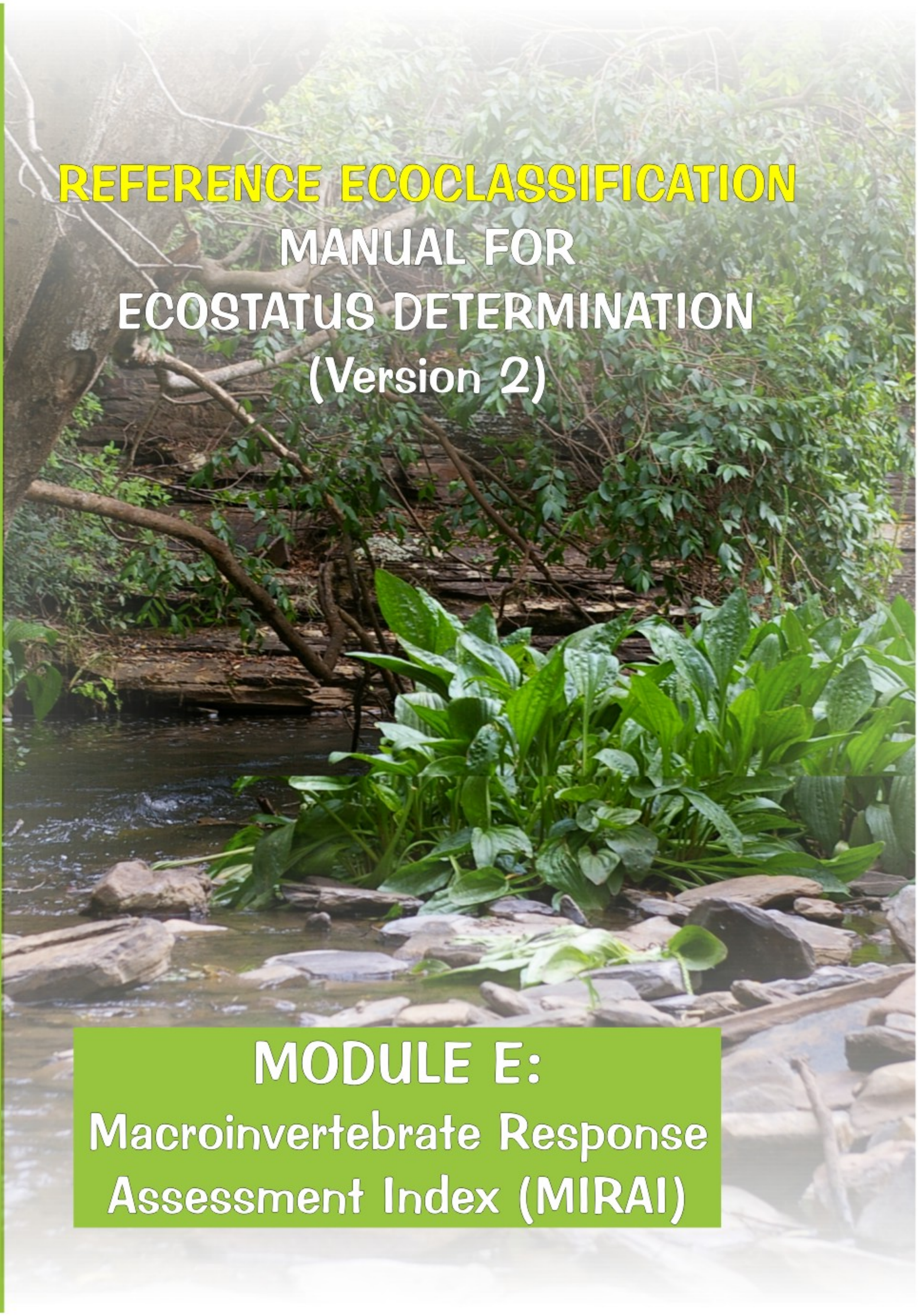
ECOCLASSIFICATION



REFERENCE ECOCLASSIFICATION MANUAL FOR ECOSTATUS DETERMINATION (Version 2)

MODULE E: Macroinvertebrate Response Assessment Index (MIRAI)

water & forestry

Department: Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA

Water Research Commission

RIVER ECOCLASSIFICATION

MANUAL FOR ECOSTATUS DETERMINATION (Version 2)

MODULE E: Macroinvertebrate Response Assessment Index (MIRAI)

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REFERENCES

Thirion, C. 2007. Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No.

STRUCTURE OF THE MANUAL

The manual consists of the following modules:

- MODULE A: ECOCLASSIFICATION AND ECOSTATUS MODELS
- MODULE B: GEOMORPHOLOGICAL DRIVER ASSESSMENT INDEX (GAI)
- MODULE C: PHYSICO-CHEMICAL DRIVER ASSESSMENT INDEX (PAI)
- MODULE D: FISH RESPONSE ASSESSMENT INDEX (FRAI)
- **MODULE E: MACROINVERTEBRATE RESPONSE ASSESSMENT INDEX (MIRAI)**
- MODULE F: RIPARIAN VEGETATION RESPONSE ASSESSMENT INDEX (VEGRAI)
- MODULE G: INDEX OF HABITAT INTEGRAITY

This module is Module E and consists of the MIRAI manual. The module provides the background to and scientific rationale for the MIRAI. It also provides the explanation of the MIRAI field sheets and the MIRAI model

PURPOSE OF THE MANUAL : MODULE E

Provides a step by step guideline to the appropriate specialists on how to use the MIRAI.

WHO SHOULD APPLY THESE MODELS?

An experienced aquatic invertebrate specialist.

NOTE: It is strongly recommended that the user participates in training courses and/or contact the author of this manual when applying the models

ABBREVIATIONS

ASPT	Average Score Per Taxon
DWAF	Department of Water Affairs and Forestry
EC	Ecological Category
EcoSpecs	Ecological Specifications
EIS	Ecological Importance and Sensitivity
ER	Ecological Reserve
EWR	Ecological Water Requirements
FAII	Fish Assemblage Integrity Index
FHS	Fish Habitat Segment
FRAI	Fish Response Assessment Index
GAI	Geomorphology Driver Assessment Index
HAI	Hydrology Driver Assessment Index
IHI	Index of Habitat Integrity
ISP	Internal Strategic Perspective
IFR	Instream Flow Requirements
MCDA	Multi-Criteria Decision Analysis
MIRAI	Macroinvertebrate Response Assessment Index
PAI	Physico-chemical Driver Assessment Index
PES	Present Ecological State
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RERM	Rapid Ecological Reserve Methodology
RHP	River Health Programme
RU	Resource Unit
RVI	Riparian Vegetation Index
SASS	South African Scoring System
VEGRAI	Riparian Vegetation Response Assessment Index

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The guidelines presented here assume that the reader is experienced in aquatic invertebrate ecology.

1 SCIENTIFIC RATIONALE

1.1 BASIS OF DERIVING AND INTERPRETING AQUATIC INVERTEBRATE RESPONSE TO DRIVER CHANGES

1.1.1 The role of aquatic invertebrates in river structure

Invertebrates include all animals without backbones. In rivers this includes aquatic insects, larvae of insects with terrestrial (often flying) adult forms, as well as mussels, clams, snails and worms that are aquatic throughout their life cycle (Allan 1995, O'Keeffe and Dickens 2000). Aquatic macroinvertebrates have been used to assess the biological integrity of stream ecosystems with relatively good success throughout the world (Rosenberg and Resh 1993, Resh *et al*. 1995, Barbour *et al*. 1996), more commonly than any other biological group (O'Keeffe and Dickens 2000).

