Extended Executive Summary:

Conservation Planning for River and Estuarine Biodiversity in the Fish-To-Tsitsikamma Water Management Area

June 2006

This publication should be cited as:

Nel, J.L., Smith-Adao, L., Roux, D.J., Adams, J., Cambray, J.A., de Moor, F.C., Kleynhans, C.J., Kotze, I., Maree, G., Moolman, J., Schonegevel, L.Y., Smith, R.J., Thirion, C. 2006. *Conservation Planning for River and Estuarine Biodiversity in the Fish-to-Tsitsikamma Water Management Area*. Water Research Commission Report K5/1486, Water Research Commission, Pretoria, South Africa.

It is accompanied by a Metadata CD available from the following ordering address:

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BACKGROUND AND APPROACH

This study forms a pilot study for a broader national initiative, which aims to develop a policy and planning framework for systematic conservation of inland water biodiversity in South Africa. The national initiative was set up in 2003 between the Department of Water Affairs and Forestry and CSIR. Subsequently the Water Research Commission added its support by sponsoring this project in the Fish-to-Tsitsikamma Water Management Area, which aims to **facilitate testing, refinement and demonstration of the river prioritization and selection tool at a sub-national scale**, providing an example of the lessons learnt and best practice for use elsewhere in the country.

The formal aims for this project, as stipulated in the Water Research Commission contract are:

1. To put in practice and refine, through a pilot study in the Eastern Cape, the policy and planning tools developed within the broader national initiative for systematic conservation planning of rivers. This would facilitate testing, refinement and demonstration of the river prioritization and selection tool, and provide an example of best practice for use elsewhere in the country.

2. To ensure local and national stakeholder participation in developing the technical approach to river prioritization and selection, as well as the reviewing of results to facilitate buy-in and ownership of the product.

"Biodiversity conservation" in this project and the broader national initiative refers to the efforts to maintain or restore the ecological integrity (including structure, composition and function) of inland water ecosystems to levels that are in accordance with the most stringent (most highly protected) water resource management class (Roux *et al.* 2006). Initiatives to conserve inland water biodiversity would thus not apply to all water resources, but only to those water resources that are awarded the highest protection level based on the national water resource classification system (DWAF 2004). In policy terms, this is consistent with "Natural" or "Good" rivers within the River Health Programme categorization (Roux 2004) or the "Natural" class within the context of the national water resource classification system (DWAF 2004).

The technical planning approach adopted for this study is based on systematic conservation planning principles and methods. Systematic conservation planning is founded upon several fundamental principles: the principle of representation and efficiency, persistence and quantitative target setting. The first principle requires the efficient conservation of a representative sample of all species, and of the habitats in which they occur (as opposed to focussing only on the ones experts know). However, conserving species and habitats, often referred to as **biodiversity pattern**, is not enough. It simply provides a snapshot of the biodiversity that currently exists. The principle of persistence requires the conservation of the **biodiversity processes** responsible for maintaining and generating biodiversity over time. Finally, the principle of **quantitative target setting** requires the formulation of explicit goals with key stakeholders, which are then translated into quantitative targets for biodiversity features (e.g. length of river, area of catchment, design targets for connectivity). For a more detailed discussion of these principles, the reader is referred to Margules and Pressey (2000) and Roux *et al.* (2006).

The fundamental principles of systematic conservation planning have formed the basis of the step-wise planning framework, which guides the approach of this project. There are seven main steps:

(i) Identify and involve key stakeholders during project initiation;
(ii) Develop spatial data layers for biodiversity pattern;
(iii) Develop spatial data layers for biodiversity process;
(iv) