



Government of **Western Australia**
Department of **Water**

Western Australia AUSRIVAS sampling and processing manual



Looking after all our water needs

Water Science
technical series

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May 2009

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Contents

Summary	v
1 WA AUSRIVAS models	1
2 General sampling information.....	2
2.1 When to sample	2
2.2 Site location	2
2.3 Habitats to sample	2
2.4 Sampling order.....	3
3 The macroinvertebrate sample.....	4
3.1 Collecting the macroinvertebrate sample	4
Channel habitat	4
Macrophyte habitat	4
Pool habitat.....	5
Riffle habitat.....	5
3.2 Processing the macroinvertebrate sample	5
60-minute live pick	5
Box sub-sampling	6
3.3 Identifying the macroinvertebrate sample	8
3.4 Quality control (QC) of macroinvertebrate samples	8
QC of the live pick.....	8
QC of the sub-sampled picks.....	9
QC of macroinvertebrate identification.....	10
4 Water quality sampling	11
4.1 Collecting water samples for chemical analysis	11
4.2 Taking the in situ readings	12
5 WA AUSRIVAS field sheets	13
5.1 Completing the WA AUSRIVAS site information sheet	13
Site information box.....	13
GPS and map details box.....	15
Access details box.....	16
5.2 Completing the WA AUSRIVAS field sampling checklist.....	17
General information	17
Completion checklist box	17
Instrument calibration box.....	17
Equipment checklist.....	18
5.3 Completing the WA AUSRIVAS field sampling sheet.....	18
Sample information box	18
Water quality and habitat in reach	19
Weather	19
General information	20
Observations	20
Riparian zone box.....	22
Habitat assessment	22
5.4 Completing the WA AUSRIVAS macroinvertebrate sampling field sheet.....	25
Sample information box	25
Habitat assessment box	27
Depth and velocity	27

Live pick tally	27
Box sub-sampler tally box.....	27
References	59

Appendices

Appendix A — Predictor variables for WA AUSRIVAS models.....	28
Appendix B — Calculating SHET, SURF and SIZE.....	30
Appendix C — Vegetation percentage cover guidelines.....	32
Appendix D — WA AUSRIVAS field sheets.....	37
Appendix E — Field vial labels	48
Appendix F — Laboratory vial labels	51
Appendix G — Macroinvertebrate identification sheet.....	54
Appendix H — Suggested taxonomic keys.....	56

Tables

Table 1 Summary of requirements for sample collection.....	12
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Summary

The Western Australian AUSRIVAS models were developed by the Department of Conservation and Land Management (now the Department of Environment and Conservation – DEC) through the National River Health Program (NRHP). Subsequent to their development, ownership of the models passed to the Department of Water (then the Water and Rivers Commission). This manual updates the earlier version of the users' manual published by DEC (Halse et al. 2002) and includes completely revised field sheets.

The NRHP had three main aims and two phases. The aims were:

- To monitor and assess the ecological condition of Australia's rivers.
- To assess the effectiveness of current management practices.
- To provide better ecological and hydrological data on which to base management decisions.

The first phase commenced in 1993 and had as its major component the Monitoring River Health Initiative (MRHI). This was a national program which set out to monitor the ecological condition of Australian rivers using macroinvertebrates by developing predictive models. These predictive models are known as the AUSRIVAS (Australian River Assessment Scheme) models and compare the observed macroinvertebrate community with the expected community at similar minimally disturbed reference sites. More information on the AUSRIVAS models can be found at: <http://ausriv.as.canberra.edu.au/index.html>.

The second phase of the NRHP involved using the AUSRIVAS models developed as part of the first phase to conduct the First National Assessment of River Health (FNARH). This involved sampling nearly 5000 sites across Australia between 1997 and 1999, with around 650 sites being sampled in Western Australia. Some of these were sampled several times in different seasons and years.

To conduct an AUSRIVAS assessment in Western Australia, this manual must be followed during the sample collection and processing stage. The Software User Manual (Ransom et al. 2005) details how to run the AUSRIVAS models and interpret the outputs.

1 WA AUSRIVAS models

There are six models currently available for Western Australia on the AUSRIVAS website, three of which are for channel habitat and three for macrophyte habitat. The only model that is recommended for use is the spring channel model. A list of the predictor variables required for each Western Australian model can be found in Appendix A.

As macrophyte habitat is not widely found in Western Australia, especially in the south-west where there is an abundance of ephemeral streams, there was an insufficient number of reference sites available with which to build a robust model (Halse et al. 2001a). Of the three channel models available, Halse et al. (2001a) recommended that the combined channel model not be used because of the 'unsatisfactory nature of the baseline data used to construct it'. Further, they noted that it does not provide any more convincing results than the spring or autumn models alone. They note that it does provide reasonably reliable assessments in the north-west of Western Australia; however, separate spring and autumn assessments will provide more informative outputs. The autumn channel model is also not recommended as it is sub-optimal due to the lack of autumn sampling in much of the south-west during the FNARH (First National Assessment of River Health).

While the spring channel model is the only model currently recommended for use, this manual does outline how to collect macrophyte samples and to calculate any derived scores that are required as predictor variables for models other than the spring channel model.

2 General sampling information

The sampling protocols described in this manual are generally based on the methods described in Davies (1994), modified for Western Australian conditions.

2.1 When to sample

There are two windows for sampling macroinvertebrates, either spring or autumn. For the south-west, spring sampling is to occur between August and October to as late as mid-November for high rainfall sites. Autumn sampling is to occur between January to March to as late as mid-April for well-watered sites. In the north-west, spring sampling is to be conducted between September to October and autumn sampling between March to May. Sampling is always to be undertaken during base-flow conditions; therefore, the exact date of sampling in any one year will be determined by the rainfall patterns for that year, and may fall outside of the recommended sampling time frames given above (i.e. a late winter will probably dictate later than normal sampling).

Never sample within two weeks of a large flow event, as this may have washed macroinvertebrates away causing sites to score more poorly than they should. It is also difficult to sample swollen streams.

It is important to note that macroinvertebrate data is not readily comparable across seasons. So, if sampling is to occur only once a year, ensure that the same season is sampled each year (spring sampling is the best option in this case).

2.2 Site location

AUSRIVAS assessments are conducted over a 100 m reach. The macroinvertebrate sample is collected from a 10 m stretch centrally located within the 100 m reach. As the correct habitat must be sampled (see section 2.3) it may not be possible to collect the macroinvertebrate sample from a 10 m unbroken area of a particular habitat. If this is not possible, then sample a number of shorter stretches of the required habitat, near the centre of the 100 m reach, ensuring that a total of 10 m is sampled.

2.3 Habitats to sample

Macroinvertebrate distribution and abundance is strongly related to habitat. To allow comparison between data it is critical that the same habitat is sampled over time at a site and also (generally) the same habitat at different sites (unless the effect of habitat is the topic of study). If the intent is to run the data through the AUSRIVAS models, then channel habitat will ideally need to be sampled, as the channel models are the most reliable. It is not valid to run data through a model if it was not collected from the habitat for which that model was developed.

If there is no intent to run the collected data through the AUSRIVAS models, then other habitats may be sampled. The AUSRIVAS methodologies supply a standard collection method, which has been extensively tested to ensure that the macroinvertebrates collected are representative of those present at the site across a range of habitats. The four main habitat types encountered in rivers are:

- Channel habitat – the central part and margins of the main channel without riffles, submerged macrophytes or pool rocks. Areas of emergent sedges and shrubs along the banks should be avoided. Some sampling must occur in the central channel but, if possible, sampling should also occur along bare stream edges. Detritus and leaf packs should be sampled if they occur in the central channel and edges (Halse et al. 2001b).
- Macrophyte habitat – areas of submerged vegetation, usually in the central part of the channel, and fringing emergent vegetation on the stream banks. Emergent vegetation may consist of sedges or shrubs growing in the water or draped into it (Halse et al. 2001b). Floating macrophytes are also classed as macrophyte habitat.
- Pool habitat – deeper areas with very slow-flowing water (Nichols et al. 2000).
- Riffle habitat – areas of flowing, broken water over gravel, pebble, cobble or boulder (this can also be formed by the presence of bricks and other building rubble in waterways), with a depth greater than 10 cm (Nichols et al. 2000).

Section 3.1 outlines the appropriate sampling method for each of the four habitats.

2.4 Sampling order

Sampling should be conducted in such a way as to minimise contamination. For this reason the recommended sampling order is:

- 1 chemical variables
- 2 physical variables
- 3 habitat variables
- 4 macroinvertebrate sweep.

While moving through the water before taking the macroinvertebrate sample, take care not to disturb the area from which the macroinvertebrate sample is to be collected. If the above order is not followed, then chemical and physical samples should be collected upstream of where the macroinvertebrate sample was taken, in order to prevent contamination.

If more than one site is to be sampled in a waterway, then the most downstream site should be sampled first and the remainder of the sampling be carried out while working upstream. Again, this is to prevent contamination of downstream sites by disturbance at upstream sites due to earlier sampling.

3 The macroinvertebrate sample

Macroinvertebrate samples are collected using a 250 µm mesh pond net. The recommended dimensions are a 350 by 250 mm opening, a 50 to 75 cm depth (tail) and a 1 to 1.5 m handle. Nets with longer tails are better than nets with shorter tails, especially when sampling fast-flowing sites, as a longer tail will help prevent reflux of materials. Check the net for holes before use at each site.

3.1 Collecting the macroinvertebrate sample

Note that the technique used for collecting macroinvertebrates varies depending on the habitat being sampled. As discussed in section 1, the only habitat for which there are reasonable AUSRIVAS models is channel habitat. Models also exist for macrophyte habitat but these are not as robust as the channel habitat models. So, if the intent is to run the data collected through the AUSRIVAS models, channel habitat should be sampled. As there may be occasions where other habitats need to be sampled (where the data is not being run through the AUSRIVAS models) instructions for sampling the four main habitat types are given below.

Channel habitat

Check the net to ensure it is clean and has no tears or holes in it. Start sampling at the downstream end of the 10 m sampling area and move upstream while collecting the sample. Sweep the net vigorously through the water column using short vertical lifts to disturb the substrate and dislodge any organisms there; then sweep the net through the disturbed substrate that has been suspended. When conducting your sweep, ensure that the net moves through the entire water column and that you sample all the different sub-components of the habitat and at different depths (see section 2.3 for definitions of habitats). At all times the net must be kept moving forward through the water to ensure that nothing swims back out of the net once it has been collected.

If the site has a particularly fast flow, a stony substrate and the water is reasonably shallow, then kick sampling may be appropriate. Face downstream and place the base of the net on the substrate with the opening facing towards you. Work your way upstream, using your feet to kick and dislodge the substrate, collecting the suspended substrate in the net.

If the net begins to fill with detritus/cobbles etc., it may be necessary to empty out the contents into a bucket with some water and then continue sampling until the full 10 m has been sampled.

Macrophyte habitat

Check the net to ensure it is clean and has no tears or holes in it. Start sampling at the downstream end of the 10 m sampling area and move upstream while collecting the sample. Sweep the net vigorously through the aquatic vegetation present to dislodge any organisms attached to the vegetation; then sweep the net through the

water to collect these. Sample at all heights along the vegetation. To do this, sweep from the base of the plants all the way to the point where they protrude from the water. Make sure that all macrophyte species in the 10 m sampling area are sampled.

If the net begins to fill with detritus/cobbles etc., it may be necessary to empty out the contents into a bucket with some water and then continue sampling until the full 10 m has been sampled.

Pool habitat

In pool habitat, the same sampling technique is used as for channel habitat (with the exception that kick sampling is not employed as there will be no fast-flowing water present).

Riffle habitat

Check the net to ensure it is clean and has no tears or holes in it. Start sampling at the downstream end of the 10 m sampling area and move upstream while collecting the sample. Riffle habitats are sampled using a kick sampling technique. Face downstream and place the base of the net on the substrate with the opening facing towards you. Work your way upstream, using your feet to kick and dislodge the substrate, collecting the suspended substrate in the net.

If the net begins to fill with detritus/cobbles etc., it may be necessary to empty out the contents into a bucket with some water and then continue sampling until the full 10 m has been sampled.

3.2 Processing the macroinvertebrate sample

There are two methods of macroinvertebrate processing which can be used, a 60-minute live pick or box sub-sampling. Both techniques are carried out in the field with live animals. The WA models were developed using samples that had been live-picked; however, Halse et al. (2001a) found that using sub-sampling more readily distinguishes between pristine and disturbed sites.

60-minute live pick

Before starting the live pick ensure that as much silt and clay as possible has been rinsed out of the net. Do this by swirling the net around in the water, taking care not to let any more water in through the mouth of the net, until the water running out is clear.

If there are any large pieces of debris present in the net, rinse them carefully (in the net) to ensure there are no macroinvertebrates sticking to them and then discard them. Set up the stack of sieves (16 mm, 2 mm, 500 μ m and 250 μ m aperture size) with the largest aperture size on top, grading down to the smallest aperture size on the bottom. Empty the contents of the net into a bucket of clean water and swirl vigorously to separate the mineral substrate from the organic component of the sample. Pour the water from the bucket (containing the macroinvertebrates and

organic material) through the sieves. It is usually necessary to add more water to the bucket, swirl again and pour out the water a number of times before all of the macroinvertebrates have been removed from the sample. Then, agitate the stack of sieves in the water to separate the contents into the four size fractions. Be very careful not to lose any of the sample at this stage. Empty each of the four sieves into separate large white sorting trays.

The sample must then be picked for a total of 60 minutes. So, if two samplers will be conducting the live pick, each sampler must pick for 30 minutes. While picking ensure that each tray is examined and swap trays between samplers during picking to help ensure no taxa are missed.

Use forceps or pipettes to remove macroinvertebrates from the tray and place into a vial containing 70 per cent ethanol. Ensure a label has been placed in the vial (see Appendix E for labels). The aim of live picking is to maximise the diversity of families picked. Start by collecting common, abundant taxa for about the first five minutes, keeping a tally of animals picked on the WA AUSRIVAS macroinvertebrate field sheet (see section 5.4 for instructions on how to complete this sheet and Appendix D for a copy of the sheet). After the first five minutes, focus on collecting rarer and inconspicuous taxa. A total of 200 animals need to be picked, with no more than 10 representatives of any one family except for Chironomidae where a total of 30 animals should be picked. Continue to keep a tally of animals picked on the field sheet. Do not pick microcrustaceans (copepods, ostracods and cladocerans) as these are not used in the models.

