meter serial number and fan details on the field sheets for future velocity calculations.

Three replicate measurements of flow and depth are taken from the sampled habitats. Cover the full range of depths and velocities within the habitat.

The flow-meter propeller should be positioned as close to the substrate as possible, without contacting the substrate. For the edge, it should be held suspended within the top 30cm of water, as close to the bank as possible.

Record the number of fan revolutions during a known time interval (eg. 40 seconds) and also note the depth of water at that point.

## Site Assessment and Observations

If intending to use the NT AUSRIVAS predictive models, it is essential that ALL predictor variables be completed for each site, for each sampled habitat. When choosing predictor variables, it is important to select parameters that are not affected by human activity, for example distance from source and altitude. Variables such as turbidity and phosphorous concentrations can be affected by human activity (eg. through riparian vegetation clearing) and should therefore not be used as predictor variables. Appendix 4 lists the predictor variables used in the NT predictive models, by habitat.

Unless otherwise specified, all assessment and observations conducted for the following variables are based on the area of river around the selected site. The area (reach) assessed is 100m in length, 50m both upstream and downstream of the water collection point. A 'plan view' is the view achieved if one were looking from above onto the landscape below (ie. a bird's eye view).

Record information for the following variables:

Date
Time
Site Code
Site Name
Field team
WQ Equipment Used     note the instrument type & serial number used to measure water quality
GPS                record the coordinates for the site using a GPS, also noting the map datum
Air Temp ($^{o}$C)         hang a calibrated thermometer in shade & record temp. after equilibration

## Physical Characteristics

*Channel transects*

Measure the stream width from water edge to water edge. Take three measurements of stream width along the 100m reach.

Measure the depths of the water along these three stream width transects. Record the depth at approximately ¼, ½ and ¾ of the way along each transect, facing downstream and measuring from left bank to right bank.

Estimates are acceptable where measurements cannot be made. Ensure the technique used is noted on the field sheets.

*Habitats within 100m reach*

Estimate the percentage cover in the reach of the different habitats in plan view. The combined percent coverage for the habitats must total 100%. For this purpose, each habitat is described below:

Sand/Silt Bed: percent cover of visible sand or silt substrate.

Gravel/Rock Bed: percent cover of visible gravel or rock substrate.

Riffle: riffle habitat is one of flowing broken water over tree roots, sand, gravel, pebble, cobble or boulder.

Macrophytes: percent cover emergent and submerged rooted plants.

Edge/Pool/Unknown substrate: percent of reach where there is good edge habitat and/or a pool with slow flowing or still waters where the substrate is unknown.

Snags: percent cover of large wood debris and logs within the stream channel.

*River characteristics*

Width between top of levee banks (bankfull width): measure or estimate the distance from the top of one levee bank to the top of the other. Note that the top of the bank is where over bank flow occurs.

Width between immediate stream banks: record if different from the measurement taken above.

Height of levee bank from water surface (bank height): measure or estimate the height of the bank from the water surface level to the top of the levee bank.

River characteristics
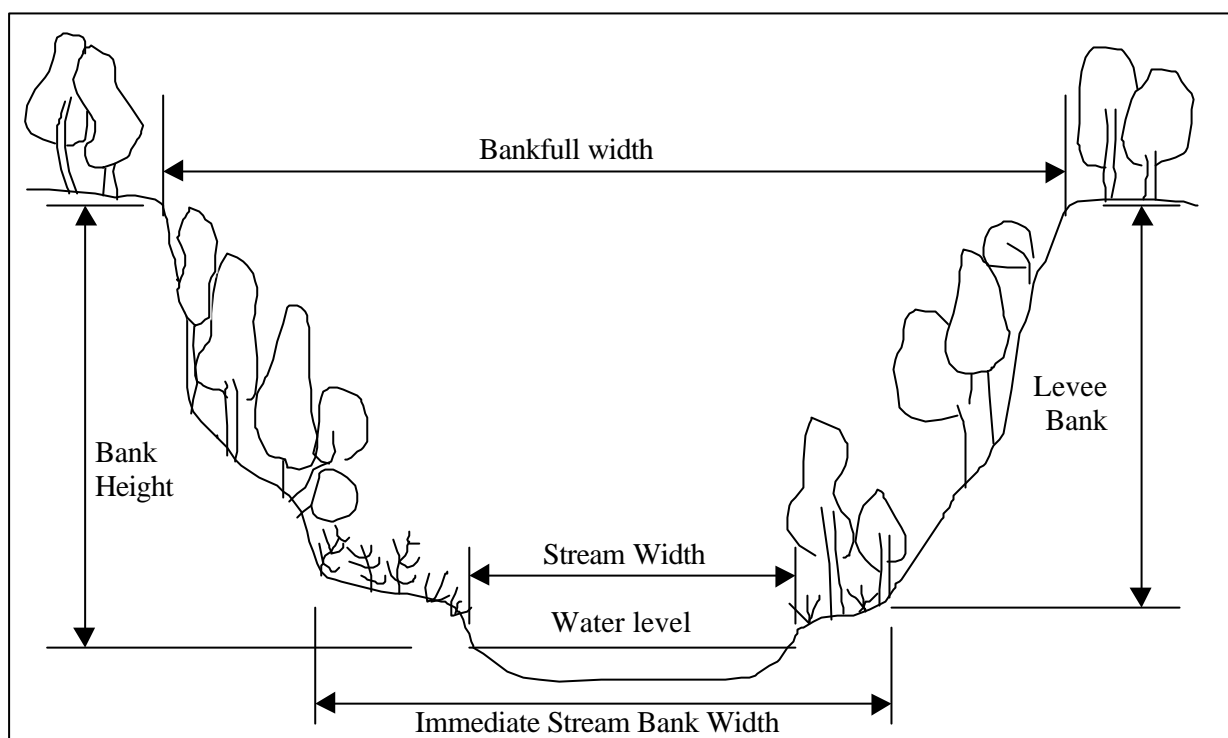


*Flow Level*

The flow level is estimated relative to the 'usual' water level during the dry season. A 'water mark' evident from the extent of terrestrial grasses, eroded areas or boundary/line in bank sediment may assist determination. Indicate the water level, relative to any watermarks, and also note whether there is any flow.

# Riparian vegetation

The riparian zone is the area from the water edge to a distance from the bank where the stream interacts with and influences the type and density of bankside vegetation. The following observations are taken within the reach being investigated.

Width of riparian zone: measure or estimate the width of the riparian zone in metres (facing downstream) for both the left and right banks. It is preferable to measure distances at a number of sites until estimates can be made with accuracy.

Vegetation cover of river: select a category which best describes the percentage shading of the river/stream by riparian vegetation. Estimate as at mid-day, in plan view of the reach.

Percent cover of riparian zone: estimate the percentage cover of the riparian zone for each vegetation type from a plan view. Combine both the left and right banks (to view as a whole) for these estimates. The categories for shrubs/vines and grasses/ferns/sedges may each total 100% and therefore the sum total of all categories may be greater than 100%.

To assist in these estimates a Specht chart may be used.  Record the species of vegetation present in each category if possible.

Percent Native and Exotic Vegetation: total percent of native and percent of exotic vegetation should not exceed 100%.  List weed types if possible.

*Erosion in the riparian zone*

Assess each bank individually (facing downstream), noting presence or absence of erosion on the field sheets.  Examine the riparian zone contained within the reach for erosion in the following categories:

Bare ground above water mark: bare ground includes eroded areas or those not supporting vegetation, due to some disturbance, that would otherwise be expected to be vegetated.

Tree roots exposed: note whether tree roots are exposed due to disturbance.

Gully erosion: record any visible gully erosion adjacent to the river.

Slumping banks: note any evidence of slumping banks adjacent to the river.

Excessive fallen trees/wood debris: record whether trees are being uprooted.  Also note whether unusual amounts of wood debris have accumulated at the site.