Aquatic macroinvertebrate assemblages and communities offer a good reflection of the prevailing flow regime and water quality in a river. In addition they form an essential component of the riverine ecosystem (O' Keeffe and Dickens 2000, Weber *et al* 2004, Allan 1995, Skorozjewski and de Moor 1999). They are important processors of transported organic matter in rivers, serve a vital function in purifying the water in a river and also provide a valuable food source for larger animals within and even outside the system (Skorozjewski & de Moor 1999, O' Keeffe and Dickens 2000, Weber *et al* 2004, Allan 1995).

In order to continue functioning optimally, species in a river system require regular inputs of nutrients and sediments, as well as flowing water. A specific river system supports a particular assemblage of species forming functional communities within reaches. These communities are adapted to the prevailing flow conditions that control temperature, sediment transport and nutrient flows. A decrease or increase in flow, sediment transport or nutrient loads will lead to changes in community structures through loss of certain species and increases in others, as well as providing conditions for a range of new or otherwise scarce species to flourish.

The four major components of a stream system that determine productivity for aquatic organisms are –

- flow regime,
- physical habitat structure (e.g., channel form and substrate distribution),
- water quality (e.g., temperature, dissolved oxygen), and
- energy inputs from the watershed (e.g., nutrients and organic matter) (Milhous and Bartholow 2004).

Distribution of an aquatic macroinvertebrate population is ultimately set by the physical-chemical tolerance of the individuals in the population to an array of environmental factors. The distribution pattern resulting from habitat selection by a given aquatic macroinvertebrate species reflects the optimal overlap between habit (mode of existence) and physical environmental conditions that comprise the habitat - substrate, flow and turbulence, for example. Thus, the discontinuous, patchy, distribution pattern of an aquatic macroinvertebrate population is the result of interplay between habitat, habit and the availability of food resources (Cummins, 1993).

1.1.2 Aquatic Invertebrate habitat

Aquatic physical habitat refers to the environment for the instream biota created by the interaction of the physical structure of the channel (the geomorphology) and the flow regime (discharge pattern over time). Habitat functions as a temporally and spatially variable physical, chemical, and biological template within which aquatic invertebrates can exist (Poff and Ward, 1990; Orth, 1987). Numerous studies have demonstrated the importance of physical habitat quantity and quality in determining the structure and composition of biotic communities (e.g. Modde *et al*., 1991; Aadland, 1993; Ebrahimnezhad and Harper, 1997).

In the context of this document, habitat can be defined as any combination of velocity, depth, substrate (bedrock, cobbles, vegetation, sand, gravel, mud), physico-chemical characteristics (such as chemical composition, turbidity, oxygen concentration, temperature) and biological features (food source and predators) that will provide the organism with its requirements for each specific life stage at a particular time and locality. These habitats can be grouped into specific invertebrate biotopes such as Stones-in-current, Stones-out-of-current, Aquatic vegetation (in or out of current), Fringing vegetation (in or out of current).

1.1.3 Interpretation of aquatic invertebrate responses to habitat changes

Populations of benthic animals reflect the micro-environment, which is an important factor in the soundness of the river ecosystem, on a scale smaller than the riverbeds of pools and riffles. Populations of benthic animals also reflect the topographic features of rivers and the effects of improvement works on the river environment (Yabe and Nakatsugawa 2004).

Suitable environmental conditions and resources (quantity, quality and timing) have to be available in order to sustain a viable long-term population (Statzner and Higler, 1986; May and MacArthur, 1972; Pianka, 1974; Colwell and Futuyma, 1971). Because a variety of factors, such as environmental conditions and resources, are required to meet the life history requirements of species, the success of aquatic organisms can be limited by a single factor or by a combination of factors (Hardy 2000).

Since many aquatic organisms have specific habitat requirements, seasonal variation in these factors may lead to seasonal variation in the distribution and abundance of benthic macroinvertebrates. Variation in discharge often translates into differences in wetted perimeter, hydraulic conditions and biotope availability. For example, biotopes such as runs become riffles under low-flow conditions, and marginal vegetation may change from lotic to lentic. Temperature often varies with season and the life cycles of many aquatic organisms are cued to temperature. Temperature may affect the rate of development, reproductive periods and emergence time of organisms. All organisms also have a range of temperatures over which optimal growth, reproduction and general fitness occur, and temperatures outside this range may lead to the exclusion of taxa unable to tolerate extreme highs or lows (Hawkins *et al*. 1997).

It is essential that all habitat features are considered when evaluating the suitability of habitat for aquatic invertebrates. As an example one can consider a river that has an extensive Stones-In-Current (SIC) biotope comprising a variety of velocities and depths and adequate water quality, but the stones are covered with a thick layer of filamentous algae. In this example one would not expect the diverse invertebrate community normally associated with the SIC biotope, due to the large amounts of filamentous algae on the cobbles. This will result in a lower EC than expected.

The approach followed in assessing invertebrate response to driver characteristics is based on a qualitative combination of information gained by a field survey, the available habitat as a result of driver condition, and the traits of the invertebrates present.

1.1.4 Requirements for the assessment of aquatic invertebrate assemblage response to driver conditions

The following approach is used to relate drivers and the resultant habitat to the aquatic invertebrate condition -

- Information on the habitat preferences and requirements of each of the taxa present should be obtained. A draft (incomplete) spreadsheet that includes a semi-quantitative rating of the intolerances (based on SASS weights), substrate (habitat) preferences and velocity preferences is included in the Macroinvertebrate Response Assessment Index (MIRAI). Where this database is not sufficient, available literature on South African aquatic invertebrates as well as local experts should be consulted. A project has recently been initiated to improve and expand the information captured in this spreadsheet.
- The habitat features are evaluated in terms of their suitability as well as the requirements of the aquatic invertebrates inhabiting the region. This includes consideration of breeding requirements (where known), abundance and frequency of occurrence in a river section, biotopes and water quality.
- Although it would be logical to assess habitat integrity and then to assess the response of the invertebrates based on this habitat template the MIRAI indirectly includes habitat integrity as part of the index. Habitat integrity is therefore not considered separately to guide invertebrate response assessment.

2 INFORMATION REQUIREMENTS FOR EC DETERMINATION

The determination of aquatic invertebrate EC is essentially based on -

- An interpretation of the environmental requirements, preferences and intolerances of Invertebrate taxa constituting the natural assemblage in a particular river delineation, and
- Their responses to changes in habitat conditions as brought about by changes in driver components.

The MIRAI is used to determine the Invertebrate EC. It is done by integrating the ecological requirements of the invertebrate taxa in a community or assemblage and their response to modified habitat conditions.

Although the MIRAI can be determined using information collected during a standard SASS survey (Dickens and Graham 2002), it can also be determined using more detailed information. Chutter (1998) developed the SASS protocol as an indicator of water quality. It has since become clear that SASS gives an indication of more than mere water quality, but rather a general indication of the present state of the invertebrate community. Because SASS was developed for application in the broad synoptic assessment required for the River Health Programme (RHP), it does not have a particularly strong cause-effect basis. The aim of the MIRAI, on the other hand, is to provide a habitat-based cause-and-effect foundation to interpret the deviation of the aquatic invertebrate community (assemblage) from the reference condition. This does not preclude the calculation of SASS scores if required. However, the recent tendency is to use the MIRAI even for RHP purposes (RHP 2005) and it is now the preferred approach.