If, after the total picking time of 60 minutes has elapsed 200 animals have not been collected, continue picking for a further 10 minutes. If 200 animals are reached during the extra picking time, stop picking. If 200 animals have not been reached during the extra picking time and new taxa were found during the extra time continue for another 10 minutes. Only stop picking once 200 animals have been collected or no new taxa were found in the previous 10 minutes of picking.

When picking, take special care to collect cryptic taxa. Groups that are commonly missed when live sorting are Elmidae larvae, Oligochaete, Empididae, Hydroptilidae Ceratopogonidae and small molluscs (especially Ancyliidae) – check for these at the end of the pick as they may be stuck to the bottom of the tray.

Once the live pick has been completed, the log abundance of each of the families needs to be estimated (for the entire sample). The codes to use are as follows:

1 = less than 10 members of the family found

2 = 11 to 100 members of the family found

3 = 101 to 1000 members of the family found

4 = greater than 1000 members of the family found.

Box sub-sampling

Before using the box sub-sampler, ensure that as much silt and clay as possible has been rinsed out of the net. Do this by swirling the net around in the water, taking care

not to let any more water in through the mouth of the net, until the water running out is clear.

If there are any large pieces of debris present in the net, rinse them carefully into the net to ensure there are no macroinvertebrates sticking to them and then discard them. Empty the contents of the net into a bucket of clean water and swirl vigorously to separate the mineral substrate from the organic component of the sample. Pour the water from the bucket (containing the macroinvertebrates and other organic material) into the box sub-sampler, taking care not to let the sample overflow out of the sub-sampler. It is usually necessary to add more water to the bucket, swirl again and decant the water a number of times before all of the macroinvertebrates have been removed from the sample. If the box sub-sampler gets too full during this process, lift out the inner portion and allow the excess water to drain through the bottom. Pour the excess water out of the tray as required.

Once all the macroinvertebrates have been placed in the box sub-sampler pour in enough water to cover the tops of the cells by approximately one cm. Then, place the lid onto the box sub-sampler and agitate it to distribute the sample evenly across the cells. Open the sub-sampler and remove the inner portion and pour out some of the water from the tray so that the water reaches below the top of the cells when the inner portion is re-inserted. Then, randomly select a cell (two eight-sided dice work well for this, assuming your box sub-sampler is eight cells by eight cells in size) and extract the contents using a hand pump and conical flask.

Tip the contents of the conical flask into a white sorting tray and pick out all the animals in the tray (with the exception of microcrustaceans Copepoda, Ostracoda and Cladocerans) using forceps and pipettes. Place the picked animals into a vial containing 70 per cent ethanol and a label (see Appendix E for vial labels). Keep track of the number of animals picked, using a hand-held counter or a tally. Once all the animals in the tray have been picked discard the remainder of the sample and randomly select a second cell and transfer this to the tray. Continue selecting cells and picking animals until a total of 200 animals is reached. Continue picking the cell which contained the 200th animal so that the entire cell has been picked. The purpose of this style of picking is to obtain a random sample of macroinvertebrates that accurately reflects the community structure of the larger sample. While all animals must be picked from a cell, this is relatively quick as there is only a small amount of material in any individual cell. Care must still be taken to ensure that cryptic taxa are not missed. Groups that are commonly missed when live sorting are Elmidae larvae, Oligochaete, Empididae, Hydroptilidae Ceratopogonidae and small molluscs (especially Ancyliidae) – check for these at the end of the pick as they may be stuck to the bottom of the tray.

Once a site has been completed, the box sub-sampler must be rinsed thoroughly to ensure that no macroinvertebrates remain in the sub-sampler.

3.3 Identifying the macroinvertebrate sample

Macroinvertebrate samples are to be identified in the laboratory using a dissecting microscope (for some specimens a compound microscope may be required).

Set up the microscope following the manufacturer's instructions. Rinse your sample in a 250 µm mesh sieve under running water to remove the ethanol. Place sample in a Petri dish with some water and identify animals to family level with the exception of Oligochaetes and Acarinids, which are left at order level. Chironomids are to be identified to sub-family. Ignore any microcrustaceans in the sample (Ostracods, Copeopods and Cladocerans) but include Conchostracans and Anostracans. Recommended taxonomic keys are listed in Appendix H.

If unsure about the identity of a particular animal obtain a second opinion from a colleague or local specialist.

As each animal is identified, place it into a glass Macartney bottle (or other suitable container) containing 70 per cent ethanol and a label (see Appendix F for vial labels). Keep a tally of each identified specimen on the macroinvertebrate identification sheet (see Appendix G for a copy of this sheet). Once the entire sample has been identified record the total number of animals in the sample, the number of taxa in the sample and the number of vials used on the macroinvertebrate identification sheet and place the vial in an evaporation proof box in a suitable storage location.

3.4 Quality control (QC) of macroinvertebrate samples

The information in this section has been sourced from Nichols et al. 2003.

QC of the live pick

All samples should be picked by two samplers, at least one of whom is experienced (having previously passed AUSRIVAS accredited QC for macroinvertebrate live sorting). At the conclusion of picking, samplers should compare the list of taxa each has picked. Unusual taxa should be shown to each other and, if one sampler is missing taxa, then the other should point them out when encountered in subsequent sampling.

The residue (after live-sorting) from the first five samples sorted and then from randomly selected samples (five or 10% of total samples) should be retained for further laboratory processing using the whole of individual sample estimate (WISE) procedure. Ensure that the residue sample is labelled appropriately.

Quality control staff should analyse the live-sort data using the WISE database, which is available for download from the AUSRIVAS website <http://ausrivas.canberra.edu.au/Bioassessment/Macroinvertebrates/Training/>. The WISE database compares the live-sorted component of a sample (LS) with an equivalent-sized representative of the whole sample (before sorting) (WSE, or whole

sample estimate). The database automatically calculates the LS/WSE taxa number ratio and various Bray-Curtis dissimilarity indices.

The preserved residues are sub-sampled in the laboratory using the following procedure:

- 1 Use a box sub-sampler to take a sufficient sub-sample of animals likely to result in slightly more animals than were live-sorted. Where less than 100 animals were live-sorted, a minimum sub-sample size of 100 animals is required.
- 2 Sort and identify the contents of sufficient cells to derive approximately 50 animals. This portion of the sub-sample is used to estimate the taxa and relative abundance of animals that are 'common' in the sample.
- 3 Sort the remainder of the sub-sample, ignoring (leaving behind) the taxa that were recovered in step 2.
- 4 Scale up the raw taxa abundances derived from step 2 to the full sub-sample fraction taken at step 1. Add together the relative abundances from step 2 (scaled up) and step 3, which now forms the sub-sample of the residue.
- 5 Enter the residue sub-sample and live-sort data into the WISE database to obtain a LS/WSE taxa number ratio and Bray-Curtis dissimilarity index.
- 6 To pass the WISE QA/QC process it is necessary that the following are achieved:
 - A sample size of 200 animals or, failing this, evidence to show that the sample was sorted for 60 minutes.
 - A sample size of > 20 for Chironomid larvae (target of 30) wherever the corresponding number in the WISE also exceeds this value.
 - A LS/WSE taxa number ratio > 0.9 (result displayed as 'Actual' LS/WSE in WISE macro results).
 - A Bray-Curtis dissimilarity measure (pres/abs) calculated between the LS and WSE that is < 0.3 (result displayed as 'Actual', 'Unadjusted Bray-Curtis: Pres/Abs' in WISE macro results).
 - A Bray-Curtis dissimilarity measure (pres/abs) calculated between the taxa in the live-sort component that are common to those in the residue, and all WSE taxa, that is ≤ 0.25 (result displayed as 'Actual', 'Bray-Curtis less taxa unique to LS Pres/Abs' in WISE macro results).

QC of the sub-sampled picks

For new samplers, projects or sampling runs, quality control staff should check for missing organisms in the residues of the first five samples sorted. To pass the QC process, 95 per cent of the total number of organisms in the sub-sample must be recovered. If one of the first five samples fails the QC protocol, the process begins again until five consecutive samples have passed.

Following the initial five samples, a random selection of samples should be checked for QC. The recommendation is that two samples are checked in the following 10,

two samples in the following 30 and two samples in the following 50 samples. If any of these samples fails the QC protocol, the sampler must again pass five consecutive samples.

Staff checking samples must have adequate experience in macroinvertebrate sample sorting. Where possible, QC of sample residues should be conducted by more than one person to avoid bias. If less than 95 per cent of the organisms are recovered from the sub-sample, commonly missing taxa should be shown to the sampler and suitable instructions given to rectify the problem. Sample record sheets should be fully completed while undertaking the QC checks using the following error code:

- CC: number of organisms recovered from the sub-sample represents less than 95 per cent of the total number of organisms in the sub-sample.

QC of macroinvertebrate identification

For new identifiers, projects or sampling runs, quality control staff should check for identification errors in the first five samples identified. To pass the QC process, a percentage taxa error of less than five per cent must be achieved. If one of the first five samples fails the QC protocol, the process begins again until five consecutive samples have passed.

Following the initial five samples, a random selection of samples should be checked for QC. The recommendation is that two samples are checked in the following 10, two samples in the following 30 and two samples in the following 50 samples. If any of these samples fails the QC protocol, the identifier must again pass five consecutive samples.

To calculate the 'percentage taxa error' count the number of 'taxa errors' (a 'taxa error' is defined as a misidentification resulting in the loss or addition of a taxon) and divide this by the 'total number of original taxa'. Multiply the outcome by 100. The grid below may be useful in performing calculations.

Percentage taxa error	
Number of taxa errors (a)	
Total number of original taxa (b)	
Percentage taxa error ($[a/b] \times 100$)	
Pass or fail? (pass if $\leq 5\%$)	

4 Water quality sampling

Water samples need to be collected for chemical analysis and in situ physical measurements need to be taken.

A number of observations are also recorded on the appropriate field sheets.

Section 5 outlines how to fill out the AUSRIVAS field sheets.

The sampling procedures for collecting water samples and taking in situ readings are outlined in the following two guideline documents:

Department of Water 2009a, *Water quality monitoring program design. A guideline to the development of surface water quality monitoring programs.*

Department of Water 2009b, *Surface water sampling methods and analysis – technical appendices. Standard operating procedures for water sampling methods and analysis.*

Both are available from the Department of Water's website and should be referred to for detailed sample collection information.

4.1 Collecting water samples for chemical analysis

Two water quality samples need to be collected at each site, a 250 mL sample for the analysis of alkalinity, turbidity, total nitrogen (TN) and total phosphorus (TP), and a 125 mL filtered sample to analyse true colour, soluble reactive phosphorus (SRP-P), nitrogen oxides (NO_x-N) and ammonia nitrogen (NH₄-N/NH₃-N).

Table 1 summarises the bottle, filling, storage and maximum holding times for each of the chemical variables.

See Department of Water 2008a and Department of Water 2008b for detailed information on collecting chemical water quality samples.

Table 1 Summary of requirements for sample collection.

Variable	Filtering requirements	Bottle type/size	Filling requirements	Preservation/treatment	Storage	Max. holding time
TN & TP	Unfiltered	250 mL HDPE	To shoulder	None	Refrigerate at 1–4°C	7 days ^B
					Freeze	30 days
NO _x -N, NH ₄ -N/NH ₃ -N, SRP-P, True colour	Filtered, 0.45 µm filter.	250 mL HDPE	Complete (no bubbles)	Keep out of sunlight	Refrigerate at 1–4°C	1–3 days ^B
Turbidity (NTU), Total Alkalinity as CaCO ₃	Unfiltered	250 mL HDPE	Complete (no bubbles)	Keep out of sunlight	Refrigerate at 1–4°C DO NOT FREEZE	1 day

HDPE = High density polyethylene

^B = Guideline experimentally derived by Hosking Chemical Services for CSIRO and the Water and Rivers Commission

The chemical samples are then transported to an appropriate laboratory, under chain of custody, for the required analysis.

4.2 Taking the in situ readings

A multi-probe is used to collect in situ physical readings for pH, temperature, dissolved oxygen and conductivity. See Department of Water 2008a and Department of Water 2008b for detailed instructions on how to take in situ physical water quality readings.

5 WA AUSRIVAS field sheets

There are three field sheets which need to be completed as part of the WA AUSRIVAS sampling. These are:

- WA AUSRIVAS site information sheet (2 pages)
- WA AUSRIVAS field sampling sheet (3 pages)
- WA AUSRIVAS macroinvertebrate sampling field sheet (2 pages)

Detailed information on how to fill out these sheets is contained in the sections below.

5.1 Completing the WA AUSRIVAS site information sheet

The site information sheet consists of two pages, a portion of which is to be filled out in the office, preferably before commencing field work (though this may not always be possible). This sheet is to be filled out in its entirety, leaving no blank spaces. If sections are not applicable then note this down on the sheet. Leaving blank spaces can lead to confusion as it will not be clear later if a space was left blank because it was forgotten, because it was not applicable, or because a zero value was recorded.

Site information box

Site name

This is the name of the site at which sampling is to take place.

Location code

This is the site code.

River system

This is the name of the river system on which your site is located.

River name

This is the name of the river on which your site is located. In some cases, this is the same as the river system but this will not always be the case (for example, sampling may occur on a tributary to a larger river system in which case the river system name will be that of the larger system, but the river name will be that of the tributary).

Altitude (m)

The altitude (in m) of the site above sea level.

Slope (m/km)

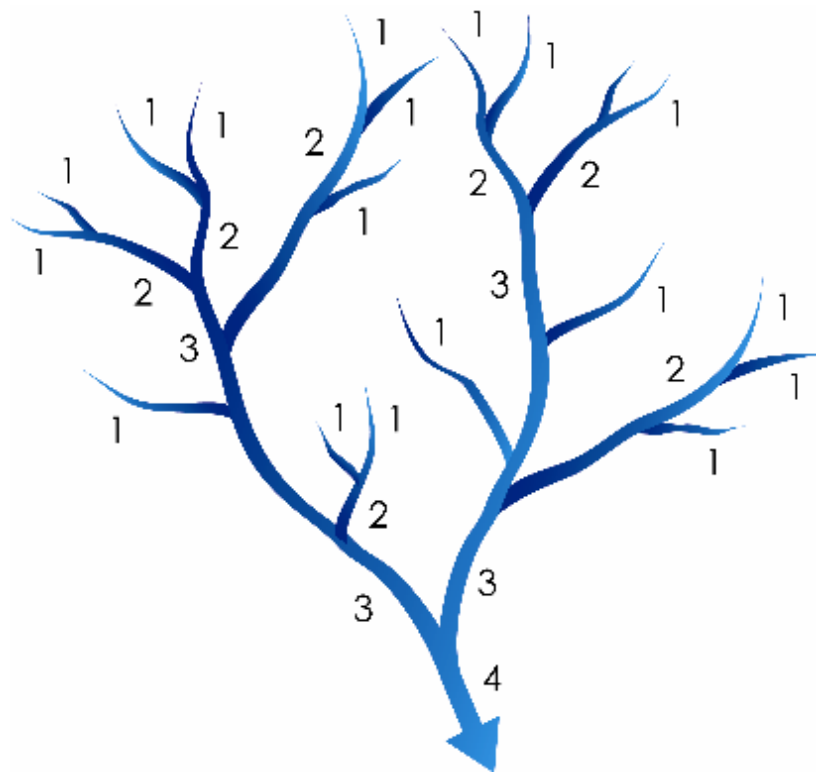
The slope (in m/km) of your river section.

DFS (km)

The distance (in km) between the source of the stream and the site being assessed.

Stream order

The stream order using the Strahler method (1952). Using this method, the streams furthest from the discharge point are the first-order streams. Two first-order streams combine to form a second-order stream, two second-order streams combine to make a third-order stream and so on. The figure below illustrates this.



Flow pattern category

Refers to the period of time that the water at the site is flowing (note, this refers to the period of flow, not the length of time water is present).

- 1 = permanent – water flowing year round, all years
- 2 = semi-permanent – water flowing year round, most years
- 3 = seasonal – subject to predictable seasonal flow
- 4 = episodic – prone to major flood events following which there is no flow.

Discharge category

Refers to the volume of water discharged in megalitres per annum. Again, this is a category:

- 1: 10 to 100 ML/a
- 2: 100 to 1000 ML/a
- 3: 1000 to 10 000 ML/a
- 4: 10 000 to 100 000 ML/a
- 5: 100 000 to 1 000 000 ML/a
- 6: 1 000 000 to 10 000 000 ML/a.

Test/reference

Refers to whether the site that is being sampled is a test or reference site. Reference sites are those with minimal or no human impacts, which are used for constructing models and as a comparison point during data analysis. Generally sites will be test sites.

Nearest rainfall station

The code or name of the nearest rainfall station to the site.

Av. ann. rainfall

The average annual rainfall as recorded at the nearest rainfall station.

GPS and map details box***GPS datum***

The datum in which the GPS is recording in.

Latitude

The latitude as recorded on the GPS. It does not matter which format this is recorded in as it can be converted. The model requires it in decimal degrees to four decimal places.

Longitude

The longitude as recorded on the GPS. It does not matter in which format this is recorded, as it can be converted. The model requires it in decimal degrees to four decimal places.

Zone

The grid zone designation for the area in which the site is located.

Easting

The easting of the site.

Northing

The northing of the site.

Map name

If a map was used to determine the site location information, then record the map name.

Scale

If a map was used to determine the site location information, then record its scale.

Number

If a map was used to determine the site location information, then record the map number.

Edition

If a map was used to determine the site location information, then record the map edition number.

Joining map names/number

If a map was used to determine the site location information, then record the adjoining map names and numbers.

Access details box

Directions

Record sufficient directions to ensure that the site can be visited in subsequent years (remembering that there may be different people undertaking the sampling).

Property owner

If the site is located on private property record the property owner's name.

Phone number

Record the contact phone number for the owner (or manager if relevant) of the property to allow future contact if required.

Address

Record the physical address of the property where the site is located. It may also be worth recording the address of the owner if it is different to the property address.

Notify before each visit

Tick 'yes' or 'no' depending on whether the owner/manager requires notification before each visit.

Permission required

Tick 'yes' or 'no' depending on whether the owner/manager needs to grant permission before each visit.

Key required

Tick 'yes' or 'no' depending on whether a key is required to access the site.

Key number/available from

Record what number key is required and from where it can be obtained.

Sketch of access route

Make a sketch of the access route to the site containing as much information as possible to allow future samplers to find the site. The sketch must be as clear as possible and include the following (as a minimum):

- the river being sampled
- flow direction
- site location within the river

- nearby roads
- any river crossings
- access details (location of turn-offs, distances and landmarks leading to the site)
- a north arrow.

Sketch of reach

Make a sketch of the 100 m reach in which the site is located. The sketch must be as clear as possible to allow future samplers to find the site and must include the following (as a minimum):

- location of riffle, channel, pool and macrophyte habitats within the reach
- flow direction
- access point
- sampling location
- a north arrow.

5.2 Completing the WA AUSRIVAS field sampling checklist

The field sampling checklist consists of two pages.

General information

River

Record the river name here. This is the same as that recorded on the site information sheet.

Sampling date

The date of sampling.

Location code

This is the site code. Record the same code as that recorded on the site information sheet.

Completion checklist box

This checklist is to be completed before leaving each site. Work down the checklist and tick off each item once it has been completed. Using this checklist will help ensure that nothing is forgotten when undertaking fieldwork.

Instrument calibration box

Record details of the instrument being used as well as the pre- and post-field calibration information in this table.

Equipment checklist

This checklist can be used when packing for field work. The list may not include everything that is required for your particular sampling.

5.3 Completing the WA AUSRIVAS field sampling sheet

The field sampling sheet consists of three pages. This sheet is to be filled out in its entirety, leaving no blank spaces. If sections are not applicable, then note this down on the sheet. Leaving blank spaces can lead to confusion as it will not be clear later if a space was left blank because it was forgotten, because it was not applicable, or because a zero value was recorded.

Sample information box

Date

Record sampling date here.

Time

Record time of sampling here.

Location code

This is the site code. Record the same code as that recorded on the site information sheet.

River name

This is the name of the river on which your site is located. In some cases, this is the same as the river system but this will not always be the case (for example, sampling may occur on a tributary to a larger river system in which case the river system name will be that of the larger system, but the river name will be that of the tributary).

Site name

This is the name of the site at which sampling is to take place.

Recorders name

The name of the person who is filling out the field sampling sheet.

Sample collected by

The name of the person who is collecting the water quality samples.

Habitat

The name of the habitat that is being sampled. This will generally be channel. See section 2.3 for a definition of the different habitat types.

% of 100 m reach

The percentage that the habitat being sampled contributes to all of the habitat available in the 100 m reach. The schematics in Appendix C may be useful.

Sample number

The sample number for the water quality samples.

COC number

The chain of custody number.

Water quality and habitat in reach

Water samples taken check boxes

Tick off as the water samples are collected.

Physical readings (water temperature, pH etc.)

Record the readings for each of the variables in the left-hand column and the instrument used in the right-hand column. Note that default units have been entered and may need to be changed. If wind direction and wind speed are estimated, then write 'obs' (for observation) in the instrument column.

Habitat area

Record the percentage cover of each of the four main habitat types (see section 2.3 for a definition of the main habitat types). If a habitat type is not present, then a '0' must be recorded. Note that these four must add to 100. The schematics in Appendix C may be useful.

Stream width

Take three measurements of the stream width over the 100 m reach and record them. Average the three readings and record this also.

Comments

Record any comments pertaining to the first page of the field sampling sheet here.

Weather

Rain in past week

Tick either 'yes' or 'no' depending on whether there has been rain in the week before sampling.

Rain today

Note whether or not there has been rain on the day of sampling.

Cloud cover

Estimate the percentage cloud cover present at the time of sampling. The schematics in Appendix C may be useful.

Comments

Record any general comments on the weather. For example, if there has been rain either in the past week or on the day of sampling, write down observations regarding this rainfall here.

General information

River

Record the river name here, this is the same as that recorded on the site information sheet.

Sampling date

The date of sampling.

Location code

This is the site code, record the same code as that recorded on the site information sheet.

Observations

With all of the observations, if the incorrect category is circled, cross it out and circle the correct one.

Water odours

Before entering the water body, determine if the water has any odour and circle the appropriate category.

Water oils

Before entering the water body, determine if there are any oils present on the surface of the water and circle the appropriate category.

Turbidity

Before entering the water body, take note of how turbid the water is and circle the appropriate category. Bear in mind that colour and turbidity are two different things.

Colour

Before entering the water body, determine if the water is coloured or not. Bear in mind that colour and turbidity are two different things.

Plume

When moving around in the water body take note of how much sediment is being kicked up and circle the correct category.

Sediment oils

When moving around in the water body, take note of any oils that are disturbed from the sediment and circle the appropriate category.

Sediment odours

When moving around in the water body, take note of any odours that are disturbed from the sediment and circle the correct category.

Water level

Take note of the water level and circle the correct category. This level is recorded in relation to the height of the water as compared to the water mark (the normal

inundation level). This can often be determined by examining staining on surrounding vegetation and infrastructure, level of erosion, boundary in bank sediment types etc. Circle the appropriate category.

Sediment deposits

Take note of any sediment deposits which occur along the reach and circle the appropriate category.

Algae on substrate

Before entering the water body, take note of any algae growing on the substrate (i.e. river bed, rocks, submerged and emergent macrophytes) and circle the appropriate category.

Algae in water column

Before entering the water body, observe the water column to see if there is any algae visible. Circle the appropriate category.

Are the undersides of stones ... black

Turn over a few stones in the water and observe the colour of the sediment attached to these stones. Circle the appropriate category (if there are no stones present, circle n/a).

Local catchment erosion

Observe the catchment surrounding the site for evidence of erosion. Circle the appropriate category.

Local PS pollution

This refers to any potential point sources of pollution in the catchment close to the site. Examples of point source pollution include piggeries, landfill and industry discharging directly to the waterway. Circle the appropriate category and note down the potential/obvious point sources of pollution.

Local NPS pollution

This refers to any potential non-point sources of pollution in the catchment. Examples of non-point sources of pollution include land uses such as agriculture and urban. Circle the appropriate category and note down the potential/obvious sources of non-point source pollution.

Dams/barriers

This refers to the presence of dams/barriers in the catchment. Take note of any dams/barriers observed or known to exist in the catchment and circle the appropriate category. If they are present, circle whether they are upstream or downstream (or both) and give some details as to the type of dam/barrier.

River braiding

This refers to the presence or absence of river braiding in the reach being sampled. Circle 'yes' or 'no' as appropriate and, if 'yes' has been circled, note down the

number of braids present. Note that where there is a single channel there are no braids present (circle 'no'); where the river is split into two it is considered to be one braid, three is two braids etc.

Land use

This refers to the dominant land-use categories on the left- and right-hand banks in the reach being sampled. The definitions for the categories are given in the field sheet. Note that the right-hand bank is defined as the bank on the right when facing downstream. Circle all the appropriate categories for each bank.

Riparian zone box

This is assessed over the entire 100 m reach and to a maximum width of 100 m. Record the average width of the riparian zone for both the left and right bank. Then estimate the percentage cover of each of the vegetation types (Appendix C provides guidelines for estimating percentage cover). As both trees and grasses (and other combinations) can occur over a single patch of ground, the total percentages can add to more than 100 per cent. Circle the appropriate categories for the different vegetation types. If an incorrect category is circled, cross it out and circle the correct category.

Habitat assessment

For each of the different headings in this table, circle the appropriate category. If an error is made, cross out the incorrect selection and circle the correct one. Note that some of the categories are assessed on both banks.

Degree of naturalness

This refers to the naturalness of the site, ranging from 'pristine' to 'totally altered'. Use the following rough guide to assist scoring:

- If the site is very impacted, that is the catchment is largely cleared, fringing vegetation has been removed and the channel has been modified, then give the site a low score (approx. 0 to 3).
- If the site has obvious evidence of disturbance to the riparian zone, the catchment is largely cleared and there is some evidence that upstream activities are having an impact on the site (i.e. there is evidence of sedimentation occurring) then score the site as moderately disturbed (approx. 7 to 9).
- If the site has a reasonably intact riparian zone, a catchment that is not entirely cleared and there is not too much evidence that upstream activities are having an impact on the site (i.e. there is only limited sedimentation occurring) then score the site as minimally disturbed (approx. 12 to 14).
- If the site is in a national park with intact fringing vegetation, a largely uncleared catchment and there is no evidence that upstream activities are having an impact on the site, score this high (approx. 18 to 20).

Catchment condition

This refers to the extent of clearing and types of land use in the catchment. This is scored based on observations in the field and what can be determined from maps or GIS. The following rough guide may assist scoring:

- If the catchment is fully cleared for intensive agriculture/urbanisation, then give the site a low score (approx. 2).
- If the catchment is partially cleared for grazing, give it a moderate score (approx. 9 to 10).
- If the catchment is partially under plantation, or has been recently logged and partially uncleared, give it a reasonably high score (approx. 15).
- If the catchment is entirely forested but there has been some previous logging activities, then give a high score (approx. 16 to 18).

Land use at site

This is based on the land use occurring within 500 m of either side of the channel and about 1 km upstream of the site. Note that this is scored independently for both banks. Score according to likely impact using the rough guide below:

- If the land use is intensive agriculture/housing/industry, give it a low score (approx. < 4).
- If the land use is plantations, give it a reasonable score (approx. 5 to 7).
- If the land use is old forest or uncleared bush, give it a high score (approx. 9 to 10).

Physical substrate characterisation

This score is based on the physical habitat heterogeneity at the site. The following rough guide will assist with scoring:

- Lack of substrate types and spaces: bedrock only, scores very poorly (approx. 0 to 5).
- Minimal substrate diversity: very few interstitial spaces; for example, sand or silt (or a mix of sand and silt), scores poorly (approx. 6 to 10).
- Sub-optimal mix of substrate types: not many interstitial spaces; for example mainly sand with some pebbles and boulders, scores moderately (approx. 11 to 15).
- Optimal mix of substrate types: many interstitial spaces; for example, a mix of boulders, pebbles, sand etc., scores highly (approx. 16 to 20).

Biological substrate characterisation

This score is based on the amount of variability in the biological substrate. Use the following rough guide for scoring:

- Complete absence of detritus and epiphytes, scores very poorly (approx. 0 to 5).

- Minimal: only a little amount of leaf litter, epiphytes etc. present scores poorly (approx. 6 to 10).
- Sub-optimal: some leaf litter, epiphytes etc. present, scores moderately (approx. 11 to 15).
- Optimal: a mix of decaying twigs, leaf litter, epiphytes etc., scores highly (approx. 16 to 20).

