RVI
RIPARIAN VEGETATION INDEX

NP Kemper

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RVI

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EXECUTIVE SUMMARY

A national monitoring programme, the River Health Programme (RHP), is being designed for South Africa which focuses on measuring and assessing the ecological state of riverine ecosystems. The overall goal of the RHP is to expand the ecological basis of information on aquatic resources, in order to support the rational management of these systems.

A pilot application of the RHP is currently being undertaken on the main rivers of Mpumalanga Province. The overall project goal of which is to develop and implement biomonitoring technologies for rivers. This included the need to develop and apply a rapid index to assess the condition of riparian vegetation which could be integrated into the biomonitoring programme for the Province.

Nigel Kemper of IWR Environmental was appointed by the Water Research Commission (WRC) to undertake the development of the Riparian Vegetation Index (RVI). The appointment involved the development and testing of a relatively simple and rapid index to assess the condition of riparian vegetation over a three year period in conjunction with the WRC - Mpumalanga pilot study. The RVI was developed and refined in stages.

Initially an aerial based method was applied to satisfy information requests for riparian vegetation condition on the Crocodile River. The method involved the assessment of the relative impacts, from an aerial video of the river under assessment, of seven criteria relevant to river degradation. The method culminated in an overall assessment of river condition for different reaches of the river according to six classes relative to a hypothetical pristine condition.

A site based method was later adapted from the Index for Stream Condition (ISC), developed for similar application in Australia. Development of the RVI involved the adaptation of each of the components of the ISC to suit specific South African riparian vegetation and site characteristics, personnel constraints and information requirements. A RVI formula was subsequently developed relating each of the components which are carefully assessed at specific sites in the field.

The RVI is derived from the following formula:

$$RVI = [(EVC) + ((SI \times PCIRS) + (RIRS))]$$

Where;

- EVC is extent of vegetation cover,
- SI is structural intactness,
- *PCIRS* is percentage cover of indigenous riparian species, and
- RIRS is recruitment of indigenous riparian species.

The assessment of the components on site is conducted by technical staff of appropriate organisations on specific field data sheets according to a carefully tested and described method. The RVI score and component scores are derived and stored in the National Biomonitoring database with the aid of the Rivers Database programme.

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1. INTRODUCTION

1.1 The need for riparian vegetation monitoring

A national monitoring programme is being designed for South Africa which focuses on measuring and assessing the ecological state of riverine ecosystems. This programme, referred to as the River Health Programme (RHP), is developed with the overall goal of expanding the ecological basis of information on aquatic resources, in order to support the rational management of these systems (Roux, 1997).

The objectives of the RHP (Roux, 1999) are to: a) measure, assess and report on the ecological state of aquatic ecosystems, b) detect and report on spatial trends in the ecological state of aquatic ecosystems, and c) identify and report on emerging problems regarding the ecological state of aquatic ecosystems in South Africa.

In the Province of Mpumalanga a pilot application of the RHP is being undertaken on the main rivers of Mpumalanga. The WRC - Mpumalanga project team identified several key areas which need to be addressed in order to achieve the overall project goal which is to develop and implement biomonitoring technologies for the rivers of Mpumalanga Province. Amongst these priorities was the need to develop and apply a rapid index to assess the condition of riparian vegetation which could be integrated into the total biomonitoring system for the Province.

Riparian vegetation forms an integral and important part of any river ecosystem and it has been reasonably well documented that riparian vegetation plays a number of important geomorphological, ecological and social roles which have a bearing on the condition and long term functioning and sustainability of the river itself (Arthington et al, 1993) and regional biodiversity (Naiman et al, 1993). These roles include stabilization of river channels, banks and floodplains; flood attenuation; maintenance of water temperature and quality; provision of habitat, refuge and migration corridors for terrestrial, avian and aquatic fauna; the interception and breakdown of pollutants; the interception and deposition of nutrients and sediments; and the provision of fuels, building materials and medicines for local communities.

It has therefore become increasingly clear that any integrated biomonitoring programme should address and consider riparian vegetation simultaneously with other aspects such as fish and aquatic invertebrates, geomorphology, hydrology and social usage in order for it to comprehensively reflect the full spectrum of changes which are likely to occur in such systems.

1.2 Challenges with riparian vegetation monitoring and an RVI

Vegetation monitoring is notoriously difficult for a number of reasons, amongst these being: the slow growth of trees, the diversity of species and growth forms, the responses of vegetation to different influences and problems associated with understanding cause and effect relationships. Consequently monitoring systems can quite easily become large and unwieldy. Riparian systems are also very complicated due to the simultaneous impact of numerous natural and anthropogenic influences which can significantly affect and shape the structural, compositional and functional characteristics of the vegetation present. Consequently, monitoring programmes designed for detecting changes in riparian systems often lack the sensitivity to detect true changes when these do occur. It is frequently necessary to identify key species which are of particular value for detecting changes in response to specific disturbances. Furthermore, given that the RVI is planned to monitor changes to a wide range of largely anthropogenic influences, and that experienced riparian vegetation staff are in general short supply it appears that a major challenge lies ahead in the development of the RVI.

2. PROJECT REQUIREMENTS AND CONSIDERATIONS

The requirements of the project have evolved since its inception and the compilation of the terms of reference. This has been largely due to the incorporation of the additional thoughts, ideas and aspirations of other team members, interested parties and other specialists during the course of the Mpumalanga pilot programme.

2.1 Terms of reference

The appointment involves the development and testing of a relatively simple and rapid index to assess the quality of riparian vegetation within the WRC - Mpumalanga project.

The following relevant conditions are applicable:

- The index should comply with the broad specifications provided by the River Health Programme (RHP or former NAEBP)

- The index should be applied to the Crocodile, Sabie, and Olifants River systems. River surveys should be co-ordinated with the rest of the project team, and in particular with Dr. Neels Kleynhans. Different developmental prototypes of a riparian index could be used during these surveys.

- Prof. Kevin Rogers should be involved as an "external reviewer" of the index development. Liaison with Prof. Rogers will provide a link between this initiative and the Kruger National Park Rivers Research Programme.

2.2 Objectives of the RVI

After numerous applications of the various site assessment forms and taking into account the information provided above, the objectives of the RVI were to:

- Comply with the broad specifications provided by the River Health Programme.

- Be developed and applied on the Crocodile, Sabie, and Olifants River systems.

- Be aimed at application on a National basis to a broad spectrum of rivers within South Africa.

- Be usable by technical personnel of Provincial and other responsible organisations. It must therefore:

    - be easily applied by a single assessor if necessary,
    - not require a high level of vegetation knowledge and experience, and
    - be as qualitative as possible and avoid technical and quantitative considerations.

- Be applied simultaneously and in conjunction with other biomonitoring components. It must therefore:

    - make use of same personnel or those specifically assigned to the RVI task,
    - make use of sites in close proximity to those used for other components, and
    - be achievable in 20 to 45 minutes to coincide with time requirements of other components.

- Provide a condition index which can be compared to indicate trends in the condition of riparian vegetation at each site over time. This index must be derived from a combination of sub-criteria scores which reflect pertinent characteristics at each site.

- Be developed within a hierarchical framework. In the initial stages of the index development the emphasis should be on an index that provides a synoptic assessment of riparian vegetation condition. Later development must provide a functional and useful index which can be applied and implemented on a wider or even national basis if necessary. It is envisaged that the refinement process would still continue beyond the scope of this appointment to the stage that more detailed or specific levels of monitoring output can be expected to take place.

- Should integrate as well as possible with the Ecological Reserve process in that its output conforms to the six assessment classes applied. The Present Ecological State (PES) step of the Reserve assessment process currently assesses each of the biological components on this basis and it would therefore be of great value to ensure that the RVI conforms with this. A specific riparian vegetation assessment scale would be the most useful way in which this integration could be achieved.

- Be housed, along with its various sub-criteria scores and raw data sets in a central database to enable appropriate access by interested parties. These must be useful for a variety of user requirements such as readily providing a useful indication of the riparian vegetation quality at a site, a description of the site characteristics, the determination of changes in condition over time at sites along with the apparent reasons for such changes.

- Should link with the Kruger National Park Rivers Research Programme.

2.3 Design considerations

The design considerations of the RVI were compiled from a number of sources as follows:

- The terms of reference and objectives of the project.

- Discussions with Dr. Neels Kleynhans throughout the development.

- Interaction with other members of the River Health and the Kruger Park Rivers Research Programme namely, Mr. Dirk Roux, Mr. James McKenzie, Mr. Mark Graham, and Dr. Harry Biggs.

- Interaction with members of the implementation team namely, Mr. Anton Linstrom and Mr. Gerry Theron of Mpumalanga Parks Board, Mr. Peter Winter of University of the North and Ms. Lorraine Mills from Gauteng Environment Affairs .

- Feedback from people who attended the biomonitoring practical courses and site demonstrations.

- Feedback and ideas from the Champions of other Provinces who have already started to apply early versions of the site assessment forms in their provinces.

2.4 The RVI in context

A wide range of vegetation monitoring techniques have been designed and implemented for terrestrial applications for the sake of wildlife management (Walker, 1976), pasture management (Foran et al, 1978; Vorster, 1982; Mentis, 1984; Trollope et al, 1989) and forestry. However, very few monitoring techniques have been developed specifically for riparian vegetation. The monitoring of riparian vegetation responses to water abstraction has received some attention by large industries in search of valuable water resources (Ward & Breen, 1983; Stromberg et al, 1993; Kemper & Coombes, 1994). A number of remote sensing techniques have also been designed (Lonard et al, 1998), but these often have poor resolution and are often prohibitively expensive. Low-level remote techniques have also been developed and effectively applied for the assessment and monitoring of riparian vegetation (Kemper, 1994). A recent trend in South Africa is the design of techniques to monitor riparian systems in response to managed releases of water for the provision of the Ecological Reserve for rivers (Marneweck, 1998) and in response to changes in flow regime and geomorphology (Mackenzie et al, 1999). Several collaborative programmes have been launched to monitor the general health and condition of rivers have involved the design of riparian monitoring techniques. Amongst these being the Australian Index of Stream Condition (CEAH, 1997) and the assessment and participatory management of riparian systems - RIPARI-MAN, a system which aims at helping certain organisations to contribute to the wise and sustainable use of more urban riparian systems in Kwazulu Natal, South Africa (Kotze et al, 1997). These monitoring systems have potential for providing guidance and assistance toward the development of a general riparian vegetation index for application on a national basis in South Africa.