Local catchment erosion: note the erosion in the surrounding catchment on the approach to the site.

*Land Use*

Record the type of landuse, for both banks, in the area surrounding the site.  More than one category may be applicable for the site.

## Additional Observations

Additional observations indicating the general condition of the site are recorded on the field sheets.  These are intended to capture extra details that may aid in assessment of the site.

Water Clarity: record the clarity of the water by estimating the depth at which visibility is still possible.

Water Odour: note whether any unusual water odours are present at the site.

Water Oils: select a category that best describes the form of oils on the surface of the water at the site (if present).  Record, if possible, the type of oils present.  If selecting '5 – Other', then describe the appearance of the oil(s).

Foam/Scum: organic material often forms a "scum" on the water's surface.  Record the content of the surface water scum.  If selecting '5 – Other', then describe the contents.

Plume: a 'plume' is created by fine sediment being suspended in the water column on disturbance.  For example, a plume may be created from sediment disturbance during biological sampling.  Record the category best describing the extent of plume.

Sediment Oils: record if any oils are visible on the sediments by examining a handful of the streambed sediment.

Sediment Odours: note the smell of the sediments as they are disturbed during biological sampling. Hydrogen sulphide (rotten egg gas) is an odour commonly encountered in de-oxygenated sediments.

Fish: note the presence or absence of fish and record the species present.

Birds: record any birds observed or heard at the site.

Other Wildlife: record any sightings of other wildlife or evidence of their visits to the site. For example, pig diggings, crocodile slides, other evidence of pastoral or feral animals.

Fire: note on approach to the site evidence of any recent fires in the riparian zone, and/or beyond the levee banks.

Evidence of Human Impact: detail all evidence of human visitation or construction at the site, for example roads, culverts, abandoned camps, boat access, litter.

*Site sketches and photos*

Sketch of 100m reach
Draw, in plan view, the stream channel and any notable features at the site. Include the location of water measurements, habitat sampling, river transect measurements and the point through which the cross-sectional sketch is drawn.

Sketch of channel cross-section
Draw, in plan view, a cross-section through the river and banks to indicate the shape of the channel heights and depths. Give a rough indication of the vegetation heights through the cross section.

Photographs
Take several colour photos at each site sampled. Standard photos are views upstream, downstream views, all habitats and any peculiarities for example algal blooms or excessive bank erosion. Photographs also aid location of the site for subsequent sampling and later data interpretation.

*General site information*

Sketch of Access Route
This sketch is essential for locating the site on subsequent visits, particularly where no previous track to the site existed. Include all information that will assist in locating the site, for example signage to the site, distances from bituminised roads, creek crossings.

Site Description
Record any information obtained from locals about possible environmental impacts at the site and the historical and/or current landuse. Note the contact details of the landholder including all requirements for access to the site.

On approach to the site, note the degree of disturbance and current impacts on the surrounding area.

*Habitat assessment (based on USEPA criteria)*

The set of habitat variables that constitute this portion of the 100m reach habitat assessment were not originally included in the MRHI program, but have been adopted nationally, and are therefore included in the assessment of each site. These variables are not currently included in the NT predictive models.

The variables in this field sheet quantify various aspects of the site and assess the quality of the habitat available for macroinvertebrates. Observations are taken from the entire reach, combining left and right banks, to view as a whole.

For each habitat variable, select a category corresponding to its condition and select a score within that category. In each category, the higher the score is, the better the condition of habitat within that category.

The field sheets for this portion of the habitat assessment are also contained in Appendix 3.

Bottom substratum/available cover: assess the amount of substratum available as macroinvertebrate habitat for example pebble, gravel, cobble, boulder, logs, undercut banks. Choose a category and circle an appropriate score within the category.

Embeddedness: assess how embedded gravel, cobble and boulders particles are within the fine sediment. Excellent embeddedness category is defined as minimal fine sediment around substratum, which may reduce available refuge for macroinvertebrates within the substratum.

Velocity/depth category: assess how many velocity/depth categories are present, of the four defined categories (slow deep (<0.3 ms$^{-1}$, >0.5 m); slow shallow; fast deep; fast shallow).

Channel alteration: choose category and circle appropriate score within the category.

Bottom scouring and deposition: an assessment of substratum stability. Larger substratum (larger than gravel/pebble) is not subject to scouring and deposition in usual flows. Smaller substratum (gravel/sand/silt/clay) is subject to both scouring and deposition during normal flows.

Pool/Riffle, run/bend ratio: calculate the distance between riffles, and divide by the river/stream width. This will provide a single number, placing it within one of the four categories.

Bank stability: choose the relevant category and circle an appropriate score within that category.

Bank vegetative stability: choose an appropriate category and nominate a score within that category.

Streamside cover: choose category and circle appropriate score within the category.

Total the scores within each category and sum to provide an overall score for the site. Record each category score and the total score on the field sheets.

# Data Processing

Consideration should be given to the method for storage of biological and habitat data. It is recommended that biological and habitat data be stored as individual files. Depending on the scale of the project, either spreadsheet or database formats may be used for this function.

If intending to make use of the NT predictive models, data should be formatted to suit model input requirements. All data should be cross-checked with the raw datasheets on entry. Ensure that the Site Code used for the habitat data is also used for biological data entry.

Several calculations will need to be performed, as follows:

Catchment area: this is the area of the catchment that sheds water to the selected site. Catchment area is calculated for each site using CAD mapping software, however a number of other methods are available.

Distance from source: the distance from the sampling point to the source of the stream is calculated using CAD mapping software and 1:250 000 mapping. Other techniques such as a "map wheel" may be used if CAD software is not available.

Stream order: use the Strahler stream ordering method, as defined from 1:250 000 topographic maps. The uppermost creeks and streams for each sub-catchment are assigned a stream order of 1. A second order stream is produced when two first order streams meet. A stream order will only change when two streams of the same order meet. A lower stream order flowing into a higher order stream will, therefore, not change the order of the higher stream. The following diagram depicts the stream order structure:
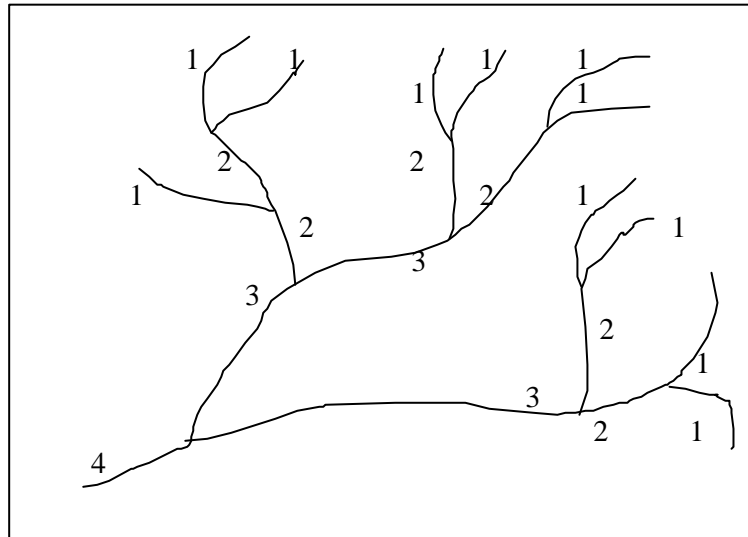


Habitat Velocities: Calibration sheets for the Pygmy Fan Set should be used in the calculation of stream velocities, from the number of revolutions measured in the field. Calculate the revolutions per second from the measured revolutions per unit time for each reading.

Look up this number on the calibration sheets to derive the velocity of water for that habitat. Average the three velocities and record the maximum, minimum and average readings.

# GENERAL CONSIDERATIONS

Field work in the Northern Territory can involve working under extreme conditions. Always leave an itinerary of the trip with someone. Do not undertake field work alone.