2.1 INFORMATION REQUIRED FOR THE APPLICATION OF THE MIRAI

2.1.1 Establish Reference Conditions

There are two methods for determining the taxa expected to occur under natural (reference) conditions -

- A minimally-impacted site in the same Level II EcoRegion and geomorphological zone with similar habitat can be used as a reference site, and information from this reference site can be used to compile a reference list of taxa for the area under consideration.
- In the absence of a suitable reference site, information from similar sites in different rivers, as well as any historical information available, can be used to compile a derived reference list of taxa expected under reference conditions. A thorough knowledge of the area under consideration is essential in order to compile a suitable referenced list. The occurrence of taxa in a different river, within the same ecoregional context, can be used to derive reference conditions in the river delineation being considered.

2.1.2 Site selection

One of the most important factors in selecting a sampling site is the aim of the study. A site selected for the RHP aimed at determining the state of a river may differ from a site selected for a Reserve study. Whatever the main aim of the study, the site should at least have suitable habitat for the aquatic macroinvertebrates. The site should be either representative of the river delineation or should represent a critical section of the river (such as a section of the river that will stop flowing before the rest of the river). Reserve sites are usually compromise sites between the requirements of the different disciplines involved. For example, a site that is suitable for invertebrates may be too complex to model accurately, while a site preferred by the hydraulician may not provide suitable habitat for the biota.

An "ideal" macroinvertebrate site would be a site at which all or most of the invertebrate biotopes are present. This means that the site would have Stones-in–current, Stones-out-of-current, Vegetation-in-current, Vegetation-out-of-current, Sand, Gravel and Mud. In addition to a variety of biotopes, the biotopes will also be of good quality and quantity. As an absolute minimum the site should have at least either a stony biotope or a vegetation biotope.

When dealing with strictly alluvial rivers, such as the lower Mhlathuze River that is characterised by a sandy bottom, it is important that there is enough vegetation present to provide adequate habitat for the invertebrates. Moving sand (in current) is such an inhospitable habitat for invertebrates that it is often nearly devoid of life.

2.1.3 Data collection

Before the site visit and actual sampling it is important to collect all available invertebrate data for the river. This will include a literature survey as well as a search on the Rivers Database and contacting specialists that have worked in the area previously. This background information will assist in setting reference conditions. Recent information will ensure greater confidence in the present state of the invertebrate community.

2.1.4 Habitat assessment

The main aim of a habitat assessment is to evaluate the template on which the invertebrates exist. An organism can only occur at a site if suitable habitat exists, and it is therefore essential to assess not only the habitat quality and quantity but also the diversity of available biotopes. The field-data sheets (Tables 2.1 – 2.5) were designed for use in the RHP, but the information collected is also of use in Reserve studies. More details about the data-sheets as well as an explanation of the terminology used are given in the River Health Programme – Site Characterisation field-manual (Dallas 2005).

One of the routine habitat assessments has been the Invertebrate Habitat Assessment System (IHAS) developed by Mcmillan (1998). IHAS is a measure of the SASS biotopes sampled. It has, however; become clear that IHAS requires validation and testing, although the basic data remains of value. As an interim measure it was decided to continue using a modified IHAS (Table 2.5) where certain parameters (Stream Characteristics) including the scoring system have been omitted (Dallas 2005). This modified version of IHAS enables one to record details about the biotopes sampled, thus assisting in the interpretation of the invertebrate community.

Table 2.1 Site information (adapted from Dallas 2005)

Assessor Name(s)							
Organisation				Date	/ /		
Site information - assessed at the site							
RHP Site Code				Project Site Number			
River				Tributary of			
Farm Name:				Farm Reg. Code:			
Latitude and longitude co-ordinates:							
Degrees-minutes-seconds		or Decimal degrees		or Degrees & decimal minutes			
S ° ' . "		S . °		S ° . '		Cape datum Clarke	
E 0 ° ' . "		E 0 . °		E 0 ° . '		WGS-84 datum HBH94	
Site Description							
Map Reference (1: 50 000)		Site Length (m)		Altitude (m)			
Longitudinal Zone	Source zone	Mountain headwater stream	Mountain stream	Transitional	Upper foothill	Lower foothill	Lowland river
Rejuvenated cascades (gorge)	Rejuvenated foothill	Upland floodplain	Other:				
Associated Systems:	Wetland	Estuary	Other:		Distance:		
Additional Comments:							

Desktop / spatial information – data used for classifying a site and subsequent querying of data								
Political Region			Water Management Area					
Ecoregion I			Ecoregion II					
Secondary Catchment			Quaternary Catchment					
Water Chemistry Management Region								
Vegetation Type			Geological Type					
Contour Range (m): From:			to:					
Source Distance (km)			Stream Order					
Rainfall Region	Summer	Winter	Aseasonal	Other:				
DWAF Gauging Station	Yes	No	Code :		Distance Upstream		Or Downstream	

Table 2.2 Stream dimensions

Estimate widths and heights by ticking the appropriate categories; estimate average depth of dominant deep and shallow water biotopes.

(m)	**< 1**	**1-2**	**2-5**	**5-10**	**10-20**	**20-50**	**50-100**	**>100**
Macro-channel width								
Active-channel width								
Water surface width								
Bank height – Active channel								
(m)	< 1			1-3			>3	
Left Bank								
Right Bank								
Dominant physical biotope		Average Depth (m)		Specify physical biotope type				
Deep-water (>0.5m) physical biotope (e.g. pool)								
Shallow-water (<0.5m) physical biotope (e.g. riffle)								

Table 2.3 Substratum composition

Estimate abundance of each material using the scale: 0 – absent; 1 – rare; 2 – sparse; 3 – common; 4 - abundant; 5 – entire

Material	**Size class (mm)**	**Bed**	**Bank**
Bedrock			
Boulder	> 256		
Cobble	100 – 256		
Pebble	16 – 100		
Gravel	2 – 16		
Sand	0.06 – 2		
Silt / mud / clay	< 0.06		

Degree of embeddedness of substratum (%)
0-25
26-50
51-75
76-100

Table 2.4 Invertebrate biotopes
(present at a site compared to those actually sampled)

Summarised river make up: ('pool' = pool only; 'run' only; 'riffle/rapid' only; '2mix' = 2 types, '3mix' = 3 types)				
Pool	run	Riffle/rapid	2 mix	3 mix

Rate abundance of each SASS and specific biotope present at a site using the scale: 0 – absent; 1 – rare; 2 – sparse; 3 – common; 4 - abundant; 5 – entire. Add additional specific biotopes if necessary.

		Specific Biotope					
SASS Biotope	**Rating**		**Rating**		**Rating**		**Rating**
Stones in current		Riffle		Run		Boulder rapid	
		Chute		Cascade		Bedrock	
Stones out of current		Backwater		Slackwater		Pool	
		Bedrock					
Marginal vegetation in current		Grasses		Reeds		Shrubs	
		Sedges					
Marginal vegetation out of current		Grasses		Reeds		Shrubs	
		Sedges					
Aquatic vegetation		Sedges		Moss		Filamentous algae	
Gravel		Backwater		Slackwater		In channel	
Sand		Backwater		Slackwater		In channel	
Silt/mud/clay		Backwater		Slackwater		In channel	

Table 2.5 Invertebrate Habitat Assessment System (IHAS)

SAMPLING HABITAT Stones in Current (SIC)						
Total length of white water (riffle/rapid) (in metres)	none	0-1	>1-2	>2-3	>3-5	>5
Total length of submerged stones in current (run) (in metres)	none	0-2	>2-5	>5-10	>10	
Number of separate SIC areas kicked (not individual stones)	0	1	2-3	4-5	6+	
Average stone size's kicked (cms); (<2 or >20 is '<2>20'); (gravel is <2; bedrock is >20)	none	<2>20	2-10	11-20	2-20	
Amount of stone surface clear (of algae, sediment etc.) (%)	n/a	0-25	26-50	51-75	>75	
Protocol: time spent actually kicking SICs (in minutes), (gravel/bedrock = 0 min)	0	<1	>1-2	2	>2-3	>3
Vegetation						
Length of marginal vegetation sampled (river banks) (in metres)	none	0-½	>½-1	>1-2	2	>2
Amount of aquatic vegetation/algae sampled (underwater) (in metres^2)	none	0-½	>½-1	>1		
Marginal vegetation sampled in or out of current	none		In current	Out of current		both
Type of vegetation (percent leafy vegetation as opposed to stems/shoots) (aquatic vegetation only = 49%). (E.g. Mostly leafy = >75%; mostly stems/shoots = 1-25%)	none		1-25	26-50	51-75	>75
Other Habitat / General						
Stones out of current (SOOC) sampled: (in metres^2)	none	0-½	>½-1	1	>1	
Sand sampled: (in minutes) ('under' = present, but only	none	under	0-½	>½-1	1	>1

under stones)						
Mud sampled: (in minutes) (‘under’ = present, but only under stones)	none	under	0-½	½	>½	
Gravel sampled: (in minutes) (if all gravel, SIC stone size = ’<2’	none	0-½	½	>½**		
Bedrock sampled: (‘all’=no SIC, sand, or gravel; then SIC stone size =’>20’	none	some			all**	
Algal presence: (‘1-2m²’=algal bed; ‘rocks’=on rocks; ‘isol.’=isolated clumps)	>2m²	rocks	1-2m²	<1m²	Isol.	none
Tray identification: (Protocol – using time: ‘corr’ = correct time)		under		corr		over

3 MIRAI: DETERMINING THE EC

3.1 RATING APPROACH

The rating approach for the MIRAI is basically the same as the generic description in section Module A. The MIRAI comprises four different metric groups that measure the deviation of the invertebrate assemblage from the reference (expected) assemblage in terms of flow modification, habitat modification and water quality modification, as well as system connectivity and seasonality.

The first step in determining the Present Ecological State (PES) of the invertebrates is to complete the data sheet (see appendix A). This includes the abundance and frequency of occurrence (if possible) of the different invertebrate taxa under natural (reference) conditions, as well as the abundance and frequency of occurrence (if possible) of the invertebrate taxa present. For this index an increase in abundance and/or frequency of occurrence, as well as a decrease in abundance and/or frequency of occurrence, is seen as an impact or change compared to natural. The six point rating system works as follows -

- 0 = No change from reference
- 1 = Small change from reference
- 2 = Moderate change from reference
- 3 = Large change from reference
- 4 = Serious change from reference
- 5 = Extreme change from reference

In addition to the rating of the different metrics, each metric (and metric group) is also ranked and weighted according to its importance in determining the EC of the invertebrate assemblage. Basically each metric is ranked in terms of which metric (if it changed from worst to best) would best indicate good integrity in terms of the metric group. In other words, which metric is the most important in determining the present state of the invertebrates? The ranking procedure is only used to guide the weighting and is not used in any calculation.

The metric ranked 1 (most important) is weighted 100%. The other metrics are then ranked as a percentage relative to the most important metric. It is important to remember that all metrics with the same rank must have the same weight, and that a lower ranked metric - 3, say - must have a lower percentage weight than a higher ranked metric - 2, for instance.

3.2 FLOW MODIFICATION

In order to facilitate the evaluation of the impact of different flows on the invertebrate community four different velocity categories have been defined -

- Very fast flowing water >0.6 m/s

- Moderately fast flowing water 0.3-0.6 m/s
- Slow flowing water 0.1-0.3 m/s
- Very slow flowing/standing water <0.1 m/s

Each invertebrate taxon has been assigned a velocity preference score (0-5), based on previous surveys and personal experience. These velocity preference scores are indicated on the Data sheet of the MIRAI set of spreadsheets (Appendix B). It is recognised that these preference scores are preliminary, and a project has been approved to identify more final preference scores for a number of the more flow sensitive taxa. The velocity preference scores were allocated according to the following system -

- 0 = No preference
- 1 = Very small preference
- 2 = Small preference
- 3 = Moderate preference
- 4 = High preference
- 5 = Very high preference

In the flow modification metric group the presence / absence, as well as the abundance and/or frequency of occurrence of taxa in all velocity categories, are evaluated. It is important to only consider a taxon in one of the velocity categories. If, for example, a taxon has a high preference for very fast flowing water, but only a moderate preference for moderately fast flowing water, it will be assessed in the very fast flowing water category.

The MIRAI makes provision to assess the presence / absence of taxa as well as their abundance and frequency of occurrence. Although the frequency of occurrence will generally be more useful than abundance, the paucity of data often necessitates the use of abundance information. However, if sufficient information is available it is preferable to use the frequency of occurrence, rather than the abundance information only.

3.3 HABITAT MODIFICATION

In order to facilitate the evaluation of the impact of habitat changes on the invertebrate community, five different habitat types have been defined -

- Bedrock: Due to the small size of invertebrates, it was decided to include boulders with bedrock in the same biotope. Bedrock and boulders include all hard surfaces larger than 256mm. It includes bedrock / boulders that are in current as well as those out-of-current.
- Cobbles: The cobbles biotope also includes pebbles. As such the cobbles biotope includes all hard surfaces within the 16-256 mm size range. As in the case of the bedrock both in-current and out-of-current cobbles are considered.
- Vegetation: The vegetation biotope includes all vegetation that can provide habitat for invertebrates. As such it includes both fringing and aquatic vegetation that might be either in-current or out-of-current
- Gravel, Sand and Mud: This biotope is a combination of the smaller grain types

(<16 mm size class) and includes gravel, sand and mud both in-current as well as out-of-current.

- Water column: This biotope includes the water surface and the water column.

Habitat preference scores were allocated in the same way as the velocity preference scores (Appendix A). The evaluation used to rate the present state is also the same as was used to rate the flow modification metric group.

3.4 WATER QUALITY MODIFICATION

To facilitate the evaluation of changes in water quality on the invertebrate community, four different groups were identified. These groups are based on SASS5 weights (Appendix D). At this stage, the water quality evaluation can therefore only be done at family level. If any species level information is available, it will be taken into account separately when rating the water quality metric group.