2.5 Definitions

Two specific definitions need to be established with the development, and implementation of a riparian vegetation index. Specifically those which deal with what constitutes a riparian zone and what constitutes riparian vegetation.

Riparian zones are also included in the definition of a wetland in the Directory of South African wetlands (Cowan and van Riet, 1998), and it is therefore also essential to clearly elucidate in which areas the RVI will be applicable.

Riparian zones have distinctive and characteristic vegetation which is often very distinct from the surrounding vegetation. It is often clearly adapted to different levels and frequency of inundation and distributed accordingly within the broad riparian zone. The more water loving or mesic species are therefore located close to the river channel, while the species which are less dependent on water are located further away. It is the ability of species to tolerate different levels of inundation, the need for excessive water availability, or the need for close river proximity for growth, propagation, temperature control and nutrient enrichment which clearly determines the structural, compositional and functional characteristics of riparian zones.

The definition for riparian vegetation adopted for the development of the RVI is therefore one which considers the structural, compositional and functional aspects of the vegetation present at any site:

> *that which is found in close proximity to rivers in a clearly defined riparian zone and which is dependant on the river for a number of functions. It displays structural, compositional and functional characteristics which are clearly distinct from the fringing terrestrial vegetation and is distributed according to clear inundation and other functional gradients.*

During the development of the index this definition was extended to include areas where the effects of

elevated river flows (or floods) have an influence on the distribution, structure and composition of vegetation. This was considered in order to address the vegetation located in high flow and seasonal channels which are not necessarily dependent on the river for their water requirements, but are clearly impacted in terms of their structure and composition. The definition of Kotze et al (1997) clearly covered this aspect:

> *That located next to stream or river, affected by stream processes such as flooding and deposition of alluvial soil, and supporting a fauna and flora different from the upland slopes.*

3. DEVELOPMENT OF THE RVI

3.1 The aerial based RVI

3.1.1 Background

Early in the development of the RVI it was required to provide results for the Crocodile River at a stage where no site specific data had been collected. It was therefore necessary to adopt an existing method which could at least provide a synoptic assessment of the condition of riparian vegetation. It was accepted that the method for assessing the conservation status of riparian vegetation (Kemper, 1994) would be adopted and suitably modified to serve as an early version of the RVI. The method was applied on the Crocodile River and the RVI assessment thereby derived was presented in Roux (1999). However, it was understood at the time of this decision that this method was not a site based assessment, but instead one which reflected the condition of 5 km segments of the river.

The method was initially developed under the auspices of the former TPA Chief Directorate for Nature and Environmental Conservation in response to a need to identify and quantify the extent of the utilisation and destruction of rivers in the Transvaal.

3.1.2 Method

The method was initially developed using that of Kleynhans (1996) for the assessment of habitat integrity as its basis. It makes use of a similar scoring and weighting system, however, specific riparian vegetation criteria were selected with weightings applicable to each. Since it was designed to operate with data taken from an aerial survey or video, the criteria selected were confined to those which are clearly discernible from the air or from the video. It was designed to operate in conjunction with the assessment of habitat integrity and therefore assessed the status of riparian vegetation in 5 km segments of the river under consideration.

The following six criteria were applied:

- The presence and degree of farming within the riparian zone which has led to a direct displacement or removal of riparian vegetation (weight=0.269).
- The presence of permanent or semipermanent forms of construction in the riparian zone such as roads, bridges, walls or houses within the riparian zone (weight=0.076).
- The presence of weirs or impoundments which leads to the inundation of the riparian zone with the loss of vegetation (weight=0.115).

- The degree of erosion within the riparian zone as a consequence of poor soil management (weight=0.153).

- The abundance of invasive plant species within the riparian zone. This is essentially limited to those species which are visible from the air and generally only included woody species which are difficult to remove from the system (weight=0.153).

These criteria and their relative weightings were selected based on the consensus of opinion of a group of vegetation specialists of the former Chief Directorate at the time of the development of the method.

The criteria were assessed on a six point scale as follows:

- None: no discernible impact of disturbance on riparian vegetation (score = 0)

- Small: The disturbance is limited to very few localities and the impact on the riparian vegetation is also very small (score = >0 to 1)

- Moderate: The disturbance is present at a small number of localities and the impact on riparian vegetation is also limited (score = 1 to 2)

- Large: The disturbance is generally present with a clearly detrimental impact on riparian vegetation. Large areas are, however, not affected (score = 2 to 3)

- Serious: The disturbance is frequently present and the riparian vegetation of almost the whole of the defined segment is influenced detrimentally (score = 3 to 4)

- Critical: the disturbance is generally present in high intensity. The riparian vegetation in almost the whole segment is detrimentally affected (score = 4 to 5)

An additional qualitative score of general riparian vegetation condition (weight=0.153) is also compared on the basis of the extent to which riparian vegetation fills the potential riparian zone, the natural or artificial transition of this vegetation with adjacent vegetation, the vertical and horizontal structure of the vegetation and the presence and extent of tree deaths. The following five point scale was applied:

- Poor: Vegetation reduced to isolated individuals and patches of mostly resilient species. Severe pruning of limbs is evident.

- Bad: Vegetation reduced to only a narrow strip of resilient species. Noticeable pruning of limbs is evident.

- Moderate: At least half of the potential riparian zone is filled, open patches common, single layered canopy, creepers are evident in patches.

- Good: Most of the potential riparian zone is filled, few open patches, evidence of multiple layered canopy in areas, natural transition with adjacent vegetation in areas, tree deaths to less than one quarter of river's edge are possible.

- Very good: Entire riparian zone is filled, multiple layered canopy very common, complete natural transition with adjacent vegetation always present, narrow strip of tree deaths may be possible at river's edge.

The method was applied to the Crocodile River during early 1998 making use of the most recent aerial video footage of the River taken during 1997.

3.2. The site based RVI

3.2.1 Phases of development

The site based RVI was developed over a 2-year period during the Mpumalanga pilot study on the Sabie and Olifants River systems. Development took place in five stages in conjunction with the other components of the study as discussed below:

A. Formulation of an understanding of riparian zones

This stage involved gaining and understanding of riparian zones such as; what are their roles, what comprises them, what are the essential components, how do they function, what drives them, how are they impacted by disturbance and utilisation and how they differ from system to system.

During the early part of the pilot programme on the Sabie River systems, the author and a number of botanically competent staff from various organisations visited the biomonitoring sites which were selected primarily for fish and aquatic invertebrate monitoring requirements. The characteristics of these sites were noted and discussed to ascertain what aspects of the sites were important in terms of their functioning, which of these are likely to change given different types of disturbances and utilisation and which of these aspects could be used to indicate changes and therefore would be of monitoring significance.

B. Collection of pertinent riparian zone data

This stage of development involved the determination of the data which would be required for monitoring and gaining an understanding of the variability of the various data sets from site to site, how these data and what aspects of these data would need to be recorded and the problems associated with this process. Various drafts of field data sheets were compiled and tested from site to site to incorporate necessary changes and additions which presented themselves as new characteristics and challenges were encountered. This process has been assisted and guided by the consideration of various similar biological indices and the nature of the data required in these instances.

C. Selection and development of a suitable index

A number of alternative functional indices were sourced during this stage of the development. These were then carefully considered in terms of their usefulness for application and potential for modification given the specific characteristics of the river systems under consideration, the constraints and objectives of the desired RVI itself.

It became evident reasonably early in the development process that few of the currently applied indices available were of any value for the development of a suitable site based RVI. One index, the Streamside Zone Index (SZI), a sub-index of the Index of Steam Condition (ISC) (CEAH, 1997) was selected which could be of value as a potential RVI . This is a site based index which is currently applied in Australia which summarises the quantity and quality of streamside vegetation. It has particular appeal in that it is also a rapid assessment of riparian vegetation condition and also forms part of an integrated programme to monitor the condition of rivers in a similar way to the RHP in South Africa.

Suitable modifications were made to the SZI to suit the specific conditions and requirements of the Mpumalanga programme and a functional version of the RVI was thereby developed which incorporates as many of the data sets which are currently being collected at the pilot study sites.

D. Testing and refinement of the RVI

Once the RVI had been initially developed, it was necessary to apply it to a variety of data sets from different sites. A number of sites with varying and different characteristics were selected from the many sites visited during the pilot study to date on the Sabie and Olifants Rivers. The point of which was to apply these data sets to the RVI to ascertain whether it is capable of handling the variety and diversity of data obtained from these sites and still provide meaningful and comparable index and sub-index scores which reflect the quality or condition of these sites.

This phase of the development proved to be very time consuming and required extensive refinement, re application and testing of the RVI for each new development of the formula. Some of the major challenges faced in this process were to provide a diverse range of RVI scores which reflect the actual characteristics of the sites, but which also realistically conform to the six assessment classes from A to F which are currently employed in the Ecological Reserve process.

In order to initially develop and calibrate the RVI score and to assign each site to a specific vegetation assessment class a "gut condition score" was subjectively assigned to each site by the assessor as a score out of five. These scores were continually compared with those derived by the RVI to indicate whether adjustments were required to the weightings of sub-indices applied.

E. Determination of specific riparian vegetation assessment classes

With the index developed to the point where it was felt that the RVI scores reasonably reflect the quality or condition of the sites and the sub-index scores reflect the diversity of the site characteristics, it became necessary to place the RVI scores into perspective in terms of the broad assessment classes currently employed in the Ecological Reserve process.

3.2.2 RVI derivation and its components

As stated previously the SZI was chosen as the basis from which to derive the RVI. The SZI comprises two areas of riparian vegetation quality at a site, the extent of coverage of the riparian zone by vegetation and the structural and compositional integrity of the vegetation present. Evaluation of the SZI score is derived from the following formula:

$$SZI = [(W + LC) + ((SI \times PCI) + R) / 2]$$

Where:

W is width
LC is longitudinal continuity
SI is structural intactness
PCI is percentage cover of indigenous species
R is regeneration of indigenous species

A. Extent of vegetation coverage of the riparian zone (EVC)

The first stage of the SZI addresses the extent of vegetation coverage of the streamside zone, i.e. width and longitudinal continuity (W+LC) (total score of 10 points). This is assessed by a measure of the width (w) of the streamside zone and the number of significant discontinuities (LC) in the 1 km length of the site. The maximum attainable score for a well-covered streamside zone is 8.