Vegetative protection

This score is based on the condition of the riparian vegetation and the intactness of all layers. Note that the left- and right-hand banks are dealt with separately for this score. Use the following rough guide for scoring:

- A few scattered trees gets a low score (approx. 1 to 2).
- Good tree vegetation but no understorey gets a moderate score (approx. 4 to 5).
- Dense trees, shrubs, sedge/grass vegetation with no weeds or disturbance gets a high score (approx. 9 to 10).

Width of riparian vegetation

This score is based on the unbrokenness (longitudinal continuity) of the riparian vegetation. Deduct points if tracks come in. Note that the left- and right-hand banks are dealt with separately for this score. Use the following rough guide to assist with scoring:

- 5 m of unbroken riparian vegetation gets a poor score (approx. 2).
- 10 m of unbroken riparian vegetation gets a fairly moderate score (approx. 4 to 5).
- 50 m of unbroken riparian vegetation gets a fairly high score (approx. 8).
- 500 m of unbroken riparian vegetation gets a high score (approx. 10).

Bank stability

This score is based on how much erosion has occurred and how likely the bank is to release sediments. Note that the left- and right-hand banks are assessed separately for this score. Use the following rough guide to assist with scoring:

- Bare soil banks with evidence of erosion get a poor score (0 to 2). Note that obvious tree/shrub roots holding soil in place may increase the score on bare-soil banks.
- Upright, or undercut banks with evidence of soil erosion get a low score (approx. 3 to 5).
- Banks that are vegetated but show some signs of erosion score moderately (approx. 4 to 7).
- Well-vegetated, sloping banks get a high score (approx. 9 to 10).

Sediment deposition

This score refers to the volume of sand/silt that has settled on the stream bed. Use the following rough guide to assist with scoring:

- Large soft sand deposits (rather than hard sand) or silt deposits get a low score (approx. < 4).
- Some silt or sand deposits in slow-flowing parts of the channel gets a moderate score (approx. 10 to 13).
- Boulder and cobble bed with minimal sand gets a high score (approx. 19 to 20)

Bear in mind that some sites will naturally have a sand bottom and this should not be confused with sedimentation.

Impoundments, abstraction or channelisation

Assign a score based on the likely effect, proximity and number of these impacts. Use the following rough guide to assist with scoring:

- If the site is immediately below a dam that has dramatically reduced or altered flow, give a low score (approx. 0 to 1).
- If the site is below a section of channelised river, give a lowish score (approx. 5 to 6).
- If the site is below a pump extracting water, score around 10 depending on the impacts of the pump on the flow volume.
- If the impacts occur well upstream of the site, then assess the likely cumulative impacts and give a reasonably high score (approx. 11 to 18).

5.4 Completing the WA AUSRIVAS macroinvertebrate sampling field sheet

The macroinvertebrate sampling field sheet consists of two pages. This sheet is to be filled out in its entirety, leaving no blank spaces. If sections are not applicable then note this down on the sheet. Leaving blank spaces can lead to confusion as it will not be clear later if a space was left blank because it was forgotten, because it was not applicable, or because a zero value was recorded.

Sample information box

Date

Record sampling date here.

Time

Record time of sampling here.

Location code

This is the site code, record the same code as that recorded on the site information sheet.

River name

This is the name of the river on which your site is located. In some cases, this is the same as the river system but this will not always be the case (for example, sampling may occur on a tributary to a larger river system in which case the river system name will be that of the larger system, but the river name will be that of the tributary).

Site name

This is the name of the site at which sampling is to take place.

Recorder's name

The name of the person who is filling out the field sampling sheet.

Sample collected by

The name of the person who is collecting the macroinvertebrate sample.

Habitat

The name of the habitat that is being sampled. This will generally be channel. See section 2.3 for a definition of the different habitat types.

% of 100 m reach

The percentage that the habitat being sampled contributes to all of the habitat available in the 100 m reach. The schematics in Appendix C may be useful.

Sample number

The sample number for the water quality samples.

COC number

The chain of custody number.

Sampling conditions

Use the tick boxes to give some indication as to how easy it was to collect the sample. This information is useful during data analysis, as the ease in which a sample was collected will have an impact on the number and types of macroinvertebrates collected.

Picking conditions

Use the tick boxes to give some indication as to how easy it was to sort the sample. This is applicable to both live and box sub-sampler picking. This information is useful during data analysis as the ease in which a pick was carried out will have an impact on the number and types of macroinvertebrates collected.

Habitat assessment box

The habitat assessment is conducted over the 10 m sampling area only, not the entire 100 m reach.

Mineral substrate

Record the percentages of the different types of mineral substrate found in the 10 m sampling area here. To help determine the size classes, use the guide below (this is also included on the bottom of the field sheet):

- boulder – anything bigger than a soccer ball
- cobble – cricket ball to soccer ball size
- pebble – five cent piece to cricket ball size
- gravel – raw sugar grain to five cent piece size
- sand – smaller than raw sugar grain
- silt or clay – less than 1 mm in diameter.

If there is a particular mineral substrate which is not present, write a '0' in the % column, never leave anything blank as it is not possible for the person assessing the data to determine if this was forgotten or not present. In the total box, add up the percentages and record the value here. This must equal 100 per cent. If it does not, check the percentages recorded.

Breakdown of habitat surface area

Record the percentage of each habitat surface present in the 10 m sampling area. For those categories that have a density rating associated with them, circle the appropriate density category. If you record a '0' against any of the habitat surface area categories then do not record a density against that category. Add up the percentages and record this value in the total box. Note that the total may be greater than 100 per cent as many of the habitat types overlay each other.

Depth and velocity

Depth

The average depth in the 10 m area from which the macroinvertebrate sweep was taken. Circle the appropriate depth.

Velocity

The maximum and minimum velocity recorded in the area from which the macroinvertebrate sweep was taken. Record both the meter used and the velocity readings returned.

Live pick tally

Use this table to keep a tally of the macroinvertebrates collected during a live pick (see section 5.4 for more information on how to complete this table).

Box sub-sampler tally box

If a box sub-sampler is used for conducting the live sort then complete this section.

Appendices

Appendix A – Predictor variables for WA AUSRIVAS models

Spring channel model

Predictor variable	Definition
DISCHARGE CAT	Mean annual discharge in megalitres per annum (category) 1 = 10 to 100 ML/a 2 = 100 to 1000 ML/a 3 = 1000 to 10,000 ML/a 4 = 10,000 to 100,000 ML/a 5 = 100,000 to 1,000,000 ML/a 6 = 1,000,000 to 10,000,000 ML/a
LATITUDE	Latitude of site. Decimal degrees to four decimal places (omit the negative sign)
LOGMAXVELOCITYCM	Log 10 of the maximum flow velocity in habitat (log ₁₀ [cm/sec])
LONGITUDE	Longitude of site. Decimal degree to four decimal places
RAINFALL	Mean annual rainfall (mm)

Autumn channel model

Predictor variable	Definition
LATITUDE	Latitude of site. Decimal degrees to four decimal places (omit the negative sign)
LOGSTWIDTH	Log 10 of the mean stream width of water (log ₁₀ [m])
LONGITUDE	Longitude of site. Decimal degree to four decimal places
PARTSIZE	Substrate particle size index – derived value see Appendix B for calculation method
RAINFALL	Mean annual rainfall (mm)

Combined channel model

Predictor variable	Definition
LATITUDE	Latitude of site. Decimal degrees to four decimal places (omit the negative sign)
LOGALTITUDE	Log 10 of the altitude of the site (log ₁₀ [m])
LOGMAXVELOCITYCM	Log 10 of the maximum flow velocity in habitat (log ₁₀ [cm/sec])
LOGRAINFALL	Log 10 of the mean annual rainfall (log ₁₀ [mm])
LONGITUDE	Longitude of site. Decimal degree to four decimal places

Dry macrophyte model

Predictor variable	Definition
LATITUDE	Latitude of site. Decimal degrees to four decimal places (omit the negative sign)
LONGITUDE	Longitude of site. Decimal degree to four decimal places
ALTITUDE	Height above sea level (m)
DFS	Distance from source (km)
FLOWTYPE	Characteristic flow regime at site: 1 = perennial 2 = almost perennial

	3 = seasonal 4 = episodic
PH	pH at site
WATERTEMP	Water temperature at site (°C)
ALKALINITY	Total carbonates (mg/L)
RIPVEG	Riparian vegetation: percentage of surface area of the habitat that is riparian vegetation draped in water (%)
MAXVELOCITY	Maximum water velocity in the habitat (m/s)

Wet macrophyte model

Predictor variable	Definition
LATITUDE	Latitude of site. Decimal degrees to four decimal places (omit the negative sign)
LONGITUDE	Longitude of site. Decimal degree to four decimal places
ALTITUDE	Height above sea level (m)
DFS	Distance from source (km)
PH	pH at site
WATERTEMP	Water temperature at site (°C)
ALKALINITY	Total carbonates (mg/L)
EMERGMACRO	Emergent macrophytes: percentage of surface area of habitat that is emergent macrophytes
RIPVEG	Riparian vegetation: percentage of surface area of the habitat that is riparian vegetation draped in water (%)
MAXVELOCITY	Maximum water velocity in the habitat (m/s)

Combined macrophyte model

Predictor variable	Definition
ALKALINITY	Total carbonates (mg/L)
DFS	Distance from source (km)
EMERGMACRO	Emergent macrophytes: percentage of surface area of habitat that is emergent macrophytes
FLOWTYPE	Characteristic flow regime at site: 1 = perennial 2 = almost perennial 3 = seasonal 4 = episodic
LATITUDE	Latitude of site. Decimal degrees to four decimal places (omit the negative sign)
LONGITUDE	Longitude of site. Decimal degree to four decimal places
MAXVELOCITY	Maximum water velocity in the habitat (m/s)
PH	pH at site
RIPVEG	Riparian vegetation: percentage of surface area of the habitat that is riparian vegetation draped in water (%)
STREAMSLOPE	Slope of reach (m/km)

Appendix B – Calculating SHET, SURF and SIZE

If the autumn channel model is to be used, it is necessary to calculate the substrate particle size index (SIZE). To do this, the substrate heterogeneity index (SHET) must also be calculated.

Calculating SHET

There are eight categories for mineral substrate on the WA AUSRIVAS macroinvertebrate sampling field sheet. SHET is calculated by scoring a 1 for each substrate category that comprised at least 10 per cent of the surface area. The table below shows some examples of how SHET is calculated.

Variable	Site A (%)	Site B (%)	Site C (%)
Bedrock	0	0	98
Boulders	10	0	0
Cobble	20	5	0
Pebble	30	15	2
Gravel	20	15	0
Sand	20	25	0
Silt	0	40	0
Clay	0	0	0
SHET score	5	4	1

Calculating SURF

There are eight categories of habitat surface area on the WA AUSRIVAS macroinvertebrate sampling field sheet. SURF is calculated in the same way as SHET; that is; a variable has to comprise at least 10 per cent of the surface area to be included in the SURF score. See table below.

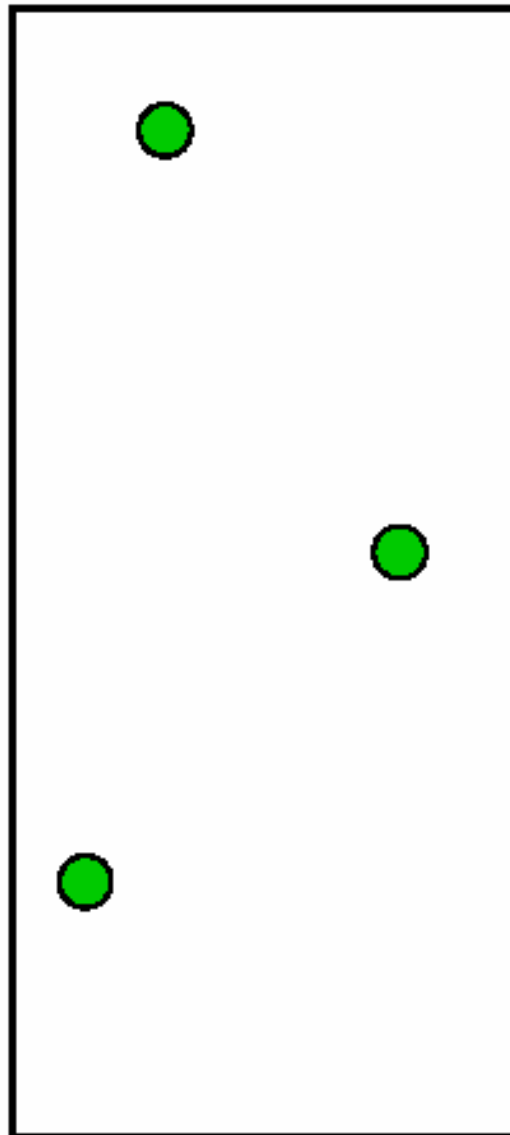
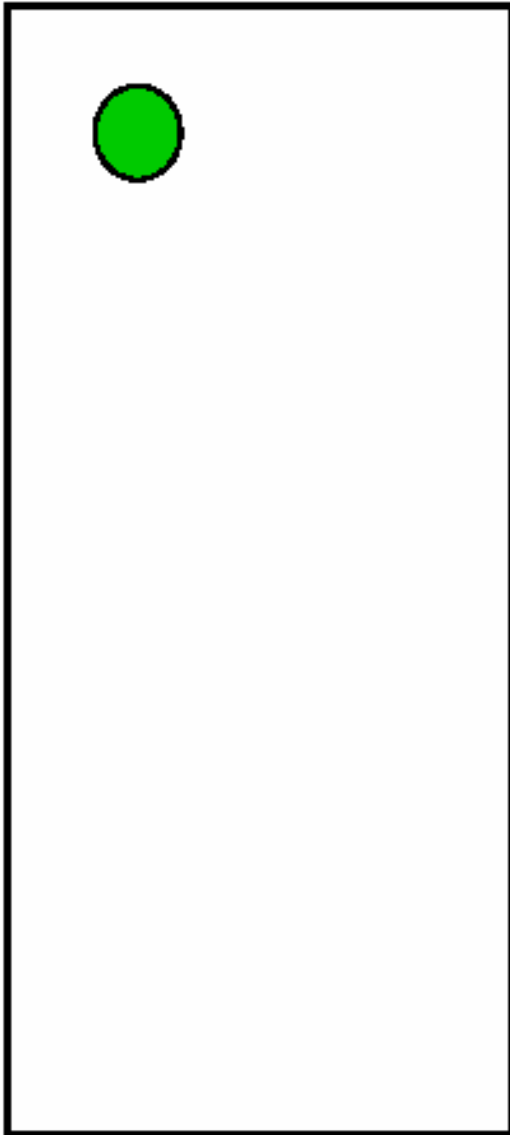
Variable	Site A (%)	Site B (%)	Site C (%)
Mineral substrate	40	60	95
Emergent macrophyte	10	0	5
Submerged macrophyte	0	0	0
Floating microphyte	0	0	0
Algal cover	20	0	0
Detritus	25	40	0
Riparian veg draped in water	5	0	0
Other	0	0	5
SHET score	4	2	1