- High requirement for unmodified physico-chemical conditions: SASS5 weights 12-15
- Moderate requirement for unmodified physico-chemical conditions: SASS5 weights 7-11
- Low requirement for unmodified physico-chemical conditions: SASS5 weights 4-6
- Very low requirement for unmodified physico-chemical conditions: SASS5 weights 1-3

In addition to the normal set of metrics regarding the presence / absence and the abundance and/or frequency of occurrence of taxa, two additional metrics - the SASS5 score and the ASPT value - are included.

Guidelines for rating SASS and ASPT changes are as follows -
SASS scores as a percentage of the reference SASS score

- >90% = 0
- 80-90% = 1
- 60-80% = 2
- 40-60% = 3
- 20-40% = 4
- <20% = 5

ASPT scores as a percentage of the reference ASPT value

- >95% = 0
- 90-95% = 1
- 85-90% = 2
- 80-85% = 3
- 75-80% = 4
- <75% = 5

3.5 SYSTEM CONNECTIVITY AND SEASONALITY

The system connectivity metrics should only be used where migratory taxa (eg.

Paleomonidae and *Varuna*) are expected to occur under reference conditions. In certain instances seasonal differences also come into play. These metrics should be used where one would expect seasonal changes in the invertebrates usually related to changes in flow pattern (cf 3.6).

3.6 ECOLOGICAL CATEGORY (EC)

The four metric groups (see appendix D) are combined to derive the invertebrate EC. These metric groups are according to the method described in the rating approach section 3.1. The metric group that will best indicate the response of invertebrates in a particular river or at a particular site is ranked 1 with a weight of 100%. The fourth metric group (system connectivity and seasonality) is not always relevant. If it was not included in the assessment, it should receive a weight of 0%.

The model automatically calculates the EC based on the percentage of reference. It does not, however, indicate the boundary categories, which include a measure of personal judgement. As a guidance, 2% under or over the percentage that defines the EC boundary indicates a boundary category. For example, 78.5% will equate to a B/C category.

3.7 INTERPRETATION OF FLOW AND NON-FLOW RELATED IMPACTS

The reasons for a specific EC can be determined by interrogating the composition of the EC, that is, which of the metric groups is most impacted. By unpacking the EC and the metric groups one can discover how the invertebrate composition has changed, and if it is due to flow or non-flow related impacts. If, for example the major reason for the change in EC is due to flow modification, one has to unpack the flow modification metric group to determine which of the metrics are most responsible for the change. From this one might be able to make recommendations regarding the maintenance or possible improvement of the invertebrate assemblage.

4 MIRAI: PREDICTIVE USES

MIRAI can also be used in a predictive way. The likely changes in flow, habitat and water quality can be described and the response to these changes used to modify the list of taxa present at the site. Possible changes can either be a loss or gain, or a change in the abundance and/or frequency of occurrence of taxa.

After changing the invertebrate composition on the data sheet of the MIRAI, the model can then be run in a predictive way to determine the EC under various different scenarios. It must, however, always be remembered when using the MIRAI predictively that the likelihood of the EC depends on the accuracy of the expected changes in the invertebrate community.

5 STEPWISE PROCEDURE FOR RUNNING THE MIRAI

- Determine the reference conditions
- Complete the data sheet
- Fill in the Season column if applicable
- Rank and weight the flow modification metrics.
- Sort the data according to the >0.6m/s velocity category.
- Compare the observed (present) taxa to the expected (reference) taxa.
- Rate the metric accordingly, indicating the reason for the rating in the comment block
- Repeat the process (3-6) for the other metrics and metric groups
- Rank and weight the metric groups.

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APPENDIX A INVERTEBRATE DATA SHEETS

Table E.A-1 Taxa with specific velocity preferences

Very Fast (>0.6 m/s)	Moderately Fast (0.3-0.6 m/s)	Slow (0.1-0.3 m/s)	Very Slow (<0.1 m/s)
Perlidae	Elmidae	Ecnomidae	Machadorythidae
Oligoneuridae	Naucoridae	Haliplidae	Veliidae
Glossosomatidae	Gomphidae	Tipuliudae	Lestidae
Hydropsalpingidae	Coenagrionidae	Hydroptilidae	Belostomatidae
Psephenidae	Libellulidae	Calopterygidae	Gerridae
Polycentropodidae	Barbarochthonidae	Lepidostomatidae	Hydrometridae
Blepharoceridae	Ephemeridae	Pisuliidae	Nepidae
Ceratopogonidae	Hydraenidae	Chironomidae	Notonectidae
Muscidae	Amphipoda	Chlorocyphidae	Pleidae
Simuliidae	Potamonautidae	Corduliidae	Dipseudopsidae
Notonemouridae	Heptageniidae	Corixidae	Calamoceratidae
Hydropsychidae	Pyralidae	Tabanidae	Ephydridae
Telagonodidae	Leptoceridae	Corbiculidae	Syrphidae
Dryopidae	Sericostomatidae	Sphaeridae	Dytiscidae
Elmidae	Corydalidae	Platycnemidae	Sialidae
Trichorythidae		Protoneuridae	Culicidae
Petrotrhincidae		Unionidae	Psychodidae
Paleomonidae		Limnichidae	Bulinae
Polymitarcyidae			Hydrobiidae
Gyrinidae			Lymnaeidae
Prosopistomatidae			Physidae
Philopotamidae			Planorbinae
Psychomyiidae			Thiaridae
Xiphocentronidae			Viviparidae
			Chlorolestidae
			Caenidae
			Dixidae
			Leptophlebiidae

Table E.A-2 Taxa with specific habitat preferences

Bedrock	Cobbles	Vegetation	Gravel, Sand, Mud	Water
Petrothirincidae	Hirudinea	Nepidae	Gomphidae	Veliidae
Psychomyiidae	Libellulidae	Belostomatidae	Syrphidae	Gerridae
Xiphocentronidae	Glossosomatidae	Peidae	Machadorythidae	Culicidae
Polycentropodidae	Chlorocyphidae	Lestidae	Dipseudopsidae	Dixidae
Porifera	Perlidae	Chlorolestidae	Sialidae	Gyrinidae
Ancylidae	Prosopistomatidae	Atyidae	Oligochaeta	Hydrometridae
	Notonemouridae	Protoneuridae	Ephemeridae	Notonectidae
	Heptageniidae	Coenagrionidae	Unionidae	Muscidae
	Telagonodidae	Haliplidae	Corbiculidae	Naucoridae
	Dryopidae	Hydrophilidae	Sphaeridae	Corixidae
	Empididae	Hydraenidae	Ephydridae	Psychodidae
	Elmidae	Calopterygidae	Polymitarcyidae	
	Trichorythidae	Helodidae	Tabanidae	
	Athericidae	Platycnemidae	Limnichidae	
	Philopotamidae	Pyralidae	Tipulidae	
	Psephenidae	Dytiscidae	Caenidae	
	Corydalidae	Hydrobiidae	Corduliidae	
	Paleomonidae	Physidae	Hydracarina	
	Potamonautidae	Thiaridae	Calamoceratidae	
	Aeshnidae	Viviparidae	Amphipoda	
	Sericostomatidae	Hydroptilidae		
	Leptophlebiidae	Bulinae		
	Blepharoceridae	Lymnaeidae		
	Oligoneuridae	Planorbinae		
	Hydropsychidae			
	Ceratopogonidae			
	Pisuliidae			
	Ecnomidae			
	Hydropsalpingidae			
	Simuliidae			
	Barbarochthonidae			

Table A.E-3 Taxa with specific water quality preferences

High	Moderate	Low	Very Low
Helodidae	Veliidae	Gyrinidae	Culicidae
Pyralidae	Gerridae	Pleidae	Notonectidae
Blepharoceridae	Dixidae	Porifera	Belostomatidae
Polycentropodidae	Hydrometridae	Ancylidae	Nepidae
Hydropsychidae >2spp	Petrothrincidae	Viviparidae	Coelenterata
Sericostomatidae	Chlorolestidae	Hydropsychidae 1sp	Hydrobiidae
Hydropsalpingidae	Psychomyiidae	Hydropsychidae 2spp	Physidae
Barbarochthonidae	Xiphocentronidae	Simuliidae	Thiaridae
Perlidae	Platycnemidae	Naucoridae	Bulinae
Prosopistomatidae	Paleomonidae	Haliplidae	Lymnaeidae
Notonemouridae	Aeshnidae	Coenagrionidae	Planorbinae
Heptageniidae	Leptophlebiidae	Dytiscidae	Turbellaria
Telagonodidae	Ecnomidae	Hydroptilidae	Muscidae
Oligoneuridae	Chlorocyphidae	Libellulidae	Corixidae
Baetidae >2spp	Dryopidae	Empididae	Potamonautidae
Amphipoda	Elmidae	Hydrophilidae	Hirudinea
Ephemeridae	Trichorythidae	Baetidae 1sp	Psychodidae
	Psephenidae	Baetidae 2spp	Chironomidae
	Hydraenidae	Leptoceridae	Syrphidae
	Calopterygidae	Ceratopogonidae	Ephydridae
	Lestidae	Tabanidae	Oligochaeta
	Atyidae	Tipulidae	Sphaeridae
	Protoneuridae	Caenidae	
	Corydalidae	Sialidae	
	Glossosomatidae	Unionidae	
	Athericidae	Corbiculidae	
	Philopotamidae	Gomphidae	
	Lepidostomatidae		
	Pisuliidae		
	Hydracarina		
	Polymitarcyidae		
	Limnichidae		
	Corduliidae		
	Calamoceratidae		
	Dipseudopsidae		

5. SASS Version 5 Score Sheet -

Version date: Feb 2005

Date:	/ /		(dd.ddddd)	**Biotopes Sampled**	Rating (1 - 5) / Time (min)
RHP Site Code:	-	**Grid reference (dd mm ss.s) Lat:**	S	Stones In Current (SIC)	
Collector/Sampler:		**Long:**	E	Stones Out Of Current (SOOC)	
River:		**Datum (WGS84/Cape):**		Bedrock	
Level 1 Ecoregion:		**Altitude (m):**	m	Aquatic Veg	
Quaternary Catchment:		**Zonation:**		MargVeg In Current	
	Temp (°C):		Cond (mS/m)	MargVeg Out Of Current	
Site Description:	pH:		Clarity (cm):	Gravel	
	DO (mg/L):		Turbidity:	Sand	
	Flow:		Colour:	Mud	
	Riparian Disturbance:			Hand picking/Visual observation	
	Instream Disturbance:				

Taxon		S	Veg	GSM	TOT
PORIFERA	5				
COELENTERATA	1				
TURBELLARIA	3				
ANNELID					
Oligochaeta	1				
Hirudinea (Leeches)	3				
CRUSTACE					
Amphipoda	13				
Potamonautidae*	3				
Atyidae (Shrimps)	8				
Palaemonidae	10				
HYDRACARINA (Water	8				
PLECOPTERA					
Notonemourida	14				
Perlidae	12				
EPHEMEROPTERA					
Baetidae 1sp	4				
Baetidae 2 sp	6				
Baetidae > 2 sp	12				
Caenidae	6				
Ephemerida	15				
Heptageniidae (Flatheaded	13				
Leptophlebiidae	9				
Oligoneuridae (Brushlegged	15				
Polymitarcyidae (Pale	10				
Prosopistomatidae (Water	15				
Teloganodidae	12				
Tricorythidae (Stout Crawlers)	9				
ODONATA (Dragonflies & Damselflies)					
Calopterygidae	10				
Chlorocyphidae	10				
Synlestidae	8				
Coenagrionidae (Sprites and	4				
Lestidae (Emerald	8				
Platycnemidae (Brook	10				
Protoneuridae	8				
Aeshnidae (Hawkers &	8				
Corduliidae	8				
Gomphidae	6				
Libellulidae	4				
LEPIDOPTERA (Aquatic					
Crambidae	12				

Taxon		S	Veg	GSM	TOT
HEMIPTERA					
Belostomatidae* (Giant water	3				
Corixidae* (Water	3				
Gerridae* (Pond skaters/Water	5				
Hydrometridae* (Water	6				
Naucoridae* (Creeping water	7				
Nepidae* (Water	3				
Notonectidae*	3				
Pleidae* (Pygmy	4				
Veliidae/M...veliidae* (Ripple	5				
MEGALOPTERA (Fishflies, Dobsonflies & Alderflies)					
Corydalidae (Fishflies &	8				
Sialidae (Alderflies)	6				
TRICHOPTERA					
Dipseudopsidae	10				
Ecnomida	8				
Hydropsychidae 1 sp	4				
Hydropsychidae 2 sp	6				
Hydropsychidae > 2 sp	12				
Philopotamida	10				
Polycentropodida	12				
Psychomyiidae/Xiphocentronida	8				
Cased caddis:					
Barbarochthonidae	13				
Calamoceratidae	11				
Glossosomatidae	11				
Hydroptilidae	6				
Hydrosalpingidae	15				
Lepidostomatida	10				
Leptoceridae	6				
Petrothrincidae	11				
Pisuliidae	10				
Sericostomatidae	13				
COLEOPTERA					
Dytiscidae/Noteridae* (Diving	5				
Elmidae/Dryopidae* (Riffle	8				
Gyrinidae* (Whirligig	5				
Haliplidae* (Crawling water	5				
Helodidae (Marsh	12				
Hydraenidae* (Minute moss	8				
Hydrophilidae* (Water scavenger	5				
Limnichidae	10				
Psephenidae (Water	10				

Taxon		S	Veg	GSM	TOT
DIPTERA (Flies)					
Athericidae	10				
Blephariceridae (Mountain	15				
Ceratopogonidae (Biting	5				
Chironomidae	2				
Culicidae*	1				
Dixidae* (Dixid	10				
Empididae (Dance	6				
Ephydridae (Shore	3				
Muscidae (House flies, Stable	1				
Psychodidae (Moth	1				
Simuliidae	5				
Syrphidae* (Rat tailed	1				
Tabanidae (Horse	5				
Tipulidae (Crane	5				
GASTROPODA					
Ancylidae (Limpets)	6				
Bulininae*	3				
Hydrobiidae*	3				
Lymnaeidae* (Pond	3				
Physidae* (Pouch	3				
Planorbinae* (Orb	3				
Thiaridae*	3				
Viviparidae* ST	5				
PELECYPODA					
Corbiculidae	5				
Sphaeriidae (Pills	3				
Unionidae (Perly	6				
SASS Score					
No. of Taxa					
ASPT					
Other biota:					
Comments/Observations:					

Procedure: Kick SIC & bedrock for 2 mins, max. 5 mins. Kick SOOC & bedrock for 1 min. Sweep marginal vegetation (IC & OOC) for 2m total and aquatic veg 1m². Stir & sweep gravel, sand, mud for 1 min total. * = airbreathers

Hand picking & visual observation for 1 min - record in biotope where found (by circling estimated abundance on score sheet). Score for 15 mins/biotope but stop if no new taxa seen after 5 mins.