In the RVI the width of streamside zone assessments and that of longitudinal continuity are replaced with percentage of vegetation coverage of the riparian zone which is assessed in two ways. By the direct assessment of the percentage vegetation coverage by the assessor on a 6-point scale and alternatively, by subtraction of the extent of anthropogenic and other disturbances, as undertaken by the site assessor on a 4-point scale, from the perceived reference state (PRS) which is 100 percent in most cases or a lesser percentage depending on whether the side is located on bedrock. The mean figure of the two alternative assessments is then taken to represent percentage of vegetation coverage. The maximum attainable score for a well-covered riparian zone is 10.

B. Structural intactness (SI)

Structural intactness in the SZI makes use of 3 scales of density/distribution namely, continuous, patchy and sparse. These are rated against the natural or reference condition for the overstorey, understorey and ground layers. The scoring system is based on a comparison matrix between the present day and the reference state on a 4-point scale. The maximum attainable score for a streamside zone with reference state vegetation structure is 4.

The RVI employs alternative scales of density / distribution for SI namely, continuous, patchy, scattered and sparse and is scored by the site assessor on a 5-point scale for the tree, shrub, reed and grass layers. These classes were modified to incorporate the natural distribution of reeds and tree clumps which occur frequently in the southern African situation. The scoring system is also based on a comparison matrix between the (PRS) and the present day state. The maximum attainable score for a riparian zone with PRS structure is 5.

C. Percentage cover of indigenous riparian species (PCIRS)

The SZI rates the percentage cover of indigenous species based on the percentages recorded on four transect lines systematically placed within the study site. These are assessed for the overstorey the understorey and ground cover layers. The maximum attainable score for a site which is rich in indigenous species is 4.

The RVI assesses the percentage cover of indigenous riparian species (PCIRS). The assessment therefore, apart from considering the extent of exotic species at the site, also considers terrestrial species and extensive reed beds which are both quite common in South African rivers. Terrestrialisation is a frequent problem in rivers which are impacted by significant reductions in their natural flow, while reed invasions are common in highly regulated rivers and rivers which are exposed to high nutrient loads as a result of return flows from adjacent areas. This assessment is made with consideration to the (PRS) which would be regarded as 100 percent in all cases. The percentage cover of terrestrial woody and exotic woody species and that of reeds (on a 5-point scale) is subtracted from this state to obtain the PCIRS. The mean value is taken for the overstorey, understorey and ground cover layers. The maximum attainable score for a site rich in desirable indigenous species is 5.

D. Regeneration of indigenous species (RIRS)

This is assessed by the SZI based on the extent of regeneration of indigenous species observed on the four transect lines. The maximum attainable score for a site with extensive regeneration of indigenous vegetation is 4. The SZI also includes the condition of streamside wetland areas or "billabongs," however this component of the index was not adopted as these areas will probably be addressed by alternative indices in the future.

The RVI makes use of a scoring system which is only concerned with indigenous riparian vegetation at the site, specifically that which comprises the dominant species within the site. The dominant species recorded at the site are scored based on the extent of regeneration observed. Desirable species at a tree dominated site include the dominant indigenous trees present. This is not necessarily restricted to seedling type recruitment but also includes coppice recruitment. At a grassland dominated site recruitment includes the spread of grass into disturbed patches. The impact of extensive grazing and browsing at a site can significantly reduce the extent of recruitment of woody species and the spread of grasses. The maximum attainable score for a site with extensive regeneration of indigenous vegetation is 5.

Given the modifications described above, the formula for the RVI is therefore:

RVI = [(EVC) + ((SI x PCIRS) + (RIRS))]

Where:

EVC is extent of vegetation cover
SI is structural intactness
PCIRS is percentage cover of indigenous riparian species
RIRS is recruitment of indigenous riparian species

The main difference between the ISC and the RVI are therefore associated with differences in the nature of the field sampling methodologies employed. The ISC streamside team employs a more quantitative method which makes use of riparian zones of 1 km in length with four systematically placed transects. The method employed for the RVI is more qualitative making use of unmarked sites with no measured dimension or transects. The characteristics of the sites selected and the time constraints placed on the biomonitoring team make it impossible to conform to such quantitative methods.

4. APPLICATION OF THE RVI

4.1 Aerial based RVI

4.1.1 Assessment of impact criteria

The procedure is applied by objectively assigning impact scores to each of the criteria for each 5 km river segment. This is usually undertaken while viewing the river video but can be undertaken during the aerial survey itself. However, riparian vegetation condition is difficult to assess from the air due to the problems associated with perceptions of the riparian zone size, slope, presence of bedrock, soil characteristics, species identification, recognition of exotic species and many other. For this reason it is often better to make the assessment using the video. It is useful to replay the video a number of times in succession to gain an understanding of the characteristics of the river and the factors influencing the vegetation and the extent of these. All assessment scores are transcribed into a spreadsheet file in which the weightings are

automatically applied to arrive at the RVI scores.

4.1.2 Graphical output

Since the RVI scores vary from segment to segment due to the influence of different types and degrees of disturbance, it is useful to present the RVI results graphically in a way which facilitates the easy comparison of river segments. The output applied and most recommended is displayed in Figure 1.

Similarly, the impact scores should also be presented graphically to aid in understanding the specific types of disturbances and the extent of these in different river segments. Figure 2 displays the recommended graphical output for this purpose.

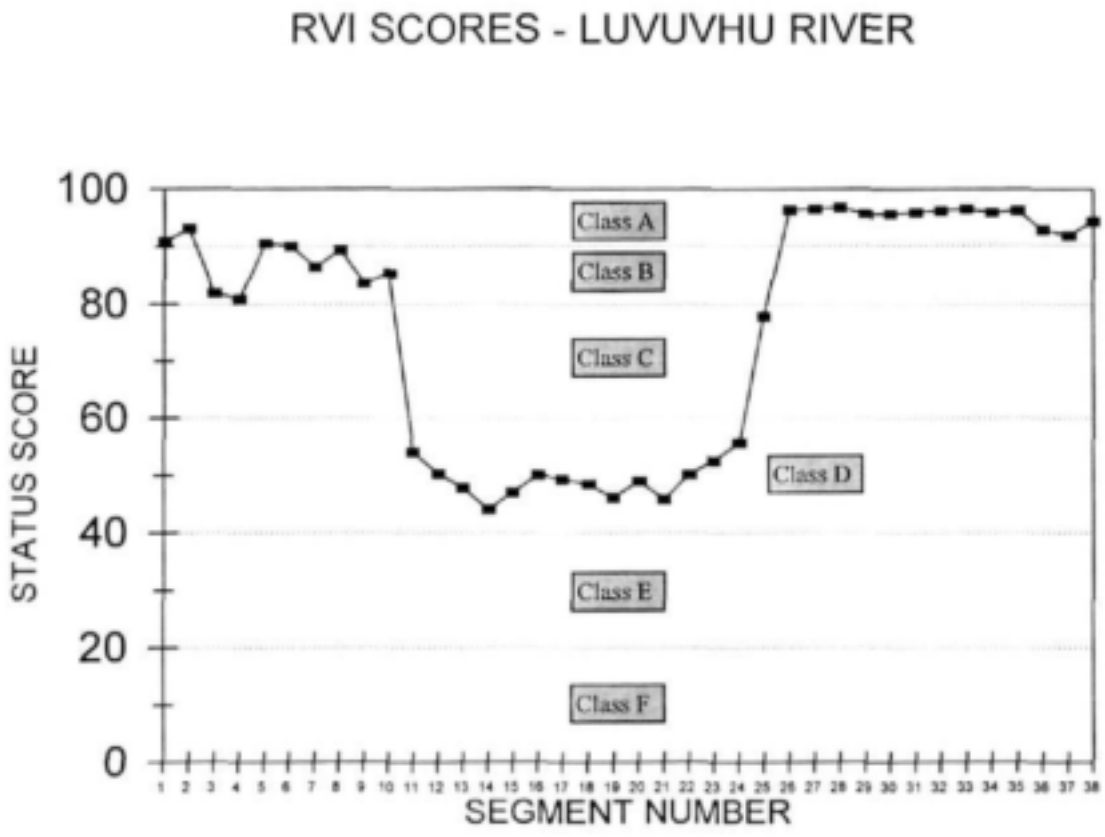

Figure 1. Example of recommended graphical presentation of aerial based RVI scores

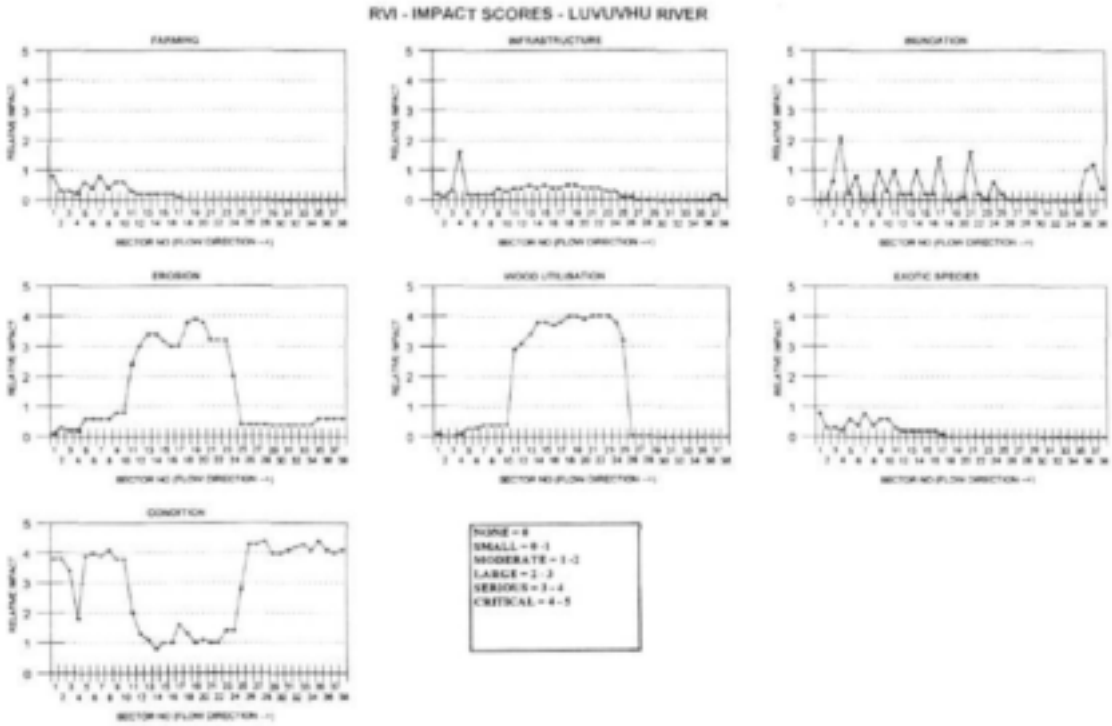

Figure 2. Example of recommended graphical presentations of RVI impact scores

While the aerial based RVI assessment was considered to be an early version of the RVI for specific application on the Crocodile River, it remains as a method which can be used in cases where the site based RVI may not be achievable due to time, budgetary or accessibility constraints. However, it must be stressed that this method is very synoptic in nature since it does not adequately take into account the structure, composition and function of the vegetation present. It only provides an indication of the extent to which the riparian zone is vegetated based on the extent to which it has been disturbed.