## Registration of samples

It is recommended that a registration system be implemented for both biological and water quality samples. All samples collected on the field trip should be recorded in the register and stored within one day of returning. Each entry should be cross-checked to ensure all collected samples have been correctly transcribed. All workers participating in the trip should sign the register as correct.

Water sample registration sheets should include the following information:

- Bottle Label;
- Collection Date;
- Submission Date; and
- Parameters to be analysed for each bottle.

Additionally, it is suggested that the following details are also recorded on the register, a copy of which should be sent with water sample bottles to the processing laboratory:

- Catchment Name; and
- Site Code

Suggested details for biological registration sheets are as follows:

- Catchment Name;
- Site Code;
- Habitat;
- Collection Date; and
- Number of jars per sample.

Upon return from the field, register water sample bottles and store appropriately until sample processing is undertaken. Register the biological samples and store in a cool place, away from the main working area, until sorting and identification can proceed.

# BIOLOGICAL SAMPLE PROCESSING PROCEDURES

When working with samples that have been preserved in alcohol, it is important to work in an area which is well ventilated or under a fume-hood. Avoid sorting for macroinvertebrates where the sample is maintained in alcohol, always rinse the sample thoroughly with water. All collected samples should be stored in a cool environment, preferably isolated from the normal workplace.

It is recommended that individual 'tally' sheets be used for macroinvertebrate identification. These sheets should include all relevant macroinvertebrate information, and sample detail, such as the site code and name, date of collection, identifier's name, the date of identification, number of vials required and room for comment.

The NT AUSRIVAS identification sheet is attached in Appendix 5.

## Macroinvertebrate sample processing

Set a 250 µm mesh sieve in a large, durable plastic container. Uncap and invert the sample in the sieve and allow the alcohol to drain into the container. Remove the sieve and rinse gently with water to remove any remaining alcohol and fine sediment. Rinse the sample pot containers and lids with water into the sieve. Refill washed containers with recycled alcohol.

Wash the sample into a sub-sampling box and fill with water. A modified version of the sub-sampler designed by Marchant (1989) was adopted by NT AUSRIVAS to sub-sample for 200 animals. A waterproof 'Pelican' case was used as the sub-sampler, with a perspex sheet constructed to hold small cylindrical plastic vials and fitted into the case. The perspex sheet holds 84 vials, of dimensions 5.6cm x 2.7cm. A fitted wire mesh is placed on top to hold the vials and perspex rack in place during agitation.



Sub-sampler used in NT AUSRIVAS program

Cover the water surface with plastic to avoid spillage and fasten case securely. Lift the case and invert so that the sample falls away from the vials. Whilst inverted, agitate the case vigorously, shaking the case from side to side, usually between 6-8 times. While sample is still being agitated, flip the case upright onto the bench top. This should ensure that the sample is evenly distributed throughout the vials.

A 200 organism sub-sample is required. Randomly select vials from the box sub-sampler, using a computer-generated random numbers sheet, and place into a rack.

## Macroinvertebrate identification and enumeration

Set-up and adjust a stereomicroscope for the user's vision and work posture, (according to the manufacture's instructions). Pour the vial contents into a channel-tray (or similar) and sort for macroinvertebrates. Select macroinvertebrates and using the keys, identify to family level. Place macroinvertebrates into specimen vials and record on tally sheet. Taxa are separated into Orders and placed into individual vials. Future curatorial preservation and storage also requires this differentiation.

When an identification problem is encountered a decision tree for identifications should be followed as is figured in Hawking and O'Connor (1997). Other staff and local taxonomists are additional sources of assistance.

Very small, damaged, immature animals or pupae that cannot be identified with confidence should be noted as such (eg. Trichoptera juvenile). These animals are counted and placed in separate vials for each category. Unidentified animals are not included in the 200 organism sub-sample count. Damaged specimens should be identified if possible. Count both heads and tails, recording the highest number, and place in the appropriate vials. If a specimen cannot be identified it should be noted as such (eg. Ephemeroptera damaged) and placed in an appropriate vial. Apply this method also in the identification of Oligochaeta. Micro-crustacea such as Ostracods, Copepods and Cladocera are not counted in the 200 organism counts. Isopoda, Amphipoda and Conchostraca are included in the 200 count.

Continue with identification until all specimens have been identified, and calculate total numbers for each taxon. Complete details on tally sheet, noting the total number of vials. A label should be inserted into each vial containing information on the sample (site code, collection date etc). Use waterproof paper, marking with pencil or alcohol-proof ink.

Record the number of plastic vials required to obtain the 200 organisms. Extracted vials must be completely sorted even if the 200 organism count is reached, to enable estimates of total abundance.

The remainder of the sample is scanned for large and/or rare taxa, which were not collected in the 200 count. These additional taxa are identified and placed into a separate specimen vial and labelled as "extras". Record extra taxa in the tally sheets as present only, ie. "1". These taxa should not be included in abundance calculations.

Replace the sample residue in the original sample jar and store appropriately.

For inclusion in the predictive models, all macroinvertebrates must be identified to family level using the keys recommended by Hawking (1999), except for Oligochaeta (Class), Acarina (Order) and Chironomidae (sub-Family). Adults and larvae for each family are numerically combined for the purposes of data entry and analysis. The following table lists the macroinvertebrates included and not included in the NT predictive models.

List of taxa included in the NT AUSRIVAS predictive modelling

| Taxa Included | | Taxa Not Included | |
|---|---|---|---|
| *Annelida* | | *Cnidaria* | |
|    Hirudinea | Leeches | *Collembola* | springtails |
|    Oligochaeta | Worms | *Crustacea* | |
| *Arachnida* | |    Cladocera | water fleas |
|    Acarina | mites |    Copepoda | |
| *Crustacea* | |    Ostracoda | shell shrimps |
|    Amphipoda | scuds | *Nematomorpha* | horsehair worms |
|    Conchostraca | clam shrimps | | |
|    Decapoda | | | |
|    Isopoda | | | |
| *Insecta* | | | |
|    Coleoptera | beetles | | |
|    Diptera | true flies | | |
|    Ephemeroptera | mayflies | | |
|    Hemiptera | bugs | | |
|    Lepidoptera | moths | | |
|    Neuroptera | lacewings | | |
|    Odonata | damsel & dragonflies | | |
|    Trichoptera | caddis flies | | |
| *Mollusca* | | | |
|    Bivalvia | mussels | | |
|    Gastropoda | snails | | |
| *Nematoda* | roundworms | | |
| *Turbellaria* | flatworms | | |

# MACROINVERTEBRATE QUALITY CONTROL/QUALITY ASSURANCE PROCEDURES

Quality control / quality assurance procedures are designed to establish an acceptable standard of macroinvertebrate sorting and taxonomic identifications. The quality control component minimises the variation in sorting and identification efficiency. Quality assurance provides potential users with the assurance that the accuracy of results is within controlled and acceptable limits.

## Sorting efficiency

All new staff should be trained in laboratory procedures, which include sub-sampling, sorting and sample storage.

On commencement of sorting, quality control staff check the residues of the first five samples sorted, for overlooked macroinvertebrates. (This procedure is repeated for the commencement of new projects and sampling runs, in addition to the training of new staff.)

After the first five samples, an assessment is made whether the individual's sorting ability is acceptable. If not considered acceptable, then sample residue checking is continued for every sample until efficiency is increased.

A sorting efficiency of >90% is deemed adequate. Sorted samples are resorted and missed animals are identified, enumerated and compared to the animals collected in the original sort. In the instance that the number of animals from a particular Family counted in the re-sort is ⸱10% of the total count (original plus re-sort count for that Family), the sorter will be given suitable instruction to ensure that particular Family is adequately collected in future samples.

If macroinvertebrate sorting for the first five samples is acceptable, a random selection of two samples in the following ten, and a further two samples in the following 30 will be checked. To ensure efficiency is maintained, one sample in every 20 will be checked on an ongoing basis, by quality control staff.

It is important when sorting to ensure all different taxa in a sample are collected. If a particular Family contributes significantly to the count (>10% of the total) an error in the count of ⸱10% is less important than the same error in a Family with a lower count. Where errors occur in the count of Families which contribute significantly to the total count, sorting staff are cautioned and made aware of the these groups to reduce the chance of significant errors in future samples. Taxa not collected in the original count but collected in the re-sort are treated as a significant error and appropriate instruction is required to correct the problem.

## Identification and enumeration efficiency

All new staff should be trained in laboratory procedures, including identification, enumeration, sample storage and archiving of specimens.

Once sample identification has commenced, quality control staff check the identification results for the first five samples. (This procedure is repeated for the commencement of new projects and sampling runs, in addition to the training of new staff)

An assessment is made following the first five samples whether identification and enumeration accuracy is satisfactory. If not satisfactory appropriate instruction is given to the person as described in below.

A mis-identification error of <10% of the total number of animals is considered acceptable. This error rate was used by the Murray Darling Freshwater Research Centre, in conducting external quality control checks on all state and territory agencies participating in the AUSRIVAS program. If the error is ≥10%, mis-identifications should be corrected under the guidance of quality control staff. All mis-identifications should be shown to the person and suitable instruction given to rectify further mis-identification. All samples containing mis-identified taxa previously processed by the original identifier, should be assessed by that person for similar identification errors.

Similar to sorting procedures, if identification and enumeration for the first five samples is acceptable, a random selection of two samples in the following ten, and a further two samples in the following 30 will be checked. To ensure efficiency is maintained, one sample in every 20 will be checked on an ongoing basis, by quality control staff.

## Quality control identification correction sheet

The QA/QC identification correction sheet employed by NT AUSRIVAS is attached in Appendix 6.

### *Quality Control Staff*

Quality control staff are staff with adequate experience in identification. Samples will be checked by different quality control staff as necessary, to avoid bias and workload increases.

# REFERENCES

Davies, P. E. (1994). National River Processes and Management Program. Monitoring River Health Initiative. River Bioassessment Manual, Version 1.0. Department of Environment, Sport and Territories, Land and Water Resources Research and Development Corporation, Commonwealth Environment Protection Agency

Franson, M. A. H. (Ed.) (1995). 19th Edition. Standard Methods for the Examination of Water and Wastewater. American Public Health Association, Washington DC.

Hawking, J. H. (1999). A preliminary guide to keys and zoological information to identify invertebrates from Australian fresh waters. Murray-Darling Freshwater Research Centre, Update of Identification Guide No 2. Presented at the 11th Taxonomy Workshop held at the Murray-Darling Freshwater Research Centre, Albury 2-4 February 1999.

Hawking, J. and O'Connor, R. (1997). Guidelines for identification and quantification for agencies participating in the MRHI based on quality control procedures. Draft 6 June 1997. Cooperative Research Centre for Freshwater Ecology/Murray-Darling Freshwater Research Centre.

Marchant, R. (1989). A subsampler for samples of benthic invertebrates. *Bulletin of the Australian Society for Limnology* **12**, 49-52.

# APPENDIX 1

# Equipment Preparation

Several procedures must be undertaken before using equipment on a field trip.

A Horiba U10 Water Quality Checker (Horiba Pty Ltd, Kiyoto) or similar water quality measuring device must be correctly calibrated for the range of conditions expected in the waterbody being investigated. Refer to the manufacturer's instructions on correctly calibrating these instruments.

Water sample bottles must be prepared according to the analysis being undertaken on the water collected. Three groups of parameters were included in the model, as follows:

- Nutrients – Total Kjedahl Nitrogen (TKN)
- Nutrients – Dissolved Reactive Phosphorous (DRP), Total Phosphorous (TP), Nitrate ($NO_3$), Nitrite ($NO_2$) and Nitrate & Nitrite as N
- General chemistry – Alkalinity, Electrical Conductivity and pH

| Bottle type | Analysis | Preparation |
|---|---|---|
| 125 mL | Nutrients (TKN) | HCl soaked, rinsed 3 times in distilled water |
| 250 mL | Nutrients (DRP etc) | HCl soaked, rinsed 3 times in distilled water |
| 250 mL | General chemistry | Decon soaked, rinsed 3 times in distilled water |

On return, water samples will require analysis. The recommended procedure is as follows (Franson, 1995):

| Water Quality Parameter | Units | Analysis |
|---|---|---|
| pH | pH units | APHA 4500-$H^+$ B |
| Conductivity | $\mu Scm^{-1}$ | APHA 2510B |
| Total Alkalinity (as $CaCO_3$) | $mgL^{-1}$ | APHA 2320B |
| Hydroxide (as OH) | $mgL^{-1}$ | APHA 2320B |
| Bicarbonate (as $HCO_3$) | $mgL^{-1}$ | APHA 2320B |
| Carbonate (as $CO_3$) | $mgL^{-1}$ | APHA 2320B |
| Nitrate & Nitrite (as N, LOD 0.001) | $mgL^{-1}$ | APHA 4500-$NO_3^-$ F |
| Nitrite (as $NO_2$, LOD 0.02) | $mgL^{-1}$ | APHA 4500-$NO_3^-$ F |
| Nitrate (as $NO_3$, LOD 0.004) | $mgL^{-1}$ | APHA 4500-$NO_3^-$ F |
| TKN (LOD 0.001) | $mgL^{-1}$ | AWQC Method 112-01 |
| Filtrable Reactive Phosphorous (as P, LOD 0.001) | $mgL^{-1}$ | APHA 4500-P E |
| Total Phosphorous (as P, LOD 0.001) | $mgL^{-1}$ | APHA 4500-P E |

# APPENDIX 2

# Equipment List

**STANDARD FIELDWORK - for field work around the Darwin region**

SAMPLING EQUIPMENT
Net
3-pronged cultivator rake
Buckets (3)
Macroinvertebrate containers in crate (2 per habitat per site)
Calibrated Horiba/Hydrolab with manual
Flow meter (Pygmy fan set) and electronic counter
Ethanol/Methylated spirits (90%)*
Water sample bottles (3 per site)

RUCKSACKS
Sieves (1x 250μm, 1x 8mm)
Chip bucket
Wash-bottle
Sorting tray (2)
Tape measure (30m)
Calibrated thermometer
Whiteboard, pen & duster
GPS (with manual, as required)
Camera & film (with manual, as required)
Field sheets (blank & previous site field sheets)
Clipboard & pens
Permanent, alcohol and waterproof markers (paintmarker pens)
First Aid bandages

REFERENCE MATERIAL
Landholder contact phone numbers
Topographic maps
ID books - bird, fish, water plants and botanical books

**EXTRA EQUIPMENT - for field work in remote areas**

SAMPLING EQUIPMENT
Site access sketches
Plastic bags (chopper work)
Esky holding methylated spirits
Esky for empty water sample bottles
Esky for full water sample bottles
Ice for water samples

* the recommended macroinvertebrate jars are 700mL in volume. Ensure enough ethanol/methylated spirits is taken to fill jars for the required number of sites.

# APPENDIX 3

## Field data sheets
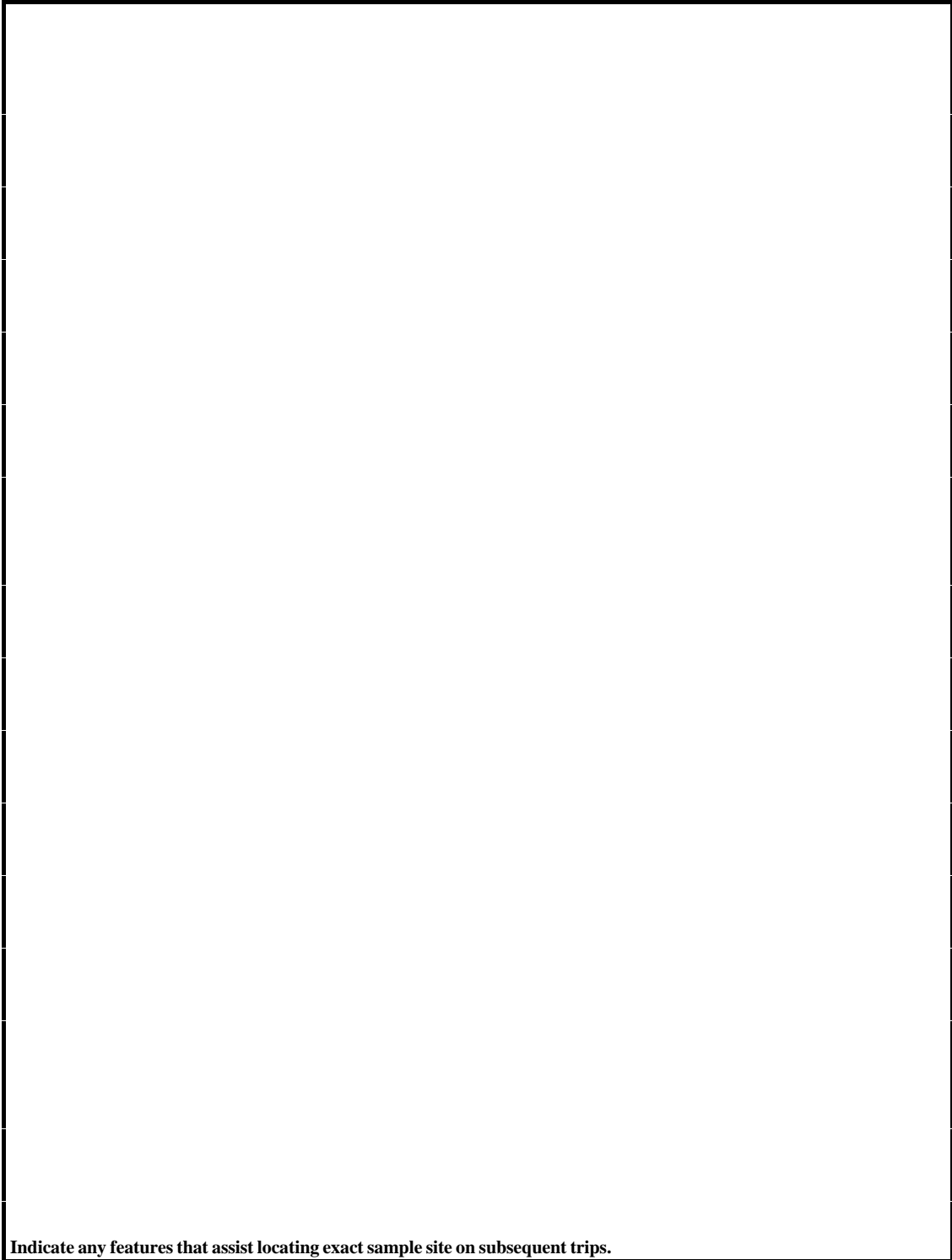
# ACCESS SKETCH

**SITE NAME**                                                                      **SITE CODE**

**Indicate any features that assist locating exact sample site on subsequent trips.**

## SITE DESCRIPTION

**Basin**                    **River**                              **Tributary**

_____

**Disturbance**          **Impacts**
®        Little          ®        Pastoralism      ®        Industrial discharge
®        Moderate        ®        Mining           ®        Impoundments
®        High            ®        Urban            ®        Agri/horticulture


**Landholders and contact details**

_____

_____

_____

_____

_____


**Site history and comments**

_____

_____

_____

_____

_____

_____


**Maps**                        **1:100,000**                    **1:250,000**
_____

**Altitude**                    **(m)**
_____

**Distance from source**        **(m)**
_____

## WATER QUALITY

| Date | Site Code | Site Name |
|------|-----------|-----------|

| Time | Horiba Serial No. | Field Team |
|------|-------------------|------------|

| pH | units | E.C. | mScm$^{-1}$ |
|----|-------|------|-------------|

| D.O. | mg/L | Turbidity | NTUs |
|------|------|-----------|------|

| Water Temp | $^{o}$C | Air Temp | $^{o}$C |
|------------|---------|----------|---------|

| GPS | southing | | easting |
|-----|----------|--|---------|

## MACROINVERTEBRATE SAMPLING

**EDGE**  Length sampled_____m   **Substrate 100%**_____%Bedrock
Sampling depth_____cm   _____%Boulders (>256mm)
Collected by  _____   _____%Cobbles (64-256m)
Containers used_____   _____%Pebbles (16-64mm)
Fine organics, mud, muck  _____%*   _____%Gravel (4-16mm)
Coarse organics, sticks, leaves _____%*   _____%Sand (1-4mm)
*Does not have to total 100%   _____%Silt/Clay (<1mm)

| Percentage coverage | <10 | 10-35 | 35-65 | 65-90 | >90 | |
|---------------------|-----|-------|-------|-------|-----|--|
| Algal cover | 0 | 1 | 2 | 3 | 4 | **Edge description** |
| Adjacent macrophytes | 0 | 1 | 2 | 3 | 4 | ®  Vertical 90$^{o}$ |
| Overhanging vegn | 0 | 1 | 2 | 3 | 4 | ®  Angled 45-90$^{o}$ |
| Trailing root vegn | 0 | 1 | 2 | 3 | 4 | ®  Undercut |

**SAND/SILT BED**  Length sampled_____m   **Substrate 100%**
Sampling depth_____cm   _____%Bedrock
Collected by  _____   _____%Boulders (>256mm)
Containers used_____   _____%Cobbles (64-256m)
Fine organics, mud, muck  _____%*   _____%Pebbles (16-4mm)
Coarse organics, sticks, leaves _____%*   _____%Gravel (4-16mm)
*Does not have to total 100%   _____%Sand (1-4mm)
**Sand sweep description**   _____%Silt/Clay (<1mm)
®  Horizontal

| ®  Angled 0-45$^{o}$ | Percentage coverage | <10 | 10-35 | 35-65 | 65-90 | >90 |
|----------------------|---------------------|-----|-------|-------|-------|-----|
| ®  Angled 45-90$^{o}$ | Algal cover | 0 | 1 | 2 | 3 | 4 |
| ®  Shallow <20cm | Adjacent macrophytes | 0 | 1 | 2 | 3 | 4 |
| ®  Deep 20-50cm | Overhanging vegn | 0 | 1 | 2 | 3 | 4 |

## PHYSICAL CHARACTERISTICS

**Habitat velocities & depths**      **Flow meter serial no.** _____ **Fan set no.** ____

| Habitat | Meter Readings (Revolutions per 40s) | | | Fan details | Habitat depths (cm) | | |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | | **1** | **2** | **3** |
| **Edge** | | | | | | | |
| **Sand/silt bed** | | | | | | | |
| **Macrophytes** | | | | | | | |

**Channel Transects (m)**      Indicate:  Estimated/Measured

| Transects | Widths | Depth 1/4 way LH bank facing downstream | Depth 1/2 way | Depth 3/4 way LH bank facing downstream |
|---|---|---|---|---|
| **1** furthest upstream | E/M | E/M | E/M | E/M |
| **2** | E/M | E/M | E/M | E/M |
| **3** furthest downstream | E/M | E/M | E/M | E/M |

**Habitats within 100m reach** (Estimate % habitat components looking from above)

| HABITAT | % TOTAL AREA | HABITAT | % TOTAL AREA |
|---|---|---|---|
| Sand/Silt bed | | Macrophytes | |
| Gravel/Rock bed | | Snags | |
| Riffle | | Pool/Edge/ unknown substrate | |

**Width between top of levee banks** _____ **m**

**Width between immediate stream banks** (if different to above) _____ **m**

**Height of levee bank from water surface** _____ **m**

**Riparian zone width**    **-left bank** (facing downstream) _____ **m**

                                   **-right bank** _____ **m**

### Flow Level

Relative to normal dry season flow, if known.  Normal inundation level marked by limit of terrestrial grasses or by eroded area, or boundary in bank sediment types.  (Note:  These markers may not be relevant to Top End rivers.)

| **1 low** | **2 moderate** | **3 high** | **4 flood** |
|---|---|---|---|
| <watermark | = watermark | >watermark | |

**1 no flow**      **2 flow**      **3 unknown**

## RIPARIAN VEGETATION (within 100m reach)

**Vegetation cover of river** (Estimation of shade on river at midday)

® <5%    ® 6-25%    ® 26-50%    ® 51-75%    ® >76%

| Vegetation type | % Cover (use Specht chart) | Description |
|---|---|---|
| trees (>10m) | | |
| trees (<10m) | | |
| shrubs / vines | | |
| grasses / ferns / sedges | | |

**Native vegetation** _____ %              **Exotic vegetation** _____ %

**Weed types:** _____

**Erosion in Riparian Zone**

|  | Left Bank (facing downstream) | | Right Bank | |
|---|---|---|---|---|
| Bare ground above water mark (due to erosion/disturbance) | 1 yes | 2 no | 3 yes | 4 no |
| Tree roots exposed (due to erosion/disturbance) | 1 yes | 2 no | 3 yes | 4 no |
| Gully erosion | 1 yes | 2 no | 3 yes | 4 no |
| Slumping banks | 1 yes | 2 no | 3 yes | 4 no |
| Excessive fallen trees or wood debris | 1 yes | 2 no | 3 yes | 4 no |

Local Catchment Erosion     **1 none    2 little       3 moderate       4 heavy**

**Landuse (left bank** (facing downstream)**)**            **Landuse (right bank)**

| | | | |
|---|---|---|---|
| ® Native Woodland | ® Forestry | ® Native Woodland | ® Forestry |
| ®Recreational | ® Grazing | ®Recreational | ® Grazing |
| ® Cropped | ® Residential | ® Cropped | ® Residential |
| ® Commercial | ® Industrial | ® Commercial | ® Industrial |
| ® Other................................................ | | ® Other................................................ | |

| OBSERVATIONS | | | | | | Score |
|---|---|---|---|---|---|---|
| **Water Clarity** | **1 clear** >1.5m | **2 good** 0.3-1.5m | **3 fair** 0.1-0.3m | **4 poor** zero vis. | | |
| **Water Odour** | **1 normal** | **2 sewage** | **3 petrol/chems** | **4 other** | | |
| **Water Oils** | **1 none** | **2 sheen** | **3 slick** | **4 globs** | **5 other** | |
| **Foam/ Scum** | **1 none** | **2 pollen/leaves** | **3 algal scum** | **4 foam** | **5 other** | |
| **Plume** | **1 little** | **2 some** | **3 lots** | | | |
| **Sediment Oils** | **1 absent** | **2 light** | **3 moderate** | **4 profuse** | | |
| **Sediment Odours** | **1 normal** **5 other** | **2 sewage** | **3 petrol/chems** | **4 anaerobic** | | |

**Fish:**  ® no  ® yes

**Birds :**

**Other wildlife :** (eg feral and pastoral animals, native reptiles and mammals - comment on scats, diggings, footprints, slide marks etc)

**Evidence of fire**  **Riparian Zone**  ® no  ® yes

**Beyond Levee Banks**  ® no  ® yes

**Comments** (eg height of tree burn scars)

**Evidence of human impact** (eg litter, pipes, drains, concrete structures, damaged vegetation, campfires, boat & vehicle access)
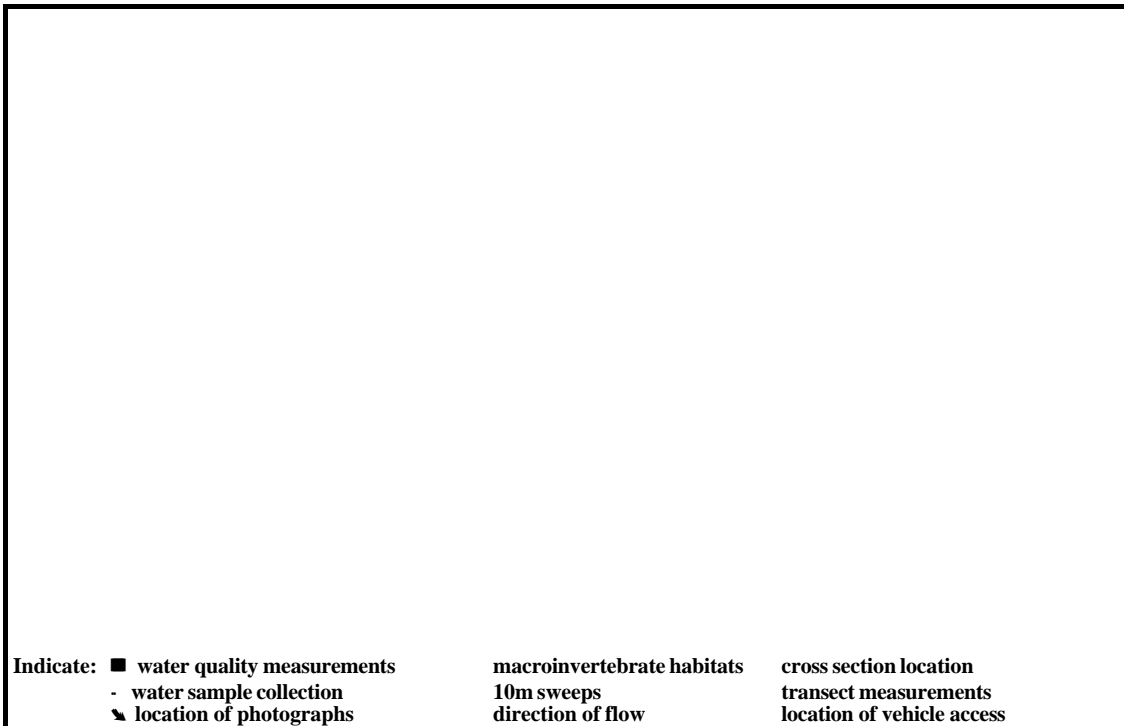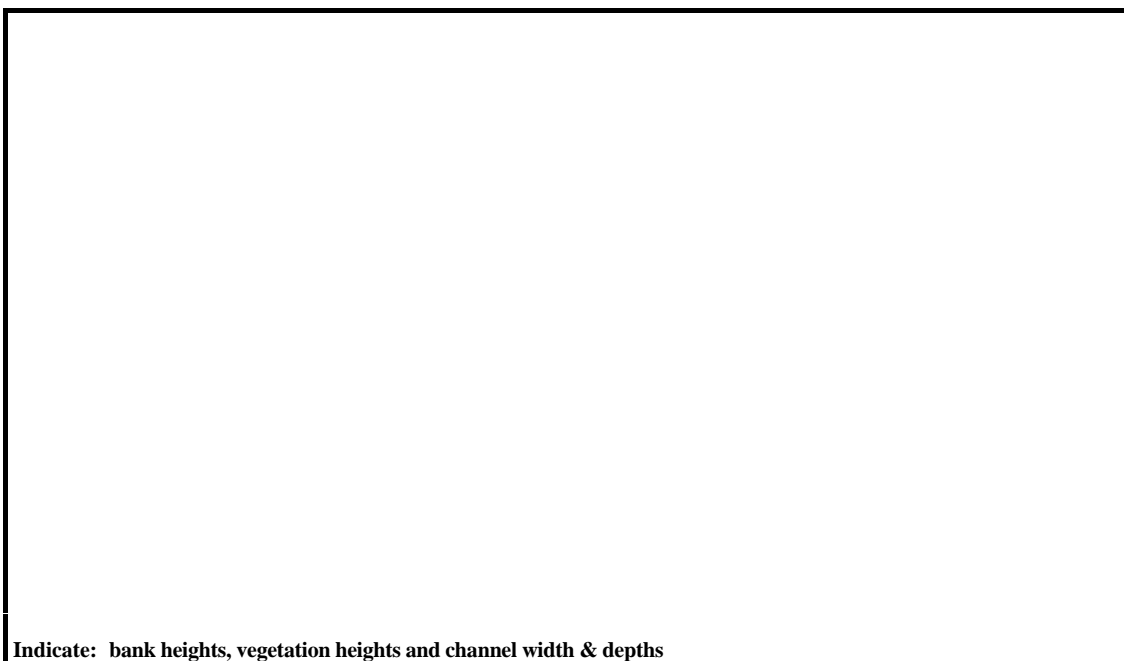
**Site accessed by:**  ® vehicle  ® helicopter