Calculating SIZE

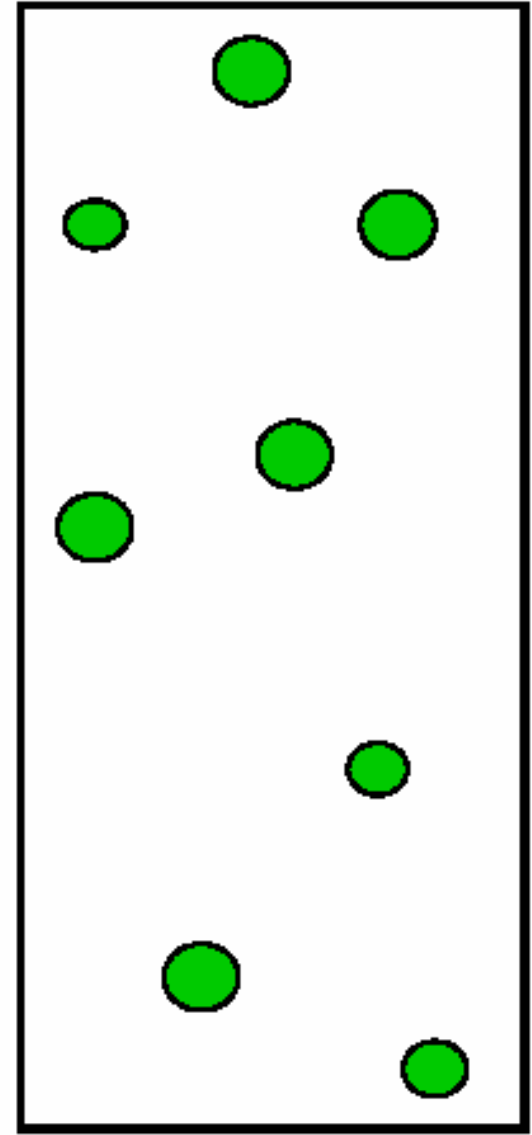
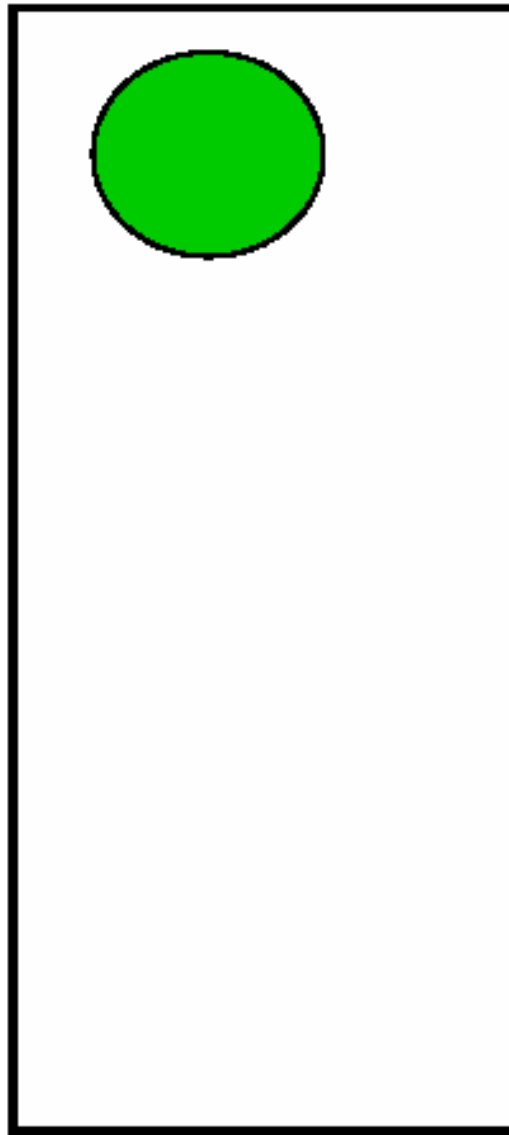
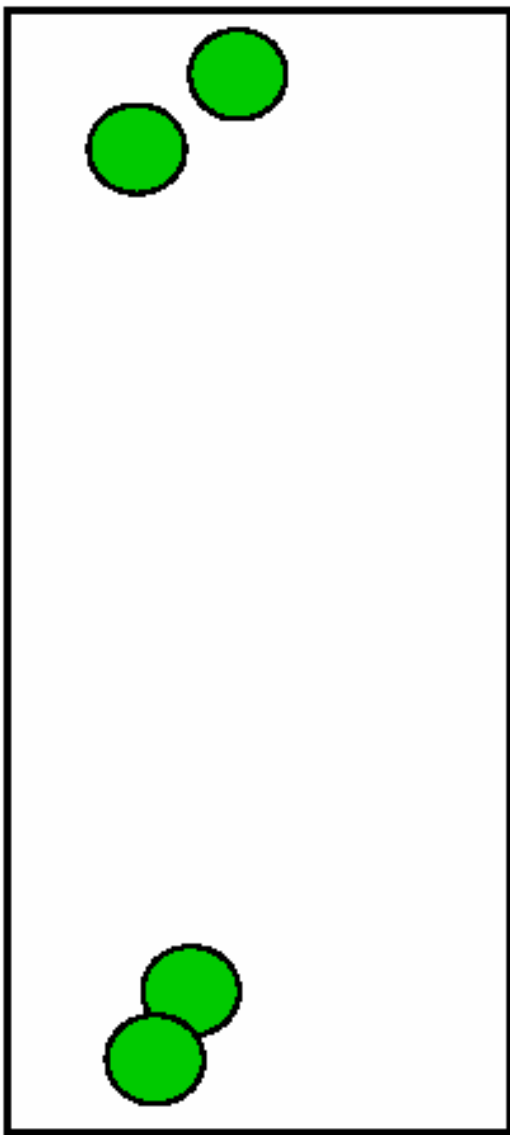
The eight categories used in the SHET score are multiplied by their appropriate PHI score (taken from the Wentworth Sediment Scale – see Gordon et al. 1992). Note: a category does NOT have to comprise at least 10 per cent of the mineral substrate to be included in the calculation (X); however, the SHET score is used as the denominator (Y) when calculating SIZE. See table below.

Variable	PHI value	Site A (%)	A% x PHI	Site B (%)	B% x PHI	Site C (%)	C% x PHI
Bedrock	-12	0	0	0	0	98	-1176
Boulders	-8	10	-80	0	0	0	0
Cobble	-7	20	-140	5	-35	0	0
Pebble	-6	30	-180	15	-90	2	-12
Gravel	-3	20	-60	15	-45	0	0
Sand	-1	20	-20	25	-25	0	0
Silt	4	0	0	40	160	0	0
Clay	8	0	0	0	0	0	0
Sum = X	na	na	-480	na	-35	na	-1188
SHET = Y	na	5	5	4	4	1	1
SIZE = (X/Y)	na	na	-96	na	-8.75	na	-1188

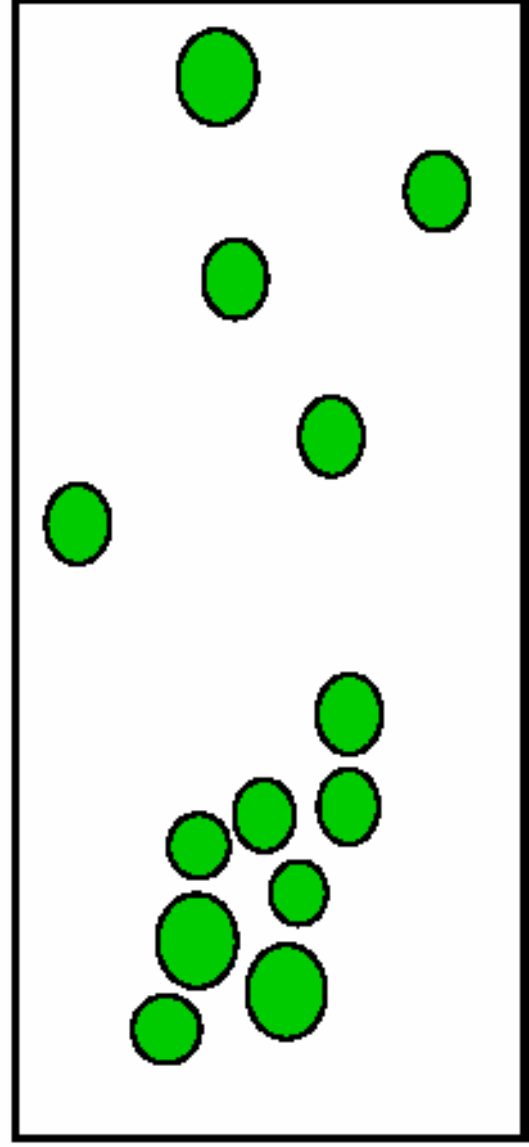
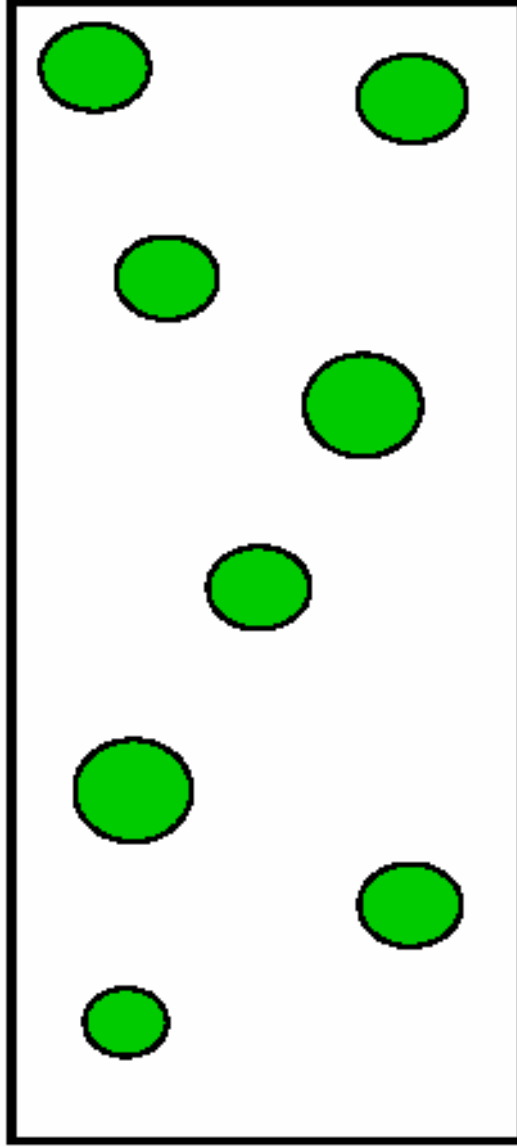
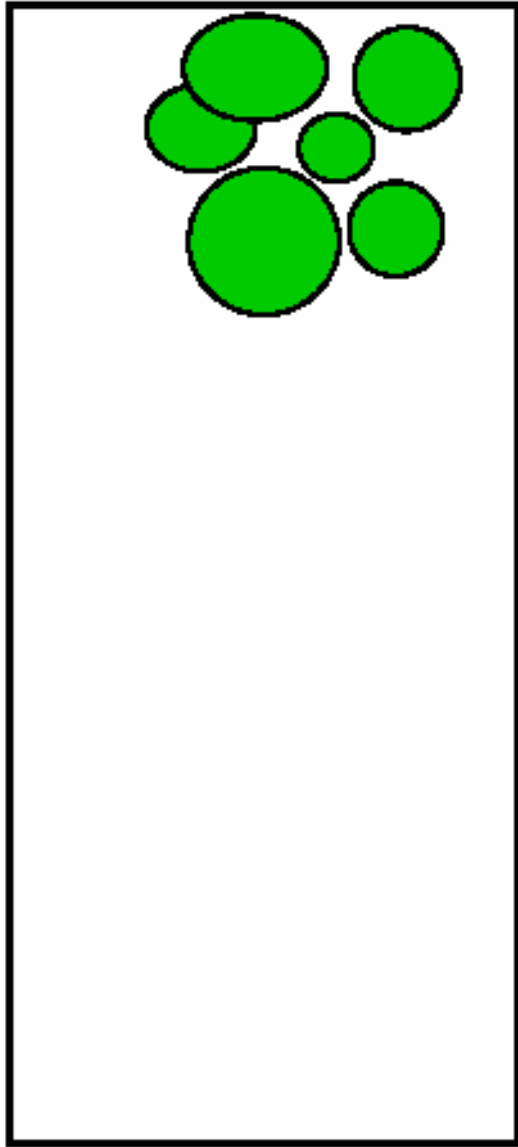
Appendix C – Vegetation percentage cover guidelines



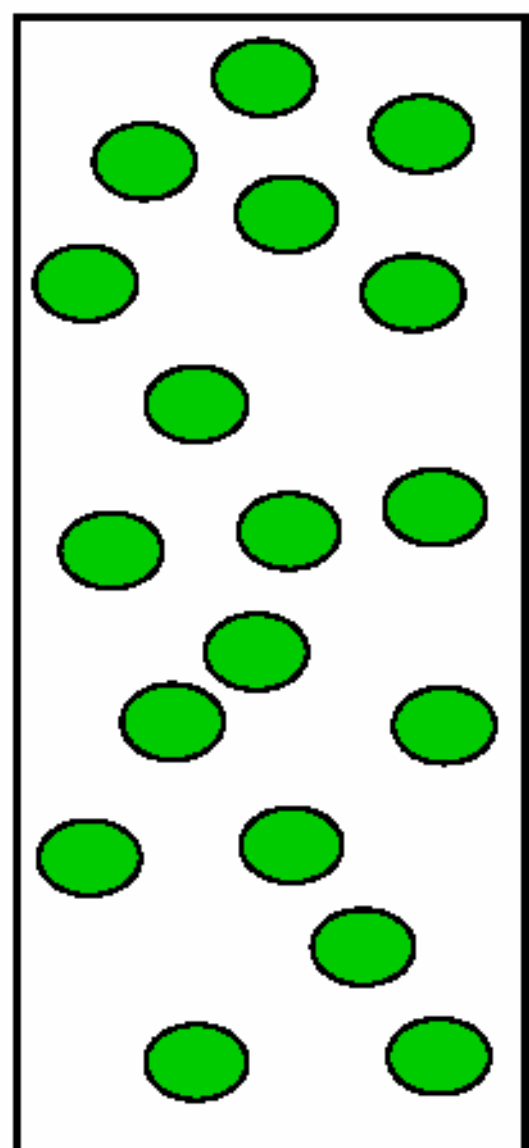
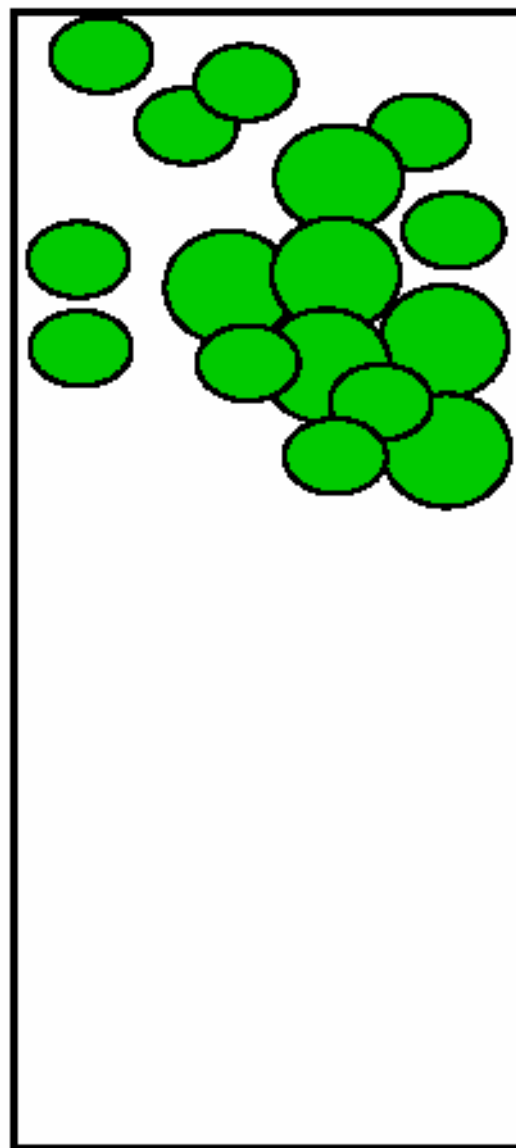
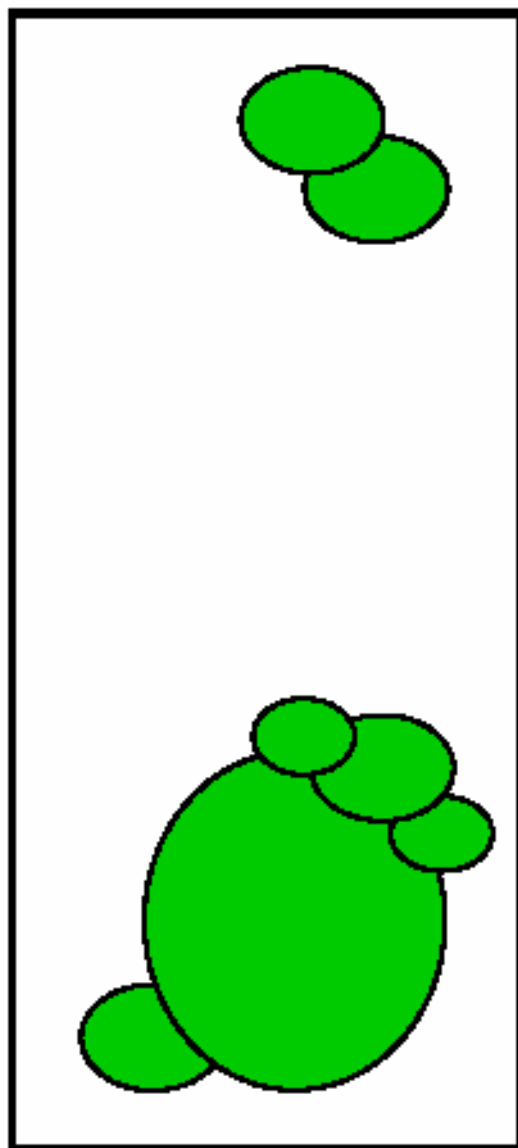
Two examples of 1% cover



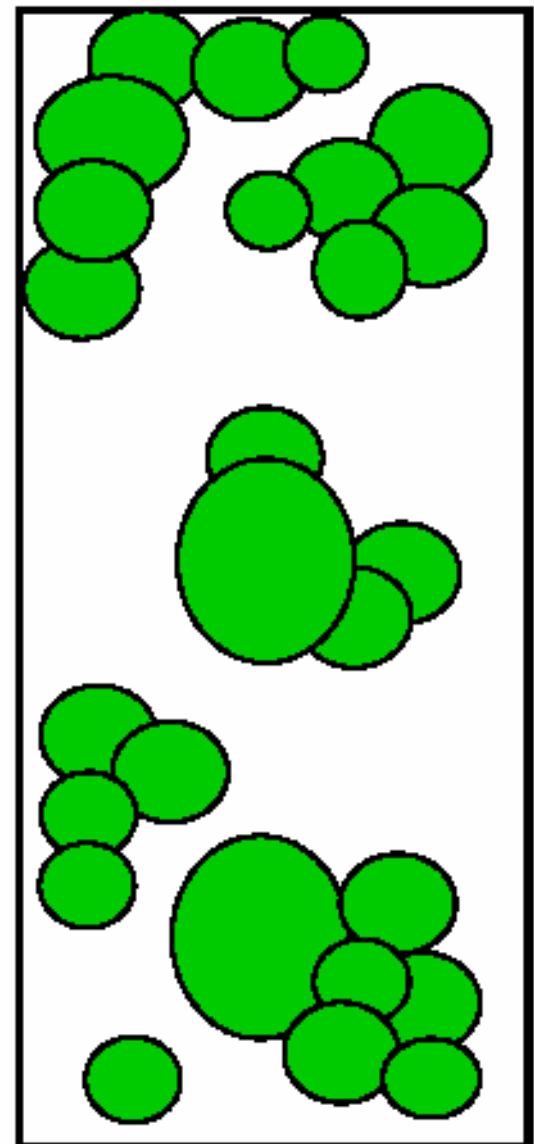
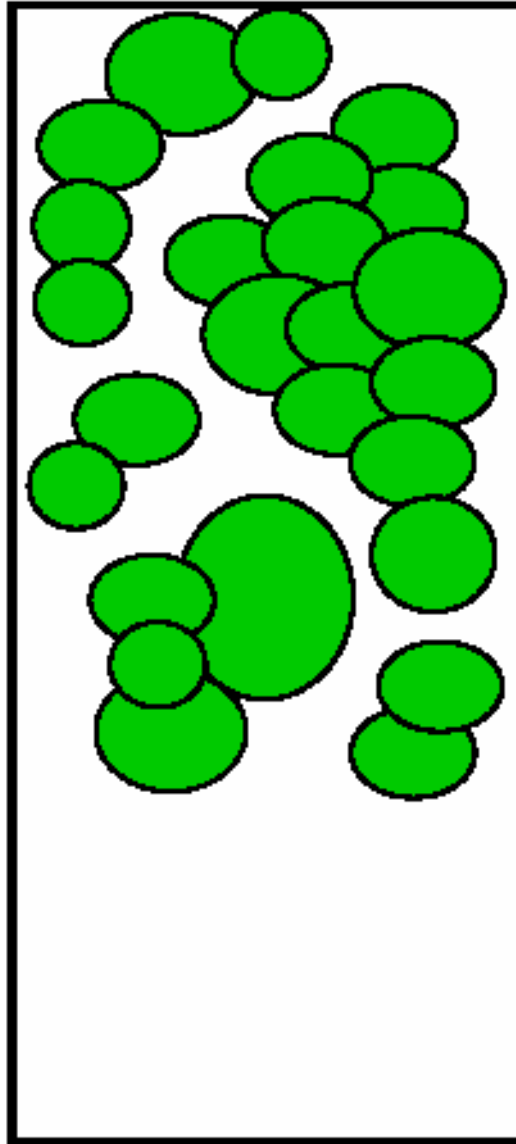
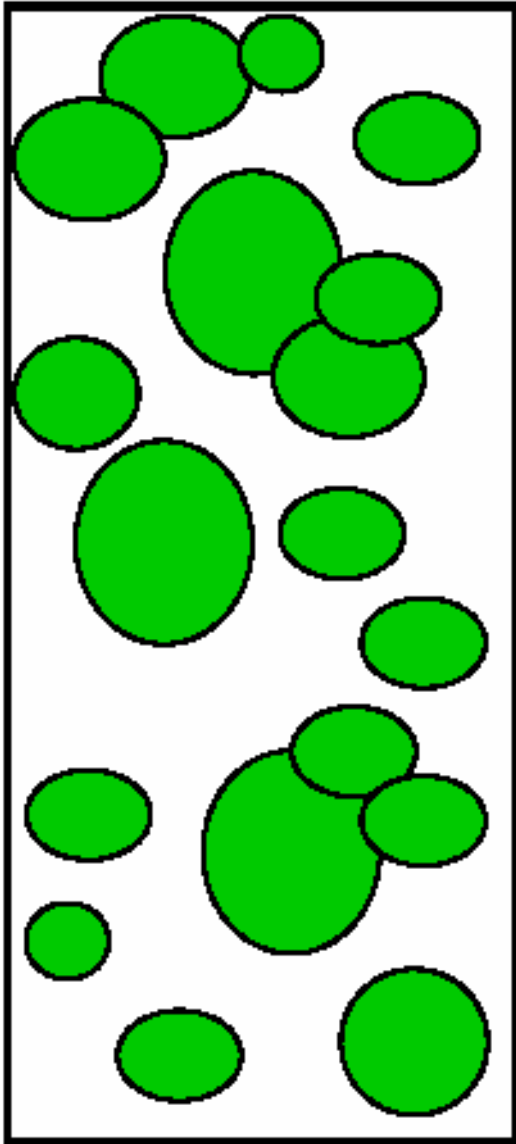
Three examples of 5% cover



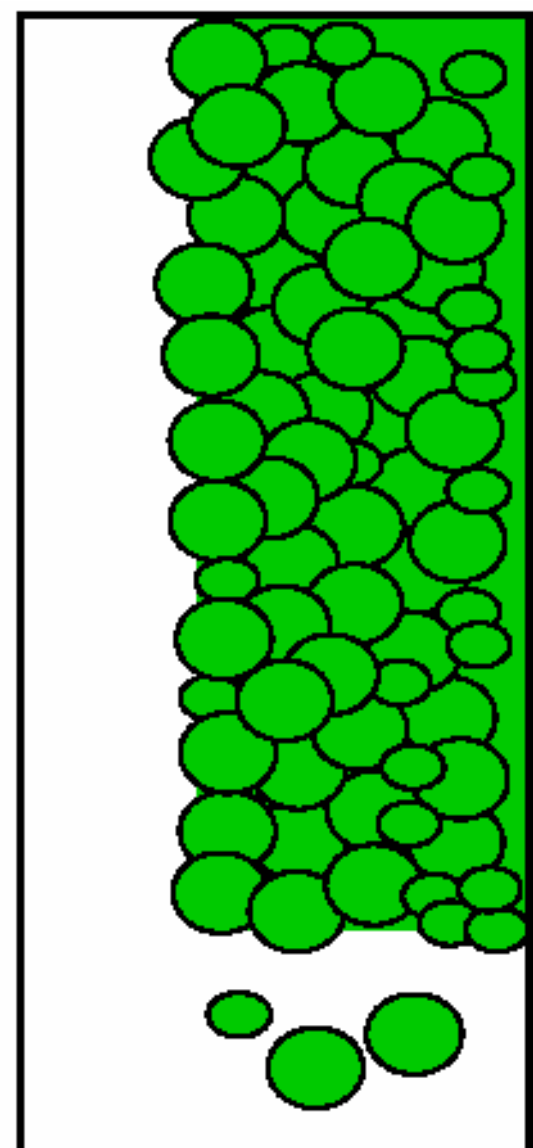
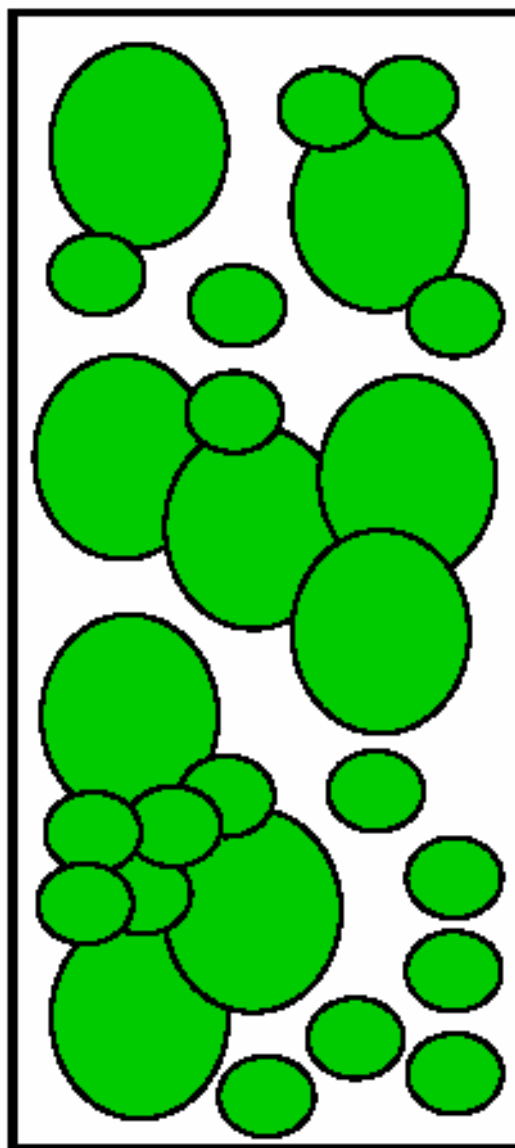
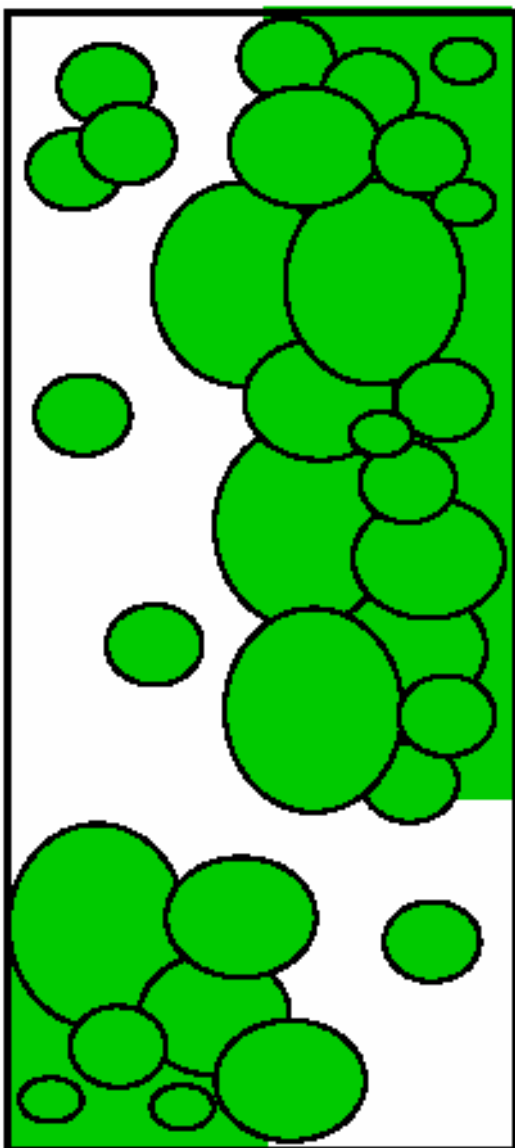
Three examples of 10% cover