4.2 Site based RVI

4.2.1 Resource and equipment requirements

In order to make the application of the RVI possible and achievable by any Provincial or responsible body, the monitoring of riparian vegetation sites and the assessment of the RVI have been designed to require as few resources as possible.

A. *Site assessment*

The most important resource is that of adequately trained and experienced staff which can undertake the site assessments. The site assessment can easily be undertaken by a single trained technician. However, it is essential that the assessor has a good understanding of the nature and functioning of riparian systems. The assessment is unfortunately not just a static assessment of existing characteristics but does intuitively involve reasonably sound knowledge of the dynamic nature of riparian systems and the processes involved in the shaping and condition of these systems and its perceived reference state. It is therefore essential that unless the chosen assessor has the appropriate understanding of riparian systems that they are exposed to this way of thinking either during in service training with an experienced assessor or by way of a training course.

Due to the subjective nature of the assessment, it is felt that more than one assessor at a site can provide a more objective and balanced assessment. This in turn will provide a more realistic RVI after the formula has been applied.

The assessor (s) will require the following equipment in order to undertake the site assessment:

- Clipboard and pen / pencil
- Field data forms, including site walkabout form.
- Global positioning system (GPS)
- Camera (optional)
- Tree identification book such as Trees of Southern Africa (Van Wyk & Van Wyk, 1997) or one which is most appropriate to the area of the assessment.
- Plant press and jewelers tags

B. Data handling and storage

This involves the safekeeping and maintenance of the field assessment forms and the capture of data in the required electronic database. It is envisaged that the same technician will be responsible for capturing the field data with the aid of a desktop or notebook computer and the specific software developed for this application. The field assessment forms will need to be carefully filed and kept in a safe place in case these are required in the future.

C. Generation of the RVI

It is envisaged that the generation of the RVI will be undertaken within the database software (Rivers Database) and will therefore be automated simultaneously with data capture. The same staff and equipment requirements are therefore necessary.

4.2.2 Site assessment

The field site assessment form has been developed over a number of months of application in the field and only addresses those characteristics of the site which provide input into the generation of the RVI and a functional description of pertinent site characteristics. The site walkabout form is to be filled in first during the initial investigation of the site and provides the assessor with a basis on which to record site characteristics during this part of the assessment. This information also feeds into various parts of the field assessment form. The field site assessment form is completed only after the site investigation has been completed.

The current version of the field site assessment form is attached as Appendix A. Various areas of this form have been highlighted and provided with either a D or F number. These will be described at a later stage under generation of the RVI.

The site assessment is undertaken in two phases, firstly the site identification and investigation and secondly the site assessment itself.

A. Site identification and investigation

Once the team has arrived in the general area of the site, the RVI team is required to identify a site suitable

for riparian vegetation assessment. Should the site have been monitored previously, further site identification is unnecessary. The site is then located with the assistance of the site map on the previous data sheet.

In the case of a new site, it must conform to certain criteria. These being; that it is large enough to assess, generally representative of the river, and as far possible from disturbances introduced by site access. The sites are invariably accessed by road or at a bridge, gauging site or weir. These infrastructures always provide a fair amount of site disturbance and therefore it is very important that the chosen site is free of such disturbance. However, a suitable compromise is required in order to select a site as close to the general site as possible.

Once identified the site is first investigated in order to establish its general characteristics. The site walkabout form is then filled in as comprehensibly as possible. The assessor must complete this to the best of his/her botanical ability. Specific emphasis must be placed spotting and identifying of prominent woody and other species within the site and the various size classes of each as they are encountered. The presence of recruitment of these species is vital. Recruitment is identified by the spotting of the smaller size classes (ie. below 2 metres in height). If the names of species are not known, suitable samples must be taken and pressed on site for later identification. The site investigation should take about 15 minutes, which indicates the approximate size of the required site. This will be approximately 200 m in length for the average site with a riparian zone of approximately 30 metres in width.

B. Site assessment

After completion of the site investigation the site assessment form is completed. It usually helps to do so at a vantage point where the full site is in view to jog the memory of the assessor and to maintain objectivity during the assessment. Careful attention must be paid to the scoring systems used for each component of the assessment. Site assessment is aided with careful reference to the field guide (Appendix B). Site assessors are strongly urged to become familiar with this guide to ensure that sites are assessed correctly and consistently.

Site assessors must also ensure that all site names and co-ordinates conform to those used by the rest of the project team to ensure full integration at a later stage in the monitoring programme.

The approximate time required to undertake site identification, investigation and assessment varies from 30 minutes to 45 minutes depending on the complexity and accessibility of the site being assessed.

C. Index generation

It is envisaged that the generation of the index will be fully automated in the monitoring database (Rivers Database). Despite the automation of this index and its various sub-indices process, it is important that the generation procedure is fully described so that it can be correctly and consistently applied. A modified site assessment form is provided in Appendix A on which a number of blocks have been highlighted. These highlighted blocks refer to the various input components to the RVI formula as well as to the site description table which should be generated for each site after each site visit. The RVI input component blocks are labeled **[F]** and the site description table component blocks are labeled as **[D]**.

A blank site assessment form is provided in Appendix C for practical field operation.

a) Riparian Vegetation Index (RVI)

The RVI formula is:

$RVI = [(EVC) + ((SI \times PCIRS) + (RIRS))]$

Where the following sub-indices apply:

EVC is extent of vegetation cover
SI is structural intactness
PCIRS is percentage cover of indigenous riparian species
RIRS is recruitment of indigenous riparian species

The RVI provides a final score out of 20 which is comparable with the six Ecological Reserve assessment classes as follows:

RVI SCORE	ASSESSMENT CLASS	DESCRIPTION
19 - 20	A	Unmodified, natural.
17 - 18	B	Largely natural with few modifications. A small change in natural habitats and biota may have taken place but the ecosystem functions are essentially unchanged.
13 - 16	C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominantly unchanged.
9 - 12	D	Largely modified. A large loss of natural habitat, biota and basic ecosystem functions have occurred.
5 - 8	E	The loss of natural habitat, biota and basic ecosystem functions are extensive.
0 - 4	F	Modifications have reached a critical level and the system has been modified completely with an almost complete loss of natural habitat and biota. In the worst instances the basic ecosystem functions have been destroyed and the changes are irreversible.

The RVI is calculated by application of the sub-indices to the RVI formula as described below:

Extent of vegetation cover (EVC)

The EVC is determined by calculating the mean score of EVC 1 and EVC 2 determined by two alternative methods:

EVC 1 = Combined vegetation cover score out of 10 for the LHB, RHB and islands (if present) - [F1].

The 6-point scoring system employed is:

Percentage score	0%	1 - 5%	6 - 25%	26 - 50%	51-75%	76 - 100%
EVC score	0	2	4	6	8	10

EVC2 = [10 - total site disturbance score]

The 6-point scoring system for site disturbances [F2] is:

Disturbance score	0	VL	L	M	H	VH
EVC score	0	1	2	4	6	10

EVC (score out of 10) = [(EVC 1 + EVC 2) / 2]

Structural intactness (SI)

SI is determined with reference to the following scoring table of vegetation distribution for present state versus Perceived Reference State - [F3].

	PRESENT STATE (P/S)			
Perceived Reference State (PRS)	Continuous	Clumped	Scattered	Sparse
Continuous	3	2	1	0
Clumped	2	3	2	1
Scattered	1	2	3	2
Sparse	0	1	2	3

- The score is determined for each of the cover classes, namely trees(SI1), shrubs(SI2), reeds(SI3), sedges(SI4) and grasses(SI5).
- SI (score out of 1) = [((SI1+SI2+SI3+SI4+SI5)/5)*0.33]

Percentage cover of indigenous riparian species (PCIRS)

The 5-point scoring system for the cover of exotic species [F4], terrestrial species [F5] and reeds [F6] is:

Cover score	0	VL	L	M	H	VH
PCIRS sub-score	0	1	2	3	4	5

- The sum of the weighted cover scores for all the invading species (exotic, terrestrial and reed species) are subtracted from the adjusted EVC score.

PCIRS (score out of 5) = [(EVC / 2) - ((exotics x 0.7) + (terrestrial x 0.1) + (reeds x 0.2))]

If no indigenous riparian species are present at the site then PCIRS (min) = 0

Recruitment of indigenous riparian species (RIRS)

The recruitment of positive significance and importance at a site is obviously that of the indigenous riparian species, particularly the dominant species present(by biomass).

The RIRS (score out of 5) is determined by application of the following scoring system to [F7].

Extent of recruitment	0	VL	L	M	H	VH
RIRS score	0	1	2	3	4	5

b) Site description table

The site description table is designed to provide a quick one look synopsis of the vegetation characteristics of each site. This is designed to provide suitable information for decision makers, river managers and monitoring staff. The site description table is compiled from a number of components of the site assessment form as follows:

RVI SITE DESCRIPTION TABLE							
A. Site details and index scores							
River	[D1]	Site No:	[D2]	Site name:	[D3]	RVI score	
EVC score:		SI score:		PCIRS score:		RIRS score:	
B. Site description							
Channel type:		[D4]		Substrate type:		[D5]	
Extent of disturbance:		[D6]		Disturbances:		[D7] 1	
						[D7] 2	
Dominant Vegetation type:		[D8] 1		Dominant species:		[D9] 1	
		[D8] 2				[D9] 2	
Species Richness:		[D10]					

4.2.3 RVI integration into the RHP database

Integration of the RVI data into the RHP database is currently in an early stage of development. The next phase of RVI development will entail the incorporation of the RVI, its sub-indices and pertinent raw data sets into the RHP Rivers Database. This will ensure that this information is available to decision makers, managers and researchers and are safely managed in the future.