## SKETCH OF 100M REACH

| | | |
|---|---|---|
| **Indicate:** ■ **water quality measurements** | **macroinvertebrate habitats** | **cross section location** |
| ∙ **water sample collection** | **10m sweeps** | **transect measurements** |
| ↘ **location of photographs** | **direction of flow** | **location of vehicle access** |

## SKETCH OF CHANNEL CROSS SECTION

**Indicate:  bank heights, vegetation heights and channel width & depths**

## HABITAT ASSESSMENT FIELD DATA SHEET

**Date:**                                        **River:**                                        **Location Code:**

**Name of recorder:**

| Habitat Variable | CATEGORY | | | |
|---|---|---|---|---|
| | **Excellent** | **Good** | **Fair** | **Poor** |
| **1. Bottom substrate / available cover** | Greater than 50% rubble, gravel, submerged logs, undercut banks or other stable habitat. | 30-50% rubble, gravel or other stable habitat. Adequate habitat. | 10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable. | Less than 10% rubble, gravel or other stable habitat. Lack of habitat is obvious. |
| | 20, 19, 18, 17, 16 | 15, 14, 13, 12, 11 | 10, 9, 8, 7, 6 | 5, 4, 3, 2, 1, 0 |
| **2. Embeddedness** | Gravel, cobble and boulder particles are between 0 & 25% surrounded by fine sediment. | Gravel, cobble and boulder particles are between 25 & 50% surrounded by fine sediment. | Gravel, cobble and boulder particles are between 50 & 75% surrounded by fine sediment. | Gravel, cobble and boulder particles are over 75% surrounded by fine sediment. |
| | 20, 19, 18, 17, 16 | 15, 14, 13, 12, 11 | 10, 9, 8, 7, 6 | 5, 4, 3, 2, 1, 0 |
| **3. Velocity / depth category** | Slow deep ($<0.3$m/s & $>0.5$m); slow shallow; fast deep; fast shallow; habitats all present. | Only 3 of the four habitat categories present (missing riffles or runs receive lower score than missing pools). | Only 2 of the four habitat categories present (missing riffles/runs receive lower score). | Dominated by one velocity/depth category (usually pool). |
| | 20, 19, 18, 17, 16 | 15, 14, 13, 12, 11 | 10, 9, 8, 7, 6 | 5, 4, 3, 2, 1, 0 |
| **4. Channel alteration** | Little or no enlargement of islands or point bars and/or no channelisation | Some new increase in bar formation, mostly from coarse gravel; and/or some channelisation present. | Moderate deposition of new gravel, coarse sand, on old and new bars; pools partly filled w/silt; and/or embankments on both banks. | Heavy deposits of fine materials, increased bar development; most pools filled with silt; and/or extensive channelisation. |
| | 15, 14, 13, 12 | 11, 10, 9, 8 | 7, 6, 5, 4 | 3, 2, 1, 0 |
| **5. Bottom scouring and deposition** | Less than 5% of the bottom affected by scouring and deposition. | 5-30% affected. Scours at constrictions and where grades steepen, some deposition in pools. | 30-50% affected. Deposits and scours at obstruction and bends. Some deposition in pools. | More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. Only large rocks in riffle exposed. |
| | 15, 14, 13, 12 | 11, 10, 9, 8 | 7, 6, 5, 4 | 3, 2, 1, 0 |

## HABITAT ASSESSMENT FIELD DATA SHEET

Date: _____  River: _____  Location Code: _____

| Habitat Variable | CATEGORY | | | |
|---|---|---|---|---|
| | **Excellent** | **Good** | **Fair** | **Poor** |
| **6. Pool/riffle, run/bend ratio.** (Distance between riffles divided by stream width) | 0-7 Variety of habitat. Deep riffles and pools. | 7-15 Adequate depth in pools and riffles. Bends provide habitat. | 15-25 Occasional riffle or bend. Bottom contours provide some habitat. | >25 Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. |
| | 15, 14, 13, 12 | 11, 10, 9, 8 | 7, 6, 5, 4 | 3, 2, 1, 0 |
| **7. Bank stability** | Stable. No evidence of erosion or bank failure. Side slopes generally <30%. Little potential for future problem. | Moderately stable. Infrequent small areas of erosion mostly healed over. Side slopes up to 40% on one bank. Slight potential in extreme floods. | Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60% on some banks. High erosion potential during extreme/high flows. | Unstable. Many eroded areas. Side slopes >60% common. "Raw" areas frequent along straight sections and bends. |
| | 10, 9 | 8, 7, 6 | 5, 4, 3 | 2, 1, 0 |
| **8. Bank vegetative stability** | Over 80% of the streambank surfaces covered by vegetation or boulders and cobble. | 50-79% of the streambank surfaces covered by vegetation, gravel or larger material. | 25-49% of the streambank surfaces covered by vegetation, gravel or larger material. | Less than 25% of the streambank surfaces covered by vegetation, gravel or larger material. |
| | 10, 9 | 8, 7, 6 | 5, 4, 3 | 2, 1, 0 |
| **9. Streamside cover** | Dominant vegetation is of tree form. | Dominant vegetation shrub. | Dominant vegetation is grass, sedge, ferns. | Over 50% of streambank has no vegetation & dominant material is soil, rock, bridge materials, culverts, or mine tailings. |
| | 10, 9 | 8, 7, 6 | 5, 4, 3 | 2, 1, 0 |

| Column Totals | | | | |
|---|---|---|---|---|

| Score | |
|---|---|

# APPENDIX 4

# Predictor variables used in the NT habitat models

**Edge Habitat**

| Early Edge | Late Edge | Combined Edge |
|---|---|---|
| Latitude[1] | Latitude[1] | Altitude (m) [2] |
| Altitude (m) [2] | Longitude[1] | Stream Order [2] |
| Catchment Area (km$^2$) [3] | Total Alkalinity (mgL$^{-1}$) [4] | Total Alkalinity (mgL$^{-1}$) [4] |
| Total Alkalinity (mgL$^{-1}$) [4] | Total Area Macrophytes (%) | Minimum Velocity (ms$^{-1}$) |
| Habitat Sampling Depth (cm) | | Pebbles (%) |
| Avg Velocity (ms$^{-1}$) | | Transect – Avg River Width (m) |
| Pebbles (%) | | Total Area Macrophytes (%) |
| Total Area Riffle (%) | | |
| Total Area Pool/Unknown (%) | | |