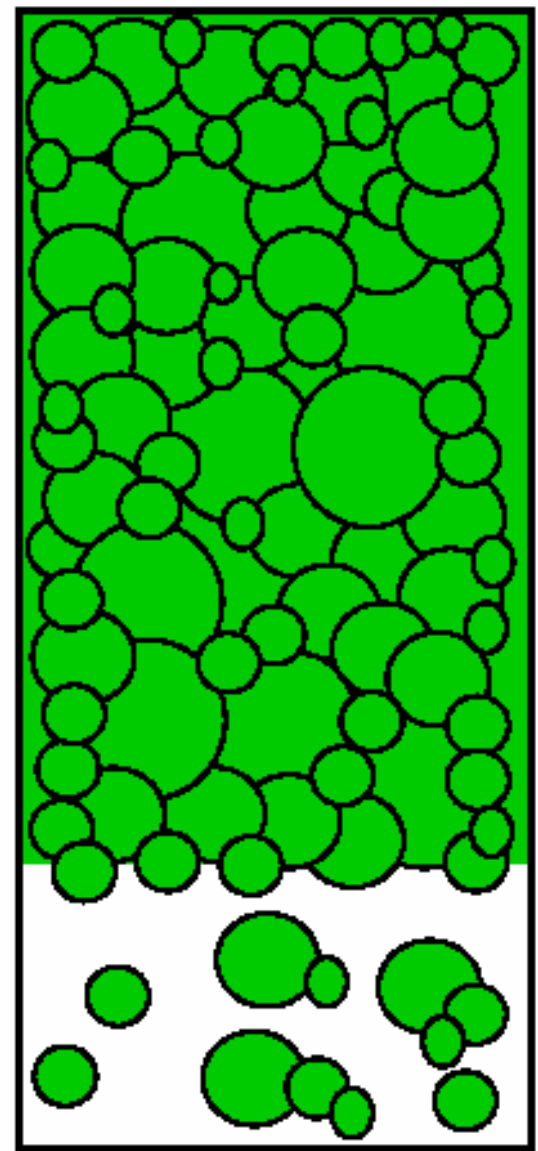
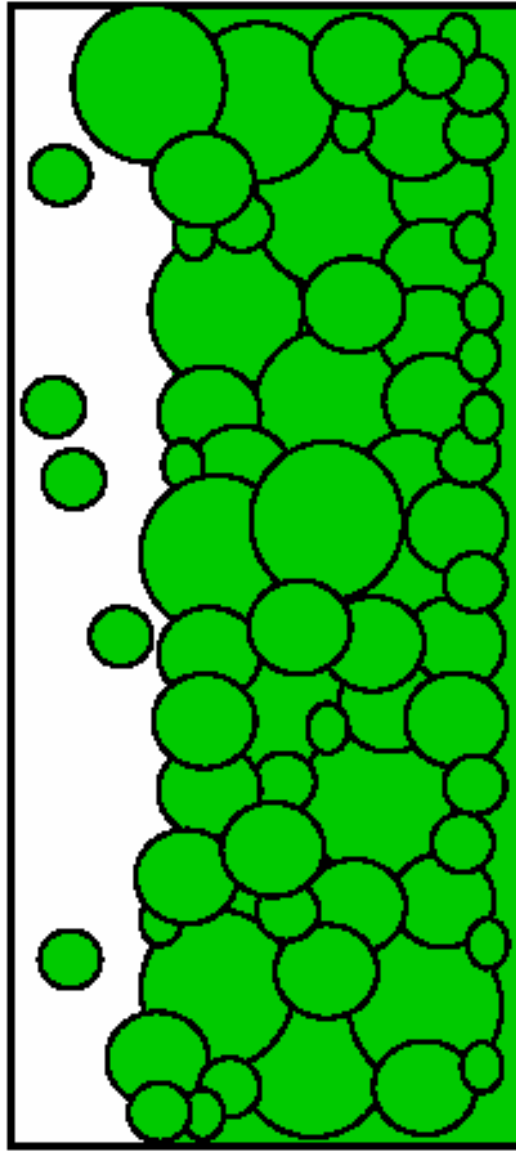
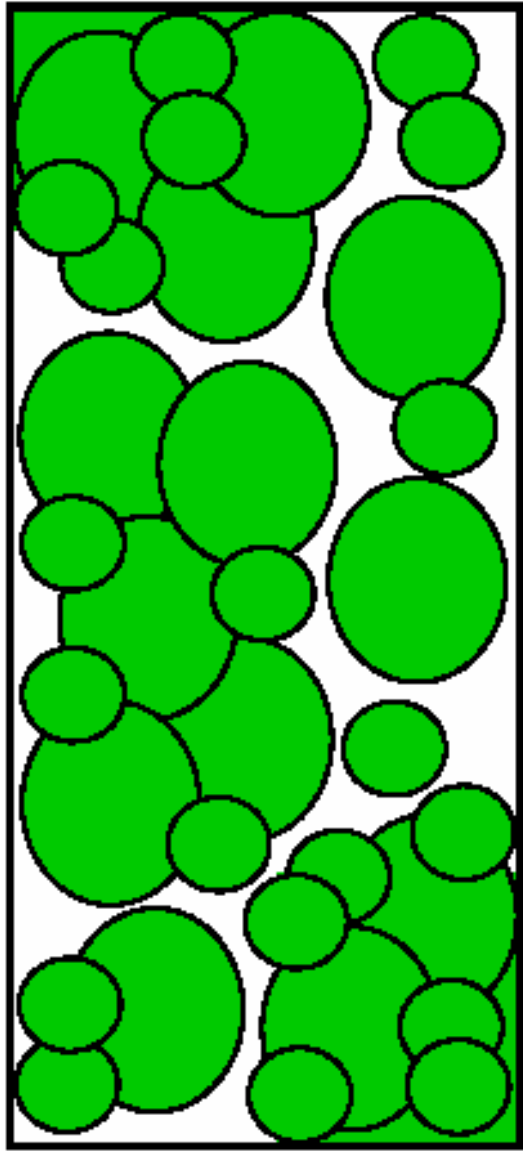
Three examples of 20% cover



Three examples of 40% cover



Three examples of 60% cover



Three examples of 80% cover

Appendix D – WA AUSRIVAS field sheets

WA AUSRIVAS SITE INFORMATION SHEET



Government of Western Australia
Department of Water

SITE INFORMATION

SITE NAME _____ LOCATION CODE _____

RIVER SYSTEM _____ RIVER NAME _____

ALTITUDE _____ (m) SLOPE _____ (m/km) DFS _____ (km) STREAM ORDER _____

FLOW PATTERN CATEGORY _____ DISCHARGE CATEGORY _____ TEST/REFERENCE
(circle)

NEAREST RAINFALL STATION: _____ AV. ANN. RAINFALL _____ (mm)

GPS & MAP DETAILS

GPS DATUM (as set on the GPS at the time you recorded your position) _____

LATITUDE _____ LONGITUDE _____

ZONE _____ EASTING _____ NORTHING _____

MAP NAME _____ SCALE _____ NUMBER _____ EDITION _____

JOINING MAP NAMES/NUMBERS _____

ACCESS DETAILS

DIRECTIONS _____

PROPERTY OWNER _____ PHONE NUMBER _____

ADDRESS _____

Notify before each visit Y [] N []
Permission required Y [] N []
Key required Y [] N []
Key number/available from: _____

SKETCH OF ACCESS ROUTE (include: river; flow direction; site location; roads; crossings; access details (location of turnoffs, distances and landmarks leading to site); and a northing.

SKETCH OF REACH (include location of riffle, channel, pool, and macrophyte habitats within the reach; flow direction; access point; channel sampling location); and a northing.

WA AUSRIVAS FIELD SAMPLING CHECKLIST



Government of Western Australia
Department of Water

RIVER _____ DATE _____ LOCATION CODE _____

COMPLETION CHECKLIST

Check off each item before leaving sampling site

- Sketch of 100m reach to be sampled
- Photographs of sampling site; photo numbers _____
- Macroinvertebrate samples collected
- Macroinvertebrate samples preserved and labelled
- Macroinvertebrate residue sample transferred to container, preserved and labelled
- Water quality measurements taken
- Water quality samples for laboratory analysis collected, labelled and stored appropriately
- COC for water quality samples filled out correctly and sample number recorded on Field Sampling Sheet
- Macroinvertebrate Sampling Field Sheet filled in completely and checked (no blank spaces)
- Field Sampling Sheet filled in completely and checked (no blank spaces)
- GPS latitude and longitude recorded
- Other sampling field sheets completed Details: _____

INSTRUMENT CALIBRATION Instrument name: _____

Air pressure _____ hPa _____ mmHg

Pre – field calibration	Salinity	pH 7	pH 10	DO%	Conductivity
Reading					
Calibrated to					

Post – field calibration	Salinity	pH 7	pH 10	DO%	Conductivity
Reading					
Calibrated to					

Please circle:

Conductivity units	uncomp	Comp (25°C)	ppt	
Conductivity setting	fresh	salt	stdMthd	None
Salinity setting	2311	stdMthd		

RIVER _____ DATE _____ LOCATION CODE _____

EQUIPMENT CHECKLIST

Item	Quantity	Check
WA sampling and processing manual	1	
Kicknet 250µm mesh	1	
Sieve 16mm	1	
Sieve 2mm	1	
Sieve 500µm	1	
Sieve 250µm	1	
Bucket	2	
Medium white tray	4	
Ethanol 100%	As required	
Bug containers for QA/QC residue 500ml	As required	
Bug containers for live pick	Minimum two per site	
250mL water sample bottle	1 per site	
125mL water sample bottle	1 per site	
Box sub-sampler and collection flask	1 (if using)	
Filter tower	1 (if filtering in field)	
Filter papers	As required	
Hand vacuum pump	1 (if filtering in field)	
Flow meter	1	
Float (if flow meter fails)	1	
Waders	2	
Multiprobe (Hydrolab or other – calibrated)	1	
GPS	1	
Camera	1	
Mobile phone	1	
Site information sheets	One per site	
Field sampling sheets	One per site	
Macroinvertebrate sampling field sheet	One per site	
Sampling checklist	1 per site	
Clipboard	1	
Maps	As required to cover area	
Tweezers	3	
Pipettes	3	
Vial labels	Minimum two per site	
Pencils	3	
Pencil sharpener	1	
Eraser	1	
Mosquito repellent	1	
Chairs for live pick	2	
Table for live pick	1	
Water	For washing hands etc	
Sunscreen	1	
Chain of custody form	As required	
Field observation form	As required	
Esky	1	
Ice bricks or ice	To cover bottom of esky	
Keys	As required	
Tape measurer	1	
First aid kit	1	
Sample numbers	1	
Gloves for water quality sampling	As required	

WA AUSRIVAS FIELD SAMPLING SHEET



Government of Western Australia
Department of Water

SAMPLE INFORMATION

DATE _____ TIME _____ LOCATION CODE _____

RIVER NAME _____ SITE NAME _____

RECORDERS NAME _____ SAMPLE COLLECTED BY _____

HABITAT _____ % OF 100m REACH _____

SAMPLE NUMBER _____ COC NUMBER: _____

WATER QUALITY AND HABITAT IN REACH

Water samples taken¹

250mL unfiltered sample for alkalinity, turbidity, TN and TP

125mL filtered sample for colour, SRP, NO_x and NH₃

Instrument

Water temperature (°C) _____

Conductivity (µS/cm) _____

pH _____

Dissolved oxygen (mg/L) _____

Dissolved oxygen (%) _____

Turbidity (NTU) _____

Wind direction _____

Wind speed _____

Habitat area in 100m Reach (%)

Channel _____

Macrophytes _____

Riffle _____

Pool _____

Total (must add to 100%) _____

Stream width (mean width of water taken from three measurements):

_____ m _____ m _____ m _____ average

Comments _____

¹ Sample taken from sampling site prior to macroinvertebrate sample being collected

WEATHER

Rain in past week Y N Comments _____

Today: Rain _____ Cloud cover (%) _____ Comments _____

RIVER _____ DATE _____ LOCATION CODE _____

OBSERVATIONS (Circle appropriate category)

WATER ODOURS Normal Anaerobic Sewage Petroleum Chemical None

WATER OILS Slick Sheen Globbs Flecks None

TURBIDITY Clear Slight Turbid Opaque

PLUME Little Some Lots
(amount of fine sediment generated when kick sampling)

COLOUR Yes No

SEDIMENT OILS Absent Light Moderate Profuse

SEDIMENT ODOURS Normal Sewage Petroleum Chemical
 Anaerobic None Other _____

WATER LEVEL (Relative to 'water mark' ie normal inundation level shown by limit of terrestrial grasses, or by eroded area, or boundary in bank sediment types).
 No Flow Low Moderate High Flood
(dry/isolated) (<water mark) (=) (>water mark)

SEDIMENT DEPOSITS None Sand Silt Other _____

Algae on substrate None Little Some Moderate Extensive
0% 1 – 10% 10 – 50% 50 – 75% > 75%

Algae in water column None Little Some Moderate Extensive

Are the undersides of stones which are not deeply embedded black? Yes No N/A

LOCAL CATCHMENT EROSION None Some Moderate Heavy

LOCAL PS POLLUTION No evidence Potential _____ Obvious _____

LOCAL NPS POLLUTION No evidence Potential _____ Obvious _____

DAMS/BARRIERS Present – upstream/downstream details _____ Absent

RIVER BRAIDING Yes – Number of braids _____ No

LANDUSE (Circle appropriate, may circle more than one)

Left Bank² AG AR CO FO IN MI PA RV TO UR VC WC

Right Bank² AG AR CO FO IN MI PA RV TO UR VC WC

² Facing downstream.

Landuse			
(AG) Agriculture	(FO) State Forest	(PA) Pastoralism	(UR) Urban
(AR) Aboriginal Reserve	(IN) Industrial	(RV) Remnant Vegetation	(VC) VCL
(CO) Conservation	(MI) Mining	(TO) Tourism	(WC) Water Catchment

RIPARIAN ZONE (To a maximum of 100m width)

Width of riparian zone Left Bank _____ m Right Bank _____ m

Bare ground* None Little Some Moderate Extensive

Grass* None Little Some Moderate Extensive

Shrubs* None Little Some Moderate Extensive

Trees < 10m high* None Little Some Moderate Extensive

Trees >10m high* None Little Some Moderate Extensive

Presence of exotic riparian species None Little Some Moderate Extensive

None = 0% Little = 1 – 10% Some = 10 – 50% Moderate = 50 – 75% Extensive > 75%

* Can add to greater than 100%

RIVER _____	DATE _____	LOCATION CODE _____
-------------	------------	---------------------

HABITAT ASSESSMENT

HABITAT PARAMETER	OPTIMAL CONDITION	SUB-OPTIMAL CONDITION	MARGINAL CONDITION	POOR CONDITION
Degree of naturalness	Pristine	Minimally disturbed	Moderately disturbed	Heavily disturbed
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Catchment Condition	Pristine	Minimally disturbed	Moderately disturbed	Heavily disturbed
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Landuse at site	Near Pristine	Minimally disturbed	Moderately disturbed	Heavily Disturbed
	Left bank 10 9	8 7 6	5 4 3	2 1 0
	Right bank 10 9	8 7 6	5 4 3	2 1 0
Physical substrate characterisation	Optimal mix of substrate types: Many interstitial spaces	Sub-optimal mix of substrate types	Minimal substrate diversity	Lack of substrate types and spaces: Bedrock only
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Biological substrate characterisation	Optimal: decaying twigs, leaf litter, epiphytes etc	Sub-optimal: some leaf litter, epiphytes etc.	Minimal leaf litter, epiphytes etc.	Complete absence of detritus and epiphytes
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Vegetative protection	Pristine	Minimally disturbed	Moderately disturbed	Heavily disturbed
	Left bank 10 9	8 7 6	5 4 3	2 1 0
	Right bank 10 9	8 7 6	5 4 3	2 1 0
Width of riparian vegetation	Pristine	Minimally disturbed	Moderately disturbed	Heavily disturbed
	Left bank 10 9	8 7 6	5 4 3	2 1 0
	Right bank 10 9	8 7 6	5 4 3	2 1 0
Bank stability	Pristine	Minimally disturbed	Moderately disturbed	Heavily disturbed
	Left bank 10 9	8 7 6	5 4 3	2 1 0
	Right bank 10 9	8 7 6	5 4 3	2 1 0
Sediment deposition	Optimal condition	Sub-optimal condition	Marginal condition	Poor condition
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0
Impoundments, abstraction or channelisation	Optimal condition	Sub-optimal condition	Marginal condition	Poor condition
	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1 0

TOTAL _____

**WA AUSRIVAS
MACROINVERTEBRATE SAMPLING
FIELD SHEET**



Government of Western Australia
Department of Water

SAMPLE INFORMATION

DATE _____ TIME _____ LOCATION CODE _____

RIVER NAME _____ SITE NAME _____

RECORDERS NAME _____ SAMPLE COLLECTED BY _____

LIVE PICK BY _____ AND _____

HABITAT _____ % OF 100m REACH _____

SAMPLE NUMBER: _____ COC NUMBER: _____

Sampling Conditions good [] average [] poor []

Picking Conditions good [] average [] poor []

HABITAT ASSESSMENT (Description of 10m sample area)

Mineral substrate	%	Breakdown of habitat surface area	%	Density (1 = sparse; 5 = dense)
Bedrock		Mineral substrate		
Boulders (> 256mm)		Emergent macrophyte		1 2 3 4 5
Cobble (64 to 256 mm)		Submerged macrophyte		1 2 3 4 5
Pebble (16 to 64 mm)		Floating macrophyte		1 2 3 4 5
Gravel (4 to 16 mm)		Algal cover		1 2 3 4 5
Sand (1 to 4 mm)		Detritus		1 2 3 4 5
Silt (<1 mm)		Riparian veg draped in water		
Clay		Other (i.e. woody debris)		
Total		Total (may be > 100%)		

DEPTH AND VELOCITY

DEPTH (Circle appropriate category) 1 (< 25cm) 2 (< 50cm) 3 (<100cm) 4 (< 200cm) 5 (> 200cm)

VELOCITY

Meter used _____ Max velocity = _____

Min velocity = _____

Examples – mineral substrate

Bedrock	
Boulder (> 256 mm)	> soccer ball
Cobble (64 – 256 mm)	cricket ball to soccer ball
Pebble (16 – 64 mm)	5c piece to cricket ball
Gravel (4 – 16 mm)	raw sugar to 5c piece
Sand (1 – 4 mm)	< raw sugar
Silt or clay (< 1 mm)	

RIVER _____ DATE _____ LOCATION CODE _____

LIVE PICK TALLY

Taxon	Log abundance	Live pick tally	Taxon	Log abundance	Live pick tally
Nematoda			Odonata		
Platyhelminthes			Anisoptera		
Oligochaeta			Zygoptera		
Hirudinea					
Bivalvia					
Gastropoda			Trichoptera		
Acarina			Leptoceridae		
			Ecnomidae		
Diptera					
Chironomidae					
Ceratopogonidae			Amphipoda		
Culicidae			Ceinidae		
Simuliidae			Perthiidae		
Stratiomyidae					
Tabanidae			Isopoda		
Plecoptera			Decapoda		
Gripopterygidae			Atyidae		
			Palaemonidae		
Ephemeroptera			Parastacidae		
Baetidae					
Caenidae					
Leptophlebiidae			Coleoptera		
			Dytiscidae		
			Hydrophylidae		
Hemiptera					
Corixidae					
Notonectidae					
Gerridae					

BOX SUB-SAMPLER TALLY

Number of cells picked: _____

Total number of cells in box: _____

Total number of macroinvertebrates picked: _____

Appendix E – Field vial labels

Appendix F – Laboratory vial labels

Appendix G – Macroinvertebrate identification sheet

Appendix H – Suggested taxonomic keys

General keys

CSIRO 1991, *The insects of Australia*, 2nd edition, Melbourne University Press, Melbourne.

Davis, J & Christidis, F 1997, *A guide to wetland invertebrates of south western Australia*, Western Australian Museum, Perth.

Hawking, JH 1995, *Monitoring River Health Initiative taxonomy workshop handbook*. MRHI Taxonomy Workshop, Murray–Darling Freshwater Research Centre, 6–7 February 1995.

Hawking, JH 2000, *Key to keys. A guide to keys and zoological information to identify invertebrates from Australian inland waters*. Identification Guide No 2. 2nd edn. Cooperative Research Centre for Freshwater Ecology, Albury.

Hawking, JH & Smith, FJ 1997, *Colour guide to invertebrates of Australian waters*, Identification Guide No 5, Cooperative Research Centre for Freshwater Ecology, Albury.

Lucid invertebrate key <<http://www.lucidecentral.com/keys/lwrrdc/public/Aquatics/>>

MDFRC online macroinvertebrate identification key
<<http://www.mdfrc.org.au/BugGuide/>>

Acarina

Harvey, MS & Grown, J 1998, *Preliminary guide to the identification of families of Australian water mites (Arachnida: Acarina)*, Identification guide No. 18, Cooperative Research Centre for Freshwater Ecology, Albury.

Coleoptera

Lawrence, JF 1992, *Australian aquatic Coleoptera (adults and larvae)*, Taxonomy Workshop, Murray Darling Freshwater Research Centre, 14 – 15 February 1992.

Watts, C 1998, *Preliminary guide to the identification of adult and larval Dytiscidae and adult aquatic Hydrophilidae (Insecta: Coleoptera)*, Identification guide No. 19, Cooperative Research Centre for Freshwater Ecology, Albury.

Crustacea

Bayly, IAE, Bishop, JA & Hiscock ID (eds) 1967, *An illustrated key to the genera of the Crustacea of Australian inland waters*, Australian Society for Limnology, Melbourne.

Horwitz, P 1995, *A preliminary key to the species of Decapoda (Crustacea – Malacostraca) found in Australian inland waters*, Identification guide No, 5, Cooperative Research Centre for Freshwater Ecology, Albury.

Horwitz, P, Knott, B & Williams, WD 1995, *A preliminary guide to the Malacostracan families (Crustacea) found in Australian inland waters*, Identification guide No. 4, Cooperative Research Centre for Freshwater Ecology, Albury.

Diptera

Cranston, PS 1995, *Keys to aquatic Dipteran families*, Taxonomy workshop, Murray–Darling Freshwater Research Centre, February 1994.

Ephemeroptera

Dean, JC & Suter, PJ 1996, *Mayfly nymphs of Australia: A guide to genera*, Identification guide No. 7, Cooperative Research Centre for Freshwater Ecology, Albury.

Suter, PJ 1997, *Preliminary guide to the identification of nymphs of Australian Baetid mayflies (Insecta: Ephemeroptera) found in flowing waters*, Identification guide No. 14, Cooperative Research Centre for Freshwater Ecology, Albury.

Suter, PJ 1999, *Illustrated key to the Australian Caenid nymphs (Ephemeroptera: Caenidae)*, Identification guide No. 23, Cooperative Research Centre for Freshwater Ecology, Albury.

Megaloptera

Theischinger, G 2000, *Australian alderfly larvae and adults (Insecta: Megaloptera)*, Identification guide No. 29, Cooperative Research Centre for Freshwater Ecology, Albury.

Mollusca

Smith, BJ 1996, *Identification keys to the families and genera of bivalve and gastropod molluscs found in Australian inland waters*, Identification guide No. 6, Cooperative Research Centre for Freshwater Ecology, Albury.

Odonata

Hawking, JH & Theischinger, G 1999, *Dragonfly larvae (Odonata). A guide to the identification of larvae of Australian families and identification and ecology of larvae from New South Wales*, CRCFE Identification guide No. 24, and AWT Identification guide No. 3, Cooperative Research Centre for Freshwater Ecology, Albury.

Trichoptera

Cartwright, DI 1997, *Preliminary guide to the identification of late instar larvae of Australian Ecnomidae, Philopotanidae and Tasmidae (Insecta: Trichoptera)*, Identification guide No. 10, Cooperative Research Centre for Freshwater Ecology, Albury.

Dean, JC 1997, *Larvae of the Australian Hydrobiosidae (Insecta: Trichoptera)*, Identification guide No. 11, Cooperative Research Centre for Freshwater Ecology, Albury.

Jackson, J 1998, *Preliminary guide to the identification of late instar larvae of Australian Calocidae, Helicophidae and Conoesucidae (Insecta: Trichoptera)*, Identification guide No. 16, Cooperative Research Centre for Freshwater Ecology, Albury.

St Clair, RM 1997, *Preliminary guide to the identification of late instar larvae of Australian Philorheithridae, Calarnoceratidae and Helicopsychidae (Insecta: Trichoptera)*, Identification guide No. 12, Cooperative Research Centre for Freshwater Ecology, Albury.

Wells, A 1996, *A preliminary guide to the identification of larval Hydroptilidae (Insecta: Trichoptera)*, Identification guide No. 13, Cooperative Research Centre for Freshwater Ecology, Albury.

References

- Davies, PE 1994, *Monitoring River Health Initiative: River bioassessment manual*, Australian Government Printing Service, Canberra.
- Department of Water 2009a, *Water quality monitoring program design. A guideline to the development of surface water quality monitoring programs*, Department of Water, Perth, Western Australia.
- Department of Water 2009b, *Surface water sampling methods and analysis – technical appendices. Standard operating procedures for water sampling methods and analysis*, Department of Water, Perth, Western Australia.
- Gordon, ND, McMahon, TA & Finlayson, BL 1992, *Stream hydrology: an introduction for ecologists*, John Wiley, Chichester.
- Halse, S, Scanlon, MD & Cocking, JS 2001a, *First National Assessment of River Health: Western Australian program, milestone report 5 and final report*, Department of Conservation and Land Management, Western Australia.
- Halse, S, Smith, M, Kay, W, Scanlon, M and Cocking, J 2001b, *AusRivAS in Western Australia, Manual for use of AusRivAS models for assessing river health in Western Australia*, Department of Conservation and Land Management, Western Australia.
- Halse, S, Smith, M, Kay, W, Scanlon, M & Cocking, J 2002, *Australia-wide assessment of river health: Western Australian AusRivAS sampling and processing manual*, Monitoring River Health Initiative Technical Report no. 18, Commonwealth of Australia and Department of Conservation and Land Management.
- Nichols, S, Barlow, A, Norris, R, Delgado, P & Veness, D 2003, *Module 1, study design and site selection*, Flexible Development Unit, University of Canberra, Canberra.
- Nichols, S, Sloane, P, Coysh, J, Williams, C & Norris, R 2000, *Australian Capital Territory AUSTRALIAN RIVER Assessment System, sampling and processing manual*, Cooperative Research Centre for Freshwater Ecology, University of Canberra, Canberra.
- Ransom, G, Coysh, J & Nichols, S 2005, *AUSRIVAS user manual for predictive modelling software version 3.1.1*, Cooperative Research Centre for Freshwater Ecology, University of Canberra, Canberra.



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