4.3 Problems / limitations encountered

4.3.1 Site selection

Site selection is of primary importance for indicating the condition of the riparian vegetation on rivers. The following aspects of the site selection process remain problematical:

- Biomonitoring sites are often chosen to provide best habitat diversity for fish and invertebrates and are therefore often located on riffles and rapids. These sites are often not ideal vegetation sites as they are often very narrow and rocky and have few riparian species present.
- Sites are often limited to areas of accessibility and are therefore often highly disturbed due to the proximity of roads, bridges, weirs and other infrastructure.
- Site vegetation and geomorphological characteristics are not necessarily representative of the river reach in which they occur.

4.3.2 Sensitivity

Due to the need for the assessment and the associated index to remain simple and easy to apply, these are mainly qualitative and may lack the sensitivity to indicate realistic and actual changes which have occurred over time.

4.3.3 Representation

Due to the nature of the site selection and that of local riparian zone disturbances present, the results at some sites may not truly represent the general condition of the riparian vegetation along the full length of the assessed river. It may be necessary to introduce a more objective method for the selection of sites to ensure that suitable sites are located in all reaches of the rivers under consideration.

5. RECOMMENDATIONS

5.1 Aerial based versus site based RVI

The aerial based RVI was initially included for the sake of assessing the condition of the Crocodile River during the early stages of development of the site based method. However, subsequent to the first application of the site based method on the Olifants River, question has been raised regarding the value and need for future implementation of the aerial method. It was felt that this may be useful for the Kruger Park Rivers Research Programme (Biggs, pers. Comm.), however, due to its lower level of resolution, it was considered to be largely superceded by the site based method.

When one considers the disadvantages of applying only a site based method, particularly on a new river, it becomes clear that some of these disadvantages can be avoided with an initial application of the aerial method. The aerial method provides a more global as well as a more linear perspective of the vegetation and its distribution as well as the suite of disturbances within the riparian zone. This view is ideal for identifying areas of different vegetation condition and where particular problems exist on a river, and can therefore be very useful for the placing of specific sites on which the site based method can then be applied. The necessary levels of detail required by decision makers can then be addressed accordingly.

This complimentary application of the two methods can also solve ongoing debate regarding the problems of scale between the two alternative methods and the need to make comparisons between the outputs of the two methods to assess their relative merits.

It is therefore recommended that the aerial based method should be retained as an alternative, but largely complimentary RVI assessment to that of the site based method, and that this method remains fully described in this report.

5.2 Implementation of the RVI

Given that the RVI is built into the Rivers Database software it is recommended that the RVI is distributed to as many implementing agencies as possible to ensure that it is consistently applied on a nationwide basis. This will ensure, in turn, that the Rivers Database grows significantly and consistently on the same scale. This will optimise the value of the database and its application for water resource managers and decision makers.

5.3 RVI training

An effort should be made, particularly during the early stages of implementation of the RHP, to ensure that sufficient training courses are made available to new implementing agencies and their staff. RVI training should focus on a thorough understanding of riparian zones and vegetation and the proper application of the RVI and its interpretation.

5.4 Refinements and changes to the RVI

It is envisaged that initial implementation of the RVI will lead to areas of the RVI which may need to be refined and possibly even redeveloped to suit the conditions and characteristics of rivers outside of Mpumalanga. It is therefore recommended that subsequent refinements should take place in a controlled manner to ensure that the RVI and its database remains standardised at a National level if at all possible. The initiative of implementing agencies in the identification of problems and areas in which the RVI can be refined should be encouraged. It is recommended that these ideas should be conveyed to a responsible person or body of people who will then be charged with undertaking the necessary changes and refinements either on a regular basis or when the need arises. New versions of the RVI and its components can then be issued to the implementing agencies in a controlled manner to ensure standardisation of its application. It is recommended that a panel of riparian vegetation ecologists should be convened for this purpose.

5.5 Future research needs

The RVI is a broad based and generic method which is not suitable for specific monitoring applications such as that for the Ecological Reserve (IFR). Future research will therefore be required for the sake of developing more specific riparian vegetation monitoring methods. Such monitoring methods would need to be tailor made to different rivers based on specific site characteristics and discharge requirements.

6. ACKNOWLEDGEMENTS

First and foremost, the WRC is gratefully acknowledged for its funding of the RVI development. The contributions of the following persons in the application and development of various field data sheets and their contributions toward the development of the RVI is also gratefully acknowledged; Messrs. A. Linström and J. Theron from Mpumalanga Parks Board, P. Winter from University of the North, and Ms. L. Mills from Gauteng Environmental Affairs. Dr. J. Engelbrecht and others from Mpumalanga Parks Board are thanked for their extensive for plant identification skills. Dr. C.J. Kleynhans provided extensive guidance and support in the conceptual aspects of the RVI and its application.

7. REFERENCES

CEAH (Centre of Environmental Applied Hydrology) and ID&A (1997) An Index of Stream Condition. Reference Manual. Report prepared for the Waterways Unit of the Department of Conservation and Natural Resources, University of Melbourne, Australia.

Armantrout N (1998) Glossary of aquatic habitat inventory terminology. American Fisheries Society, Bethesdal, Maryland.

Arthington AH; Bunn SE & Caterall CP (1993) The ecological roles of riparian vegetation. In: Woodfull J; Finlayson B & McMahon T (eds) The role of buffer strips in the management of waterway pollution from diffuse urban and rural sources. Proceedings of a workshop. Occasional paper 01/93. University of Melbourne, Australia.

Cowan GI & van Riet W (1998) A directory of South African Wetlands. Department of Environmental Affairs and Tourism, Pretoria.

Kemper NP (1994) An assessment of the Conservation Status of Riparian Vegetation on the Luvuvhu River and Selected Tributaries. TPA Chief Directorate for Nature and Environmental Conservation, Pretoria.

Kemper NP & Coombes PJ (1994) Incorporating the water requirements of a diamond mine and a natural riparian system in South Africa. Proceedings of the International Wildlife Management Congress, Costa Rica.

Kleynhans CJ (1996) A qualitative procedure for the assessment of the habitat integrity status of the Luvuvhu River (Limpopo system, South Africa). Journal of Aquatic Ecosystem Health 5: 1-14.

Kotze DC, Steytler NS & Kirkman S (1997) RIPARI-MAN, assessment and participatory management

of riparian systems. World Wildlife Fund Report, Parts 1 & 2.

Mackenzie, JA, van Coller AL & Rogers KH (1999) Rule based modeling for management of riparian systems. Water Research Commission, Pretoria, South Africa.

Marneweck, GC (1998) Riparian vegetation monitoring system, Komati River, Maguga Dam project. Report prepared for Afridev Consultants and KOBWA.

Mentis MT (1984) Monitoring in South African Grasslands. South African National Scientific Programmes, Report number 91, 53 pp.

Naiman RJ, Decamps H & Pollock M (1993) The role of riparian corridors in maintaining regional biodiversity. Ecol. Appl. 3, 209 - 212.

Roux DJ (1997) National Aquatic Ecosystem Biomonitoring Programme: Overview of the design process and guidelines for implementation. NAEBP Report Series No 6. Institute for Water Quality Studies, Department of Water Affairs and Forestry, Pretoria, South Africa.

Roux DJ (1999) A procedure for the adaptive assessment and management of the ecological state of riverine ecosystems, with an example of the Crocodile and Elands rivers, Mpumalanga, South Africa. Water S.A.

Stromberg, JC, Wilkinson SD & Tress J (1993) Vegetation-hydrology models: implications for management of *Prosopis velutina* riparian ecosystems. Ecological applications, 3(2) 307 - 314.

Trollope WSW, Potgieter ALF & Zambatis N. Assessing veld condition in the Kruger National Park using key grass species. Koedoe 32/1, 67 - 93.

Van Wyk B & van Wyk P (1997) Field guide to trees of Southern Africa. Struik Publishers. 536 pp.

Vorster M (1982) The development of the ecological index method for assessing veld condition in the Karroo. Proc. Grassld. Soc. Sth. Afr. 17:84 - 89.

Walker, BH (1976) An approach to the monitoring of changes in the composition and utilisation of woodland and savanna vegetation, S. Afr. J. Wild. Res: 6(1): 1-32.

APPENDIX A

MODIFIED FIELD ASSESSMENT FORM

APPENDIX A : RIPARIAN VEGETATION - RVI (1) MODIFIED SITE ASSESSMENT FORM

Ver: 05/02/00

RIVER: _**[D1]**_____ Date: _____/_____/___

Site/Segt No:_**[D2]**_ Site Name:_[D3]_____ LatLong: S:_____°_____'_____

Assessor names (print): _____ E:_____°_____'_____

CHANNEL DESCRIPTION

Channel type (tick): **[D3]**

CHANNEL TYPE:	Single		Multiple	Braided		Anabranching		Mixed	

Active channel width:

Width (m)		**[D4]**

RIPARIAN ZONE DESCRIPTION

Width of potential riparian zone:

Width (m)	LHB		RHB		Islands	

Substrate (tick): **[D5]** - **Top 1**

Bedrock	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	
Rock/cobble	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	
Soil	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	
Gravel/sand	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	
Sediment	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	

Percentage vegetation cover (all vegetation) (tick): **[F1]**

Total cover	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	

SITE CONDITION

Reason(s) why less than 100% vegetation cover: (refer to field guide)

REASON	EXTENT (tick)									
Natural	VL		L		M		H		VH	
Disturbed - extent	VL		L		M		H		VH	

[D6][F2]

Site disturbances:**[D7] - top 3**

DISTURBANCE	IMPACT ORDER	EXTENT OF IMPACT (tick)									
Floods, elevated flows		VL		L		M		H		VH	
Flow regulation (dam upstream)		VL		L		M		H		VH	
Weir / dam (local inundation)		VL		L		M		H		VH	
Bush clearing / ploughing		VL		L		M		H		VH	
Vegetation removal (fuel, materials, feed)		VL		L		M		H		VH	
Crop farming		VL		L		M		H		VH	
Forestry		VL		L		M		H		VH	
Grazing / browsing / trampling (stock)		VL		L		M		H		VH	
Sand winning, quarrying, mining		VL		L		M		H		VH	
Picknicking, golf course, trails and paths		VL		L		M		H		VH	
Roads, bridges, other infrastructures		VL		L		M		H		VH	
Vegetation invasion (exotic, terr, reeds)		VL		L		M		H		VH	
Erosion / sedimentation		VL		L		M		H		VH	
Other: specify		VL		L		M		H		VH	

Surrounding land-use (tick):

Nature reserve, game farming		Stock farming (various stock)	
Subsistence (rural) farming		Irrigation farming (formal), crops	
Forestry		Picknick site / recreational	
Residential (urban)		Residential (rural)	
Mining / quarrying		Dumping	
Sewerage treatment		Other: Specify	

DISTRIBUTION AND EXTENT OF VEGETATION COVER

NB. canopy cover for trees and shrubs; ground cover for grass, sedges and reeds

Cover: [D8] - top 2 components

	Cover component											
	Trees		Shrubs		Reeds		Sedges		Grasses		Bare ground	
Cover score	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS
0%												
1 - 5%												
6 - 25%												
26 - 50%												
51 - 75%												
76 - 100%												

Distribution: [F3]

	Component											
	Trees		Shrubs		Reeds		Sedges		Grasses		Bare ground	
Score	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS
Continuous												
Clumped												
Scattered												
Sparse												

INVASION OF RIPARIAN ZONE

Exotic species: (refer to field guide)

Species (list in order of problem)	Invasive/Recruit				Extent of invasion (tick)									
	I		R		VL		L		M		H		VH	
	I		R		VL		L		M		H		VH	
	I		R		VL		L		M		H		VH	
	I		R		VL		L		M		H		VH	
	I		R		VL		L		M		H		VH	
	I		R		VL		L		M		H		VH	
Total extent of invasion **[F4]**					VL		L		M		H		VH	

Terrestrial species: (refer to field guide)

Species (list in order of problem)	Extent of invasion (tick)									
	VL		L		M		H		VH	
	VL		L		M		H		VH	
	VL		L		M		H		VH	
	VL		L		M		H		VH	
	VL		L		M		H		VH	
	VL		L		M		H		VH	
Total extent of invasion **[F5]**	VL		L		M		H		VH	

Reeds: (refer to field guide)

Species	Extent of Problem (tick)									
Phragmites sp.	VL		L		M		H		VH	
Typha latifolia	VL		L		M		H		VH	
Arundo donax (Spanish reed)	VL		L		M		H		VH	
Other: specify	VL		L		M		H		VH	
Total extent of invasion **[F6]**	VL		L		M		H		VH	

SPECIES COMPOSITION:

NB: Includes only woody species (trees and shrubs) including exotics species.
Order - refers to order of species in descending order of abundance within site.

Dominance by biomass: [D9] - top 2

		Height class (enter number of individuals per class)				
Order	Species	2-4m	4-8m	8-12m	12m+	Total

Dominance by recruitment

		Height class (enter number of individuals per class)		
Order	Species	< 1 m	1 - 2m	Total

Recruitment of indigenous riparian species: (refer to field guide)

Extent of Recruitment	None		VL		L		M		H		VH		**[F7] [D10]**

Species richness:

Number of indigenous tree and shrub species	
Number of exotic tree and shrub species	
Total species	

ASSESSOR GUT SCORE:

Insert appropriate site score based on gut feeling only.

Score	1 - 4		5 - 8		9 - 12		13 - 16		17 - 18		19 - 20	
Class	F		E		D		C		B		A	

SITE MAP:

Hand drawn map including pertinent details such as: river course; direction of river flow; riparian zones; banks; distinctive vegetation communities / clumps; north arrow; point of access to site; area where SASS and fish surveys were undertaken; infrastructure such: as bridges, roads and fences.

RIPARIAN VEGETATION - WALK ABOUT FORM

During the initial site investigation, record the number of individuals of each prominent components with small ticks in the appropriate size class blocks.
Use a "c" to describe clumps applicable to reeds and prominent forbs, sedges and grasses in average size class blocks.
Type is either (t) tree, (s) shrub, (f) forb, (r) reed or (g) for sedges and grasses. Add (e) if exotic.

SPECIES	Type	<1	1-2	Sub-Total (1)	Order	2-4	4-8	8-12	>12	Sub-Total (2)	Order

APPENDIX B

RVI FIELD GUIDE

APPENDIX B : RVI FIELD GUIDE

Compiled by:

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1. INTRODUCTION

This manual is designed to assist the field assessor with understanding the RVI site assessment form and how to complete it at various sites. Each site is unique, which often makes it difficult to apply a generic site assessment form. Various guidelines are presented below which are aimed at understanding each data requirement on the assessment form and how these should be understood and applied on site.

A blank site assessment form is provided in Appendix C of the RVI document. Field assessors are urged to photocopy this form and make use of it for all site assessments.

2. THE RVI SITE

2.1 Site selection

The site selection process can be a difficult one given that most sites are usually located at some form of road access point such as a bridge, weir or drift. It is also often located on a riffle for the sake of the SASS and fish requirements. The vegetation at these sites is often either disturbed, or not very representative of the rest of the river. It is therefore often necessary to find a suitable vegetation site either upstream or downstream of the general site. It is necessary to have some basic knowledge of the river in order to assist with this selection. Every attempt must be made to choose something which is as representative of the river as possible. General site disturbances such as grazing, subsistence farming, infrastructures etc. which are common to the river, should be included as well as the representative riparian vegetation.

It is necessary to bear in mind that the site should be within easy access of the SASS and fish sites, as anything further than that will reduce your time available for the assessment of the site. Areas upstream of a weir or bridge are often inundated, either permanently or seasonally and are therefore quite disturbed, while areas downstream of bridges and weirs are often scoured out or impacted by modified flow regimes. It will be up to the discretion of the assessor to decide which is most representative of the river and that which is least disturbed.

2.2 Site characteristics

The site should be characterised, if possible, by the typical riparian vegetation of the river being assessed.

If you are in a gorge where little riparian vegetation exists due to rock, then you will need to optimise and do the best you can, knowing that the gorge vegetation is typically devoid of vegetation and that this also needs to be represented. The site typically comprises both sides of the river, but if access to the other side is restricted due to high flows or local fauna, it may be necessary to assess only one side. This must be noted in the field assessment form, usually on the site map. The site is also usually at least two hundred metres in length, or long enough to conduct a suitable walkabout investigation. It must be accessible and safe enough to conduct such an investigation.

2.3 Equipment and requirements

The following equipment is required to undertake the site assessment:

1) Handheld GPS (global positioning system).
2) Clip board and pen.
3) Site assessment form and field guide (this document).
4) Plant press and other plant collection requirements and equipment (see 2.6 plant collection).

2.4 Field assessment form

It is essential that this form is completed fully and correctly at each site. Once site selection has been finalised, the first part of the form must be completed. Please ensure that the site names, segment numbers and co-ordinates for the site coincide with those for the rest of the monitoring team. This will prevent future site confusion and will save a lot of time if undertaken correctly at this stage. Allow the GPS sufficient time to initiate and establish satellite connection and establish the true co-ordinates. Please enter your name (first) as the main assessor and those of any assistants. It is essential that you take responsibility for the assessment of the site. You may be contacted in the future to discuss site queries and to decipher any problems associated with the assessment.

Thereafter, the site walkabout will then need to be undertaken. The walkabout form is filled in during the site investigation to ensure that all details are recorded as they are encountered.

Once this has been completed the assessor must then find a suitable vantage point somewhere at the site and complete the rest of the assessment form. The vantage point, usually located on high ground in or near

the site, will assist with the compilation of the site map as well as familiarize the assessors of the site and its characteristics while completing the remainder of the form.

2.5 Site walkabout

The assessor should plan to investigate both banks of the river systematically. Select a suitable point (usually a distinctive tree or natural feature) as your starting point and note where the corresponding end point will be on the opposite bank. However, if the other bank is inaccessible, a long investigation of one bank is in order. The species are recorded as they are encountered during the walkabout. A small line or tick is then placed in the appropriate height class block. These will be counted up at the end of the walkabout, so ensure that sufficient space remains in each block to complete the full investigation. Take particular care to ensure that the juveniles (<1 metre individuals) are all identified as these represent the recruitment of the species, which is an important measure of the condition of the site. Large trees, are also often missed, so particular care must also be made to record these individuals. The walkabout needs to be of sufficient length to ensure that a representative number of different species and size classes are included on the walkabout form. The RVI focusses mainly on the more river dependent plants such as the trees and shrubs as they provide most information about the condition of the site. It also obviously includes reeds and other significant plants at the site as well which are also dependant on river flow. The site investigation will take forever if extensive detail is paid to small forbs and grasses which are not specifically dependent on the river itself. The walkabout should take about 15 minutes in total to complete. Should certain species be unidentified during the investigation, a suitable sample of this or these plants should be taken and pressed as soon as possible (see plant collection). The new or inexperienced assessor should not let plant identification slow down his or her progress, as the samples will be identified by professionals after the field visit. Only a name needs to be recorded on the walkabout form, which must coincide with that attached to the pressed sample.

Once the site investigation has been completed the assessor is to tally up the species totals and establish the recruitment and biomass dominant species and their dominance orders.

2.6 Plant collection for later identification

Significant plant species which are not identified during the initial site walkabout should be collected for later identification. Each person has got his or her own style of collecting plants, however, for the first time

collector the following basic guideline is provided.

The following equipment is required:

a) A small pick or geological hammer to dig up underground plants such as bulbs and grass roots.

b) A knife to slice twigs, bulbs and fruit.

c) A black refuse bag.

d) Pen, pencil and ruler.

e) Small note book for sample notes and information (collection register).

f) Plant press with sufficient corrugated cardboard separator sheets and blotting paper.

vi) Jewellers tags.

Some instructions should be followed in collecting riparian species: (1) collect material which is not infected with diseases and which is not damaged by insects, (2) ensure that the plant has flowers and / or seeds (sterile material makes identification difficult), (3) if the specimen is herbaceous, the underground parts should also be collected (e.g. grasses and bulbous plants), and (4) the new growth of many plants is often not characteristic of the plant, and should therefore be avoided.

If possible, the plants should be placed in the press immediately. During a survey when plants cannot be pressed immediately, carefully place the samples in the black refuse bag until such time when the press can be used. In the mean time, write the necessary sample information on a jewellers tag and attach it to the sample. The type of information commonly required is: Sample name, river, Site/Segment number and the date. This can help when pressing takes place at a later stage.

Each collector should have his/her own collecting register. Before any specimens are pressed, it is essential to complete this collecting register. This information will later be transferred to the herbarium label and is essential for the identification of the plant.

This information (Fig. 1) will be entered in the collecting book every time a collection is made. The following guidelines should be adhered to as best as possible:

a) Sample name (name which coincides with that on the walkabout form).

a) Date - day, month and year when plant was collected.

b) GPS co-ordinates.

c) Locality - Name and number of farm and / or name of river, site no. and site name.

d) Slope - Even (0-2°), slight slope (2-10°), moderate slope (10-45°) or steep slope (>45°).

e) Aspect - N, S, W, E, NE, SW, etc.

f) Altitude - Obtain from GPS or contour readings.

g) Soil & Geology - Gravel, sand, clay, loam, peat, humus, shale, sandstone, granite, quarts, etc.

h) Morphological unit - channel bed, channel bar, channel shelf, channel bank, island or flood plain.

i) Habitat - this includes the following:

1. Type of vegetation — desert, Karoo; open/closed/sparse grassveld; open/closed/sparse shrub savanna; open/closed/sparse woodland; forest; fynbos etc.
2. Substrate - Soil, stony soil, talus, krans (cliff), rock slab, termite mound, marginal zone etc.
3. Moisture - River bank, macro-channel floor, marginal zone, flood plain etc.
4. Exposure - Shade, semi-shade, full sun, etc.
5. Biotic effect - None observed, overgrazed, recently burned.

Each specimen's information is unique and should therefore be completed for each plant individually. The description of the plant should include the following (if available):

a) Growth form - Tree, shrub, herbaceous, grass, fern.

b) Habit (type of growth) - Upright, climber, floating, lying along the ground (decumbent).

c) Height - Where applicable.

d) Variable characteristics - Describe the colour, patterns, textures, scent and taste of the following: underground parts, bark, leaves, flowers, fruit, seeds.

e) General - How common is the plant, phenology (percentage of plants in flower), pollination activity, influence of herbivores, economical factors, etc.

The specimen to be pressed is then placed in the plant press until the plant has been dried for identification purposes. The specimen is then sent into the nearest institute or organisation who will be responsible for its identification. Once this has been undertaken, the correct name for the species should be entered into the walkabout and site assessment forms to complete the assessment.

EX HERBARIO **BIOMONITORING - RIPARIAN VEGETATION**	
Family	Genus no.
Name	
Site Co-ordinates S E	Date
Locality	Altitude
Habitat	
Morphological unit	
Slope	Aspect
Soil	
Description	
General	
Legit	Coll. No.

Fig. 1. Example of a herbarium label used by the Mpumalanga Parks Board.

2.7 Specific site assessment components

Each component of the site assessment are discussed below to ensure that these are consistently assessed from site to site and from assessor to assessor.

a) Channel description

A variety of different channel types are evident in South African Rivers. These generally fall into the category of single or multiple channels. Unstable river beds with multiple channels as seen in the classical sand rivers are termed "braided". Other rivers have multiple channels which flow between stable bedrock areas are termed "anabranching". The mixture between sand bed and bedrock areas is termed "mixed anabranching".

The active channel width refers to the area of the channel which actively flows most of the year. Other channels may be evident which flow only during the wet season, these are referred to as seasonal channels.

b) Riparian zone description

The outer edges of the riparian zone needs to be identified at a site in order to undertake the site assessment. This takes some experience to identify, but is most commonly identified by a distinctive vegetational transition. Usually the riparian vegetation comprises distinct riparian species which are often larger in size, display mesic characteristics such as larger leaves, multiple stems and other features. The grasses are also distinctively more mesic in form and sedges are often common. On some rivers, alluvial soils are evident within the riparian zone while the adjacent terrestrial areas comprise more consolidated soils derived from an underlying parent material. A debris line comprising grass and other plant matter is quite commonly found at or near the upper edge of the riparian zone. The measurement of riparian zone width is that taken from the edge of the active channel to the outer edge of the riparian zone. The word "potential" is used as often subsistence farming and ploughing takes place well into the riparian zone. Here identification of the outer edge of the zone becomes more problematical and relies on some experience.

Substrates vary considerably within riparian zones from bedrock or distinctive and exposed outcrops of rock, to very fine sediments deposited by floods. A qualitative estimate of the cover of each of these different substrate types within the riparian zone is required. Sand and gravels are most common which are associated with alluvial conditions and flood deposits.

Vegetation cover refers to the percentage of ground which is essentially covered by vegetation of any kind. This includes grasses, sedges, forbs, reeds, shrubs and trees. A qualitative estimate of this cover is required.

Any areas which are not covered in vegetation are exposed either because of substrate conditions such as exposed bedrock, rocks and cobbles are sand bars, or because of some form of disturbance in the riparian zone. Disturbances need to be identified carefully by examining the evidence on site. Once these have been identified it is necessary to order them in terms of their severity of impact. The relative size of each needs to be qualitatively assessed. Surrounding land-use is an important consideration in determining the types and history of disturbances presently or previously impacting on a site.

c) Distribution and extent of vegetation cover

Various vegetation components are distributed differently and in different abundances at a site. The change in the nature and extent of this cover, for the significant components namely, trees, shrubs, reeds, sedges and grasses provides valuable clues regarding the present condition of the site relative to the perceived reference state. The distribution scale ranges from continuous to sparse as follows:

- Continuous refers to the situation where the component of interest is distributed continuously from one side of the site to the other. The canopies of trees which are continuously distributed, for example, are touching or overlapping down the full length of the site.

- Clumped refers to the situation where the component is evident in distinctive clumps within the site. Often clumps are touching each other, but generally are isolated within the site.

- Scattered refers to the situation where individuals of a vegetation type are dotted throughout the site, but in reasonably large numbers without displaying clumped or continuous distributions.

- Sparse refers to the situation where a small number of individuals of a component are present but in different areas within the study site.

The reference state (RS) is that which refers to the "natural" condition or characteristics of the site. Unfortunately we have no real botanical evidence of this state on any rivers, and consequently one has to imagine what this condition was actually like, and therefore we refer to a perceived reference state (PRS). We all have our own perceptions of this condition, which often is quite similar. A number of assessors working together can agree to such a condition based on evidence present at the site.

d) Invasion of the riparian zone

Invasion of the riparian zone occurs when other vegetation elements are seen to take over or exist to a significant extent within the riparian zone when in actual fact their natural place is somewhere else. The typical and most common invasion is that of exotic species which usually originate from foreign countries. This often occurs because of the impacts of disturbances which open the sites up to the colonisation of faster growing and more resilient exotic species. The severity of the invasion depends on the species, its abundance, its invasive traits and extent of recruitment within a site. The total extent of invasion by a number of species simultaneously is difficult to assess, but depends on the number, extent and recruitment rate of the problem species present. Invasion is considered to be very high or serious when all exotic species present are invasive, are recruiting at an alarming rate and are significantly out competing the indigenous riparian species.

Invasion by terrestrial species usually occurs when the flow regime of a river is reduced to the point that mesic riparian species can no longer exist, and they are replaced by xeric terrestrial species instead. This situation often occurs downstream of dams and weirs which no longer allow for the natural flows downstream of the impoundment, or due to the extensive abstraction of the water and the eventual death of the river.

Reed invasion occurs frequently after the extensive deposition of large quantities of sediments in the river bed and on the macro-channel floor. It is often then exacerbated by raised or regulated baseflows and the provision of nutrient into the system due to irrigation return flows from adjacent lands. Such rivers can become completely choked by reeds and their condition can deteriorate rapidly.

The total extent of invasion of terrestrial and reed species is also a subjective assessment derived from a global invasion by different species with different levels of severity and abundances.

e) Species composition

This aspect of the field assessment form investigates which species are dominant at the site by abundance or by recruitment. This is derived from the relative abundances of individuals of different species and the range of height classes of each which are encountered during the site investigation. This provides a good indication of the condition of the vegetation present, whether this will improve, persist, die out, be replaced,

and if so what will replace the present vegetation. It can even provide some clue regarding the time frame involved, although this is not considered for the derivation of the RVI. This replacement might be a natural one or one which is directed by a specific type or suite of disturbances.

f) Recruitment of indigenous riparian species (RIRS)

In order for the natural vegetation at a site to perpetuate (and maintain good condition) it is important that the natural or indigenous vegetation displays recruitment. The dominant indigenous species (particularly by biomass) are most important at a site as recruitment will ensure their persistence. The assessment of recruitment (RIRS) at a site is therefore levelled at a comparison between recruitment of indigenous versus exotic species present. Recruitment can be achieved by means of both seedlings and coppice from rootstocks and existing plants. The extent of recruitment is made with reference to sub-total 1 of the site walkabout form.

The following table provides guidance with this assessment:

SCORE	Indigenous species	Exotic species (if present)
0	No evidence of recruitment.	Only exotic recruitment evident.
VL	Evidence of recruitment of any species is rare.	Large quantities evident.
L	Recruitment of mainly abundance dominant species.	Moderate quantities evident
M	Recruitment of moderate numbers of both abundance and biomass dominant species.	Recruitment common.
H	Recruitment of large quantities of biomass dominants species.	Limited recruitment is evident
VH	Extensive recruitment of the majority of species mainly biomass dominant species.	None evident

2.8 The RVI and its application

The RVI formula is currently built into the Rivers Database software and consequently does not form part of the assessors responsibility. Once the species identifications have been undertake after the site visit, the assessors final responsibility will be to ensure that the site data is correctly entered into the software.

3. REFERENCES

Krynauw, S. 1997. Herbarium Management Course. Mpumalanga Parks Board.

APPENDIX C

BLANK FIELD ASSESSMENT FORM

RIPARIAN VEGETATION - RVI (1)

Ver: 05/02/00

BIOMONITORING SITE ASSESSMENT FORM

RIVER: _____ Date: _____/_____/___

Site/Segt No:_____ Site Name:_____ LatLong: S:____°_____'____

Assessor names (print): _____ E:____°_____'____

CHANNEL DESCRIPTION

Channel type (tick):

CHANNEL TYPE:	Single		Multiple	Braided		Anabranching		Mixed	

Active channel width:

Width (m)	

RIPARIAN ZONE DESCRIPTION

Width of potential riparian zone:

Width (m)	LHB		RHB		Islands	

Substrate (tick):

Bedrock	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	
Rock/cobble	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	
Soil	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	
Gravel/sand	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	
Sediment	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	

Percentage vegetation cover (all vegetation) (tick):

LHB	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	
RHB	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	
Islands	0%		1 - 5%		6 - 25%		26 - 50%		51 - 75%		76-100%	

SITE CONDITION

Reason(s) why less than 100% vegetation cover: (refer to user manual)

REASON	EXTENT (tick)									
Natural	VL		L		M		H		VH	
Disturbed	VL		L		M		H		VH	

Site disturbances:

DISTURBANCE	IMPACT ORDER	EXTENT OF IMPACT (tick)									
Floods, elevated flows		VL		L		M		H		VH	
Flow regulation (dam upstream)		VL		L		M		H		VH	
Weir / dam (local inundation)		VL		L		M		H		VH	
Bush clearing / ploughing		VL		L		M		H		VH	
Vegetation removal (fuel, materials, feed)		VL		L		M		H		VH	
Crop farming		VL		L		M		H		VH	
Forestry		VL		L		M		H		VH	
Grazing / browsing / trampling (stock)		VL		L		M		H		VH	
Sand winning, quarrying, mining		VL		L		M		H		VH	
Picknicking, golf course, trails and paths		VL		L		M		H		VH	
Roads, bridges, other infrastructures		VL		L		M		H		VH	
Vegetation invasion (exotic, terr, reeds)		VL		L		M		H		VH	
Erosion / sedimentation		VL		L		M		H		VH	
Other: specify		VL		L		M		H		VH	

Surrounding land-use (tick):

Nature reserve, game farming		Stock farming (various stock)	
Subsistence (rural) farming		Irrigation farming (formal), crops	
Forestry		Picknick site / recreational	
Residential (urban)		Residential (rural)	
Mining / quarrying		Dumping	
Sewerage treatment		Other: Specify	

DISTRIBUTION AND EXTENT OF VEGETATION COVER

NB. canopy cover for trees and shrubs; ground cover for grass, sedges and reeds

Cover:

	Cover component											
	Trees		Shrubs		Reeds		Sedges		Grasses		Bare ground	
Cover score	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS
0%												
1 - 5%												
6 - 25%												
26 - 50%												
51 - 75%												
76 - 100%												

Distribution:

	Component											
	Trees		Shrubs		Reeds		Sedges		Grasses		Bare ground	
Score	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS	P/S	PRS
Continuous												
Clumped												
Scattered												
Sparse												

INVASION OF RIPARIAN ZONE

Exotic species: (refer to user manual)

Species (list in order of problem)	Invasive/Recruit				Extent of invasion (tick)									
	I		R		VL		L		M		H		VH	
	I		R		VL		L		M		H		VH	
	I		R		VL		L		M		H		VH	
	I		R		VL		L		M		H		VH	
	I		R		VL		L		M		H		VH	
	I		R		VL		L		M		H		VH	
	I		R		VL		L		M		H		VH	
Total extent of invasion					VL		L		M		H		VH	

Terrestrial species: (refer to user manual)

Species (list in order of problem)	Extent of invasion (tick)									
	VL		L		M		H		VH	
	VL		L		M		H		VH	
	VL		L		M		H		VH	
	VL		L		M		H		VH	
	VL		L		M		H		VH	
	VL		L		M		H		VH	
Total extent of invasion	VL		L		M		H		VH	

Reeds: (refer to user manual)

Species	Extent of Problem (tick)									
Phragmites sp.	VL		L		M		H		VH	
Typha latifolia	VL		L		M		H		VH	
Arundo donax (Spanish reed)	VL		L		M		H		VH	
Other: specify	VL		L		M		H		VH	
Total extent of invasion	VL		L		M		H		VH	

SPECIES COMPOSITION:

NB: Includes only woody species (trees and shrubs) including exotics species.
Order - refers to order of species in descending order of abundance within site.

Dominance by biomass

		Height class (enter number of individuals per class)				
Order	Species	2-4m	4-8m	8-12m	12m+	Total

Dominance by recruitment

		Height class (enter number of individuals per class)		
Order	Species	< 1 m	1- 2m	Total

Recruitment of indigenous riparian species: (refer to user manual)

Extent of Recruitment	None		VL		L		M		H		VH	

Species richness:

Number of indigenous tree and shrub species	
Number of exotic tree and shrub species	
Total species	

ASSESSOR GUT SCORE:

Insert appropriate site score based on gut feeling only.

Score	1 - 4		5 - 8		9 - 12		13 - 16		17 - 18		19 - 20	
Class	F		E		D		C		B		A	

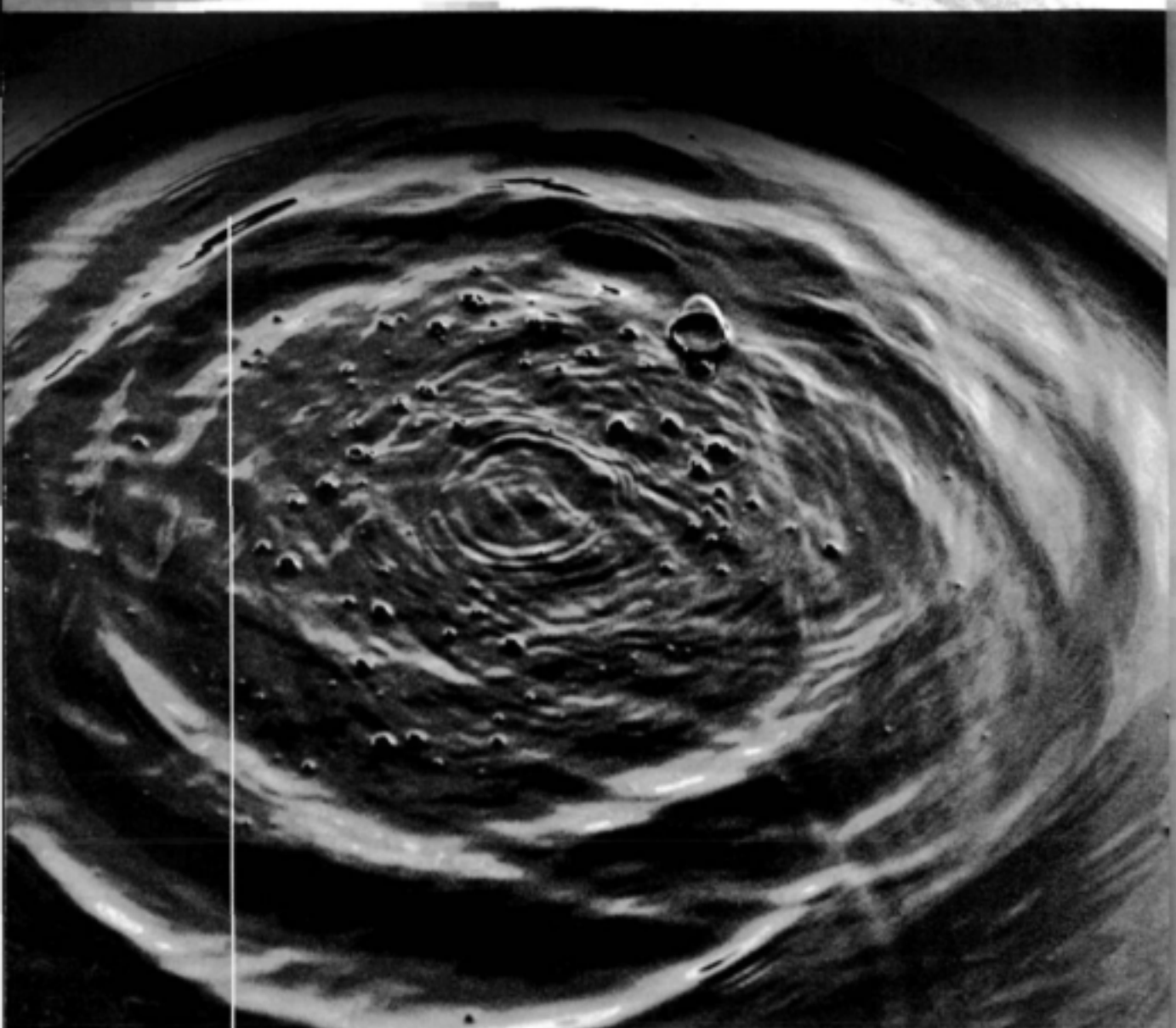
SITE MAP:

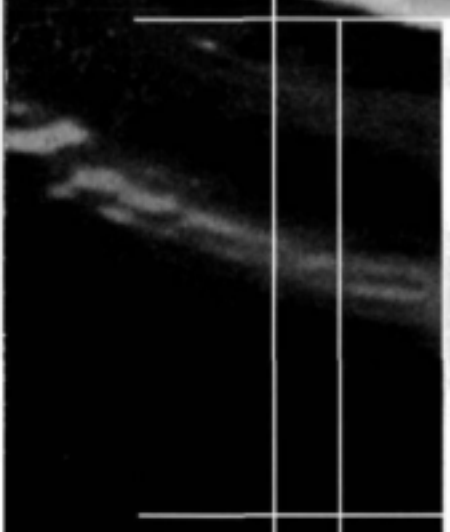
Hand drawn map including pertinent details such as: river course; direction of river flow; riparian zones; banks; distinctive vegetation communities / clumps; north arrow; point of access to site; area where SASS and fish surveys were undertaken; infrastructure such: as bridges, roads and fences.

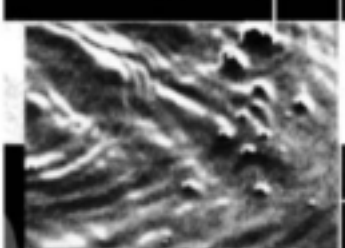
RIPARIAN VEGETATION - WALK ABOUT FORM

During the initial site investigation, record the number of individuals of each prominent components with small ticks in the appropriate size class blocks.
Use a "c" to describe clumps applicable to reeds and prominent forbs, sedges and grasses in average size class blocks.
Type is either (t) tree, (s) shrub, (f) forb, (r) reed or (g) for sedges and grasses. Add (e) if exotic.

SPECIES	Type	<1	1-2	Sub-Total (1)	Order	2-4	4-8	8-12	>12	Sub-Total (2)	Order







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