Estimate abundances: 1 = 1, A = 2-10, B = 10-100, C = 100-1000, D = >1000 S = Stone, rock & solid objects; Veg = All vegetation; GSM = Gravel, sand, mud SWC = South Western Cape, T = Tropical, ST = Sub-tropical

Rate each biotope sampled: 1=very poor (i.e. limited diversity), 5=highly suitable (i.e. wide diversity)

APPENDIX B MIRAI SPREADSHEETS

Portion of the Datasheet as an example. For complete Datasheet refer to the model.

Taxon	Season	Ref abun	Ref freq	Pres Abun	Pres freq	<0.1	0.1-0.3	0.3-0.6	>0.6	BEDROCK	COBBLES	VEG	GSM	WATER	QUALITY
Porifera						2	2	2	2	3	2	1	0	0	LOW
Coelenterata						2	2	1	0	2	2	1	0	0	NONE
Turbellaria						1	2	3	4	1	4	0	0	0	NONE
Oligochaeta						2	2	2	1	0	1	0	4	0	NONE
Hirudinea						2	2	1	1	0	4	1	1	0	NONE
Amphipoda						1	2	3	2	0	2	2	3	0	HIGH
Potamonautidae						1	1	3	2	0	3	1	1	0	NONE
Atyidae						2	2	0	0	0	1	4	1	0	MODERATE
Paleomonidae						0	2	2	3	0	3	0	0	0	MODERATE
Hydracarina						0	2	2	0	1	1	2	3	1	MODERATE
Notonemouridae						1	1	2	4	1	4	1	0	0	HIGH
Perlidae						1	1	1	5	1	4	1	0	0	HIGH
Baetidae 1sp						2	2	2	2	2	2	2	2	1	LOW
Baetidae 2spp						2	2	2	2	2	2	2	2	1	LOW
Baetidae >2spp						2	2	2	2	2	2	2	2	1	HIGH
Caenidae						3	2	1	1	0	2	1	3	0	LOW
Ephemeridae						2	2	3	2	0	1	0	4	0	HIGH
Heptageniidae						1	1	3	2	1	4	1	0	0	HIGH
Leptophlebiidae						3	2	2	1	1	3	2	0	0	MODERATE
Machadorythidae						5	0	0	0	0	1	0	4	0	
Oligoneuridae						0	0	1	5	2	3	1	1	1	HIGH
Polymitarcyidae						2	2	2	3	0	1	0	3	0	MODERATE
Prosopistomatidae						1	1	2	3	1	4	1	0	0	HIGH
Telagonodidae						0	0	2	4	1	4	1	0	0	HIGH
Trichorythidae						0	1	1	4	1	4	1	0	0	MODERATE
Calopterygidae						1	3	1	0	0	1	3	1	0	MODERATE
Chlorocyphidae						2	3	1	0	1	4	1	0	0	MODERATE
Chlorolestidae						3	2	1	0	0	1	4	0	0	MODERATE
Coenagrionidae						1	2	3	1	0	1	4	1	0	LOW
Lestidae						4	1	0	0	0	1	4	1	0	MODERATE
Platycnemidae						2	3	1	1	0	2	3	0	0	MODERATE
Protoneuridae						2	3	1	1	0	1	4	1	0	MODERATE
Aeshnidae						1	2	2	2	0	3	2	0	0	MODERATE
Corduliidae						2	3	1	0	0	2	1	3	0	MODERATE
Gomphidae						0	2	3	0	0	1	0	5	0	LOW
Libellulidae						1	2	3	1	1	4	0	1	0	LOW
Pyralidae						1	1	3	2	0	2	3	0	0	HIGH
Belostomatidae						4	1	0	0	0	0	4	0	1	NONE
Corixidae						2	3	1	0	1	1	1	1	4	NONE
Gerridae						4	1	0	0	0	0	0	0	5	MODERATE
Hydrometridae						4	1	0	0	0	0	2	0	4	MODERATE
Naucoridae						2	2	3	0	1	1	1	1	4	LOW
Nepidae						4	1	0	0	0	0	5	0	0	NONE
Notonectidae						4	1	0	0	0	0	2	0	4	NONE
Pleidae						4	1	0	0	0	0	4	0	1	LOW
Veliidae						5	1	1	0	0	0	0	0	5	MODERATE
Corydalidae						0	0	3	2	0	3	0	1	0	MODERATE
Sialidae						4	3	1	0	0	1	0	4	0	LOW
Dipseudopsidae						4	1	0	0	0	1	0	4	0	MODERATE
Ecnomidae						1	5	0	0	2	3	2	0	0	MODERATE
Hydropsychidae 1sp						0	1	2	4	2	3	1	0	0	LOW
Hydropsychidae 2spp						0	1	2	4	2	3	1	0	0	LOW
Hydropsychidae >2spp						0	1	2	4	2	3	1	0	0	HIGH
Philopotamidae						0	1	2	3	1	4	1	1	0	MODERATE
Polycentropodidae						0	0	3	4	4	3	0	0	0	HIGH
Psychomyiidae						0	1	2	3	4	2	1	0	0	MODERATE
Xiphocentronidae						0	1	2	3	4	2	1	0	0	MODERATE
Barbarochthonidae						0	2	3	1	2	3	2	0	0	HIGH
Calamoceratidae						4	1	0	0	0	2	2	3	0	MODERATE
Glossosomatidae						0	2	3	4	1	4	0	1	0	MODERATE
Hydroptilidae						0	3	2	2	1	2	3	1	0	LOW
Hydropsalpingidae						0	1	3	4	2	3	2	0	0	HIGH
Lepidostomatidae						1	3	2	1	2	2	2	2	0	MODERATE
Leptoceridae						0	1	3	2	2	2	2	2	0	LOW
Petrothrincidae						0	0	1	4	4	1	0	0	0	MODERATE
Pisuliidae						1	3	2	1	2	3	2	2	0	MODERATE
Sericostomatidae						0	1	3	2	0	3	2	0	0	HIGH
Dytiscidae						4	2	1	0	1	2	3	1	2	LOW
Elmidae						0	0	4	2	1	4	1	0	0	MODERATE
Dryopidae						0	0	2	4	1	4	1	0	0	MODERATE
Gyrinidae						1	2	2	3	0	0	0	0	5	LOW
Haliplidae						3	4	1	1	1	1	4	1	1	LOW
Helodidae						2	2	2	1	0	2	3	0	0	HIGH

FLOW MODIFICATION METRICS (FM)

FLOW MODIFICATION METRICS. WITH REFERENCE TO VELOCITY PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	% Weight	COMMENTS
Presence of taxa with a preference for very fast flowing water				
Abundance and/or frequency of occurrence of taxa with a preference for very fast flowing water				
Presence of taxa with a preference for moderately fast flowing water				
Abundance and/or frequency of occurrence of taxa with a preference for moderately fast flowing water				
Presence of taxa with a preference for slow flowing water				
Abundance and/or frequency of occurrence of taxa with a preference for slow flowing water				
Presence of taxa with a preference for standing water				
Abundance and/or frequency of occurrence of taxa with a preference for standing water				
Overall % change in flow dependance of assemblage			#DIV/0!	

Velocity Preference Scores: **GENERIC GUIDELINES FOR SCORING (0-5)** 0=No change from reference 1= Small change from reference 2=Moderate changefrom reference 3=Large change from reference 4=Serious change from reference 5=Extreme change from reference (completely dominant or absent)	**Velocity Categories:** Very Fast flowing water >0.6 m/s; Moderately fast flowing water 0.3-0.6 m/s; Slow flowing water 0.1-0.3 m/s; Standing water <0.1 m/s	
Ranking of metrics: Rank order in terms of which metric (if it changed from worst to best) would best indicate good integrity in terms of velocity categories. Do not rank metrics that are not relevant (leave them blank)	**% Weight:** Give 100% to rank 1, then say how big the impact of each of the others is as a % of that (irrespective of the rating).	

HABITAT MODIFICATION METRICS (H)

HABITAT MODIFICATION METRICS. WITH REFERENCE TO INVERTEBRATE HABITAT PREFERENCES, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	METRICS	% WEIGHT	COMMENTS
Has the occurrence of invertebrates with a preference for bedrock/boulders changed relative to expected?				
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for bedrock/boulders changed?				
Has the occurrence of invertebrates with a preference for loose cobbles changed relative to expected?				
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for loose cobbles changed?				
Has the occurrence of invertebrates with a preference for vegetation changed relative to expected?				
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for vegetation changed?				
Has the occurrence of invertebrates with a preference for sand, gravel or mud changed relative to expected?				
Has the abundance of any of the taxa with a preference for sand, gravel or mud changed relative to expected?				
Has the occurrence of invertebrates with a preference for the water column or water surface changed relative to expected?				
Has the abundance and/or frequency of occurrence of any of the taxa with a preference for the water column/water surface changed?				
Overall % change in flow dependanceof assemblage			#DIV/0!	
Habitat Preference Scores: **GENERIC GUIDELINES FOR SCORING (0-5)** 0=No change from reference 1= Small change from reference 2=Moderate changefrom reference 3=Large change from reference 4=Serious change from reference 5=Extreme change from reference (completely dominant or absent)				
Ranking of metrics: Rank order in terms of which metric (if it changed from worst to best) would best indicate good integrity in terms of habitat types. Do not rank metrics that are not relevant (leave them blank)	% **Weight:** Give 100% to rank 1, then say how big the impact of each of the others is as a % of that (irrespective of the rating).			

WATER QUALITY METRICS (WQ)

WATER QUALITY METRICS. WITH REFERENCE TO WATER QUALITY REQUIREMENTS, WHAT ARE THE CHANGES TO THE FOLLOWING OBSERVED OR EXPECTED TO BE?	RATING	RANKING OF METRICS	% WEIGHT	COMMENTS
Has the number of taxa with a high requirement for unmodified physico-chemical conditions changed?				
Has the abundance and/or frequency of occurrence of the taxa with a high requirement for unmodified physico-chemical				
Has the number of taxa with a moderate requirement for unmodified physico-chemical conditions changed?				
Hasthe abundance and/or fequency of occurrence of the taxa with a moderate requirement for modified physico-chemical				
Has the number of taxa with a low requirement for unmodified physico-chemical conditions changed?				
Has the abundance and/or frequency of occurrence of the taxa with a low requirement for unmodified physico-chemical				
Has the number of taxa with a very low requirement for unmodified physico-chemical conditions changed?				
Has the abundance and/or frequency of occurrence of the taxa with a very low requirement for unmodified physico-chemical				
How does the total SASS score differ from expected?				
How does the total ASPT score differ from expected?				
Overall change to indicators of modified water quality			#DIV/0!	

Water Qaulity delineations (Based on SASS5 weights) High Water Quality Preference: (SASS weights 12-15) Moderate Water Quality Preference: (SASS weights 7-11) Low Water Quality Preference: (SASS weights 4-6) Very low Water Quality Preference: (SASS weights 1-3)	**SASS Scores:** **GUIDELINES FOR SCORING (% of reference)** >90% = 0 80-90% = 1 60-80% = 2 40-60% = 3 20-40% = 4	
Water Quality Preference Scores: **GENERIC GUIDELINES FOR SCORING (0-5)** 0=No change from reference 1= Small change from reference 2=Moderate change from reference 3=Large change from reference 4=Serious change from reference 5=Extreme change from reference (completely dominant or absent)	**ASPT Values:** **GUIDELINES FOR SCORING (% of reference)** >95% = 0 90-95% = 1 85-90% = 2 80-85% = 3 75-80% = 4	
Ranking of metrics: Rank order in terms of which metric (if it changed from worst to best) would best indicate good integrity in terms of water quality requirements. Do not rank metrics that are not relevant (leave them blank)	% **Weight:** Give 100% to rank 1, then say how big the impact of each of the others is as a % of that (irrespective of the rating).	

SYSTEM CONNECTIVITY AND SEASONALITY (CS)

WHAT IS THE EXTENT OF THE FOLLOWING	RATINGS	COMMENTS
Weirs and causeways	2.00	
Impoundments		
Changes in seasonality		

Based on observed and derived data, with reference to migration and seasonality, how did the following change?	RATING	RANKING OF METRICS	% Weight	COMMENT
Impact on distribution of migratory taxa		2		
Impact on abundance and/or frequency of occurrence of migratory taxa				
Impact on occurrence of taxa with seasonal distribution	2	1	100	
Impact on abundance and/or frequency of occurrence of taxa with seasonal distribution				
Overall % change in flow dependance of assemblage			**40**	

ECOLOGICAL CATEGORY

Which of these measures will best indicate the response of invertebrates (***in this system at this site***)							
			INVERTEBRATE EC: BASED ON WEIGHTS OF METRIC GROUPS				
INVERTEBRATE EC METRIC GROUP		METRIC GROUP CALCULATED SCORE	CALCULATED WEIGHT	WEIGHTED SCORE OF GROUP	RANK OF METRIC GROUP	% WEIGHT FOR METRIC GROUP	COMMENTS
FLOW MODIFICATION	FM	#DIV/0!	*#DIV/0!*	#DIV/0!			
HABITAT	H	#DIV/0!	*#DIV/0!*	#DIV/0!			
WATER QUALITY	WQ	#DIV/0!	*#DIV/0!*	#DIV/0!			
CONNECTIVITY & SEASONALITY	CS	60.0	*#DIV/0!*	#DIV/0!			
						0	
INVERTEBRATE EC				#DIV/0!			
INVERTEBRATE EC CATEGORY				**#DIV/0!**			
>89=A; 80-89=B; 60-79=C; 40-59=D; 20-39=E; <20=F							

Guidelines for ranking of metric groups.
Which of the Metric Groups will best indicate the response of invertebrates at this site or reach/invertebrate habitat segment.

Considering the range from 5 to 0 of each of these metric groups, which one would most affect overall Invertebrate Response (PES) if it changed from 0 to 5? (irrespective of the rating). This metric group is ranked as 1, the next most responsive, ranked as 2, etc.

Guidelines for weighting of metric groups.
Give 100% to rank 1, then say how big the impact of each of the others is as a % of that (irrespective of the rating).