**Sand Habitat**

| Early Sand | Late Sand | Combined Sand |
|---|---|---|
| Latitude[1] | Longitude[1] | Catchment Area (km$^2$) [3] |
| Altitude (m) [2] | Stream Order [2] | Water Temperature ($^o$C) |
| Avg Habitat Depth (m) | Distance from Source (km) [3] | Total Alkalinity (mgL$^{-1}$) [4] |
| Avg Velocity (ms$^{-1}$) | Catchment Area (km$^2$) [3] | Habitat Sampling Depth (cm) |
| Total Area Pool/Unknown (%) | Conductivity (µScm$^{-1}$) | Avg Velocity (ms$^{-1}$) |
| | Water Temperature ($^o$C) | Minimum Velocity (ms$^{-1}$) |
| | Habitat Sampling Depth (cm) | Cobbles (%) |
| | Maximum Velocity (ms$^{-1}$) | Total Area Pool/Unknown (%) |
| | Cobbles (%) | |
| | Sand (%) | |
| | Total Area Snags (%) | |

[1] decimal degrees

[2] obtained from 1:250 000 topographic maps

[3] used CAD mapping package

[4] as $CaCO_3$

# APPENDIX 5

## Macroinvertebrate Identification Sheet

# Macroinvertebrate Identification Sheet

| | |
|---|---|
| SITE CODE : _____  BASIN : _____ | ID |
| SITE NAME : _____ | CODE _____ |
| _____  COLLECTION DATE : _____ | FRACTION :        / 170 |

**HABITAT :** (Tick one)

| [  ] | EDGE |
| [  ] | SAND / SILT |
| [  ] | ROCK / GRAVEL |
| [  ] | MACROPHYTE |
| [  ] | RIFFLE |

**SAMPLING RUN :** (Tick one)

| 1996 | | 1998 | | 1999 | |
|---|---|---|---|---|---|
| Early Dry | Late Dry | Early Dry | Late Dry | Early Dry | Late Dry |
| | | | | | |

(MRH)          (AUSRIVAS)          TOTAL VIALS :  [    ]

SORTED BY : _____
ON : _____
IDENTIFIED BY : _____
ON : _____

ENTERED INTO DBASE BY :
_____
ON : _____
CHECKED BY :
_____
ON : _____

| MUSEUM CODE | TAXA | TAXA CODE | EXTRA | EXTRAS TALLY | TOTAL COUNT |
|---|---|---|---|---|---|
| | Ceratopog | FO1P | | | |
| | Ceratopog. | F01 | | | |
| | Chaoborid | F02 | | | |
| | Culcidae | F03 | | | |
| | Chiro-pupa | F05P | | | |
| | Aphroten. | F0A | | | |
| | Ch_minae | F04 | | | |
| | Tanypod | F05 | | | |
| | Orthoclad | F06 | | | |
| | Tabanid | F07 | | | |
| | Tipulid | FO8 | | | |
| | Simuliid | F09 | | | |
| | Dolicho | F10 | | | |
| | Empidid | F12 | | | |
| | Stratiomyid | F13 | | | |
| | Psychodid | F14 | | | |
| | Sciomyzidae | F15 | | | |
| | | | | | |
| | Paleomonid | P01 | | | |
| | Atyidae | P02 | | | |
| | Conchostr. | P03 | | | |
| | Sundatel. | P04 | | | |
| | Parastacid | P06 | | | |
| | Paramelitid | P07 | | | |
| | Cirolanid | P08 | | | |
| | Hymenosom. | P09 | | | |
| | Oniscidae | P10 | | | |
| | | | | | |
| | Cordulidae | D01 | | | |
| | Gomphidae | D03 | | | |
| | Libellulidae | D05 | | | |
| | Aeshnidae | D08 | | | |
| | | | | | |
| | Protoneurid | D04 | | | |
| | Isostictidae | D07 | | | |
| | Coenagrion. | D09 | | | |

| MUSEUM CODE | TAXA | TAXA CODE | EXTRA | EXTRAS TALLY | TOTAL COUNT |
|---|---|---|---|---|---|
| | Notonectid | H01 | | | |
| | Corixidae | H02 | | | |
| | Gerridae | H03 | | | |
| | Naucoridae | H04 | | | |
| | Pleidae | H05 | | | |
| | Nepidae | H06 | | | |
| | Veliidae | H07 | | | |
| | Mesoveliid | H08 | | | |
| | Hebridae | H09 | | | |
| | Gelastocor. | H10 | | | |
| | Hydrometrid | H11 | | | |
| | Belostomat. | H12 | | | |
| | Octeridae | H13 | | | |
| | Elmidae | C01A | | | |
| | Elmidae | C01L | | | |
| | Dytiscid | C03A | | | |
| | Dytiscid | C03L | | | |
| | Hydrophilid | C04A | | | |
| | Hydrophilid | C04L | | | |
| | Hydraenid | C05A | | | |
| | Hydraenid | C05L | | | |
| | Staphylinid | C08A | | | |
| | Staphylinid | C08L | | | |
| | Scirtidae | C09A | | | |
| | Scirtidae | C09L | | | |
| | Carabidae | C11A | | | |
| | Carabidae | C11L | | | |
| | Gyrinidae | C12A | | | |
| | Gyrinidae | C12L | | | |
| | Chrysomelid | C13A | | | |
| | Chrysomelid | C13L | | | |
| | Curculionid | C14A | | | |
| | Curculionid | C14L | | | |
| | Noteridae | C15A | | | |
| | Noteridae | C15L | | | |
| | Haliplidae | C16A | | | |
| | Haliplidae | C16L | | | |
| | Hygrobiidae | C17A | | | |
| | Hygrobiidae | C17L | | | |
| | Heterocerid | C18A | | | |
| | Heterocerid | C18L | | | |
| | Limnichid. | C19A | | | |
| | Limnichid. | C19L | | | |

| MUSEUM CODE | TAXA | TAXA CODE | EXTRA | EXTRAS TALLY | TOTAL COUNT |
|---|---|---|---|---|---|
| | Hydracarina | M01 | | | |
| | Pyralidae | M02 | | | |
| | Oligochaeta | M03 | | | |
| | Nematoda | M05 | | | |
| | Sysyridae | M07 | | | |
| | Richardson. | M08 | | | |
| | Glossiphon. | M09 | | | |
| | Dugesiidae | M10 | | | |
| | Temnoceph. | M11 | | | |
| | | | | | |
| | Hydroptilid | T01 | | | |
| | Leptocerid | T02 | | | |
| | Ecnomidae | T03 | | | |
| | Calamocer. | T04 | | | |
| | Hydropsych. | T05 | | | |
| | Philopotam. | TO6 | | | |
| | Polycentrop. | T09 | | | |
| | Dipseudop. | T10 | | | |
| | Psychomyid | T11 | | | |
| | Helicopsych. | T12 | | | |
| | | | | | |
| | Leptopheb. | E03 | | | |
| | Baetidae | E05 | | | |
| | Caenidae | E09 | | | |
| | | | | | |
| | Ancylidae | G01 | | | |
| | Lymnaeidae | G02 | | | |
| | Thiaridae | G03 | | | |
| | Hydrobiidae | G04 | | | |
| | Vivipariidae | G05 | | | |
| | Planorbidae | G07 | | | |
| | | | | | |
| | Sphaeriidae | B01 | | | |
| | Hydriidae | B02 | | | |
| | Corbiculidae | B03 | | | |

**COMMENTS**

SORT COUNT :

ID COUNT :

# APPENDIX 6

## QA/QC Correction sheet

| Site code | Habitat | Season | Date |
|-----------|---------|--------|------|
|           |         |        |      |

| Taxon | | Quantity | | Error Score |
|-------|-|----------|-|-------------|
| Original identification | Corrected identification | Original | Recount | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| Percent new taxa | | Incorrect identifications or counts | |
|------------------|-|-------------------------------------|-|
| Total taxa (a) | | Total number of organisms in sample (a) | |
| Number new taxa (b) | | Number of organisms incorrectly identified (b) | |
| Percent ([b/a]x100) | | Percent ([b/a]x100) | |
| Pass or fail | | Pass or fail | |

Bray-Curtis dissimilarity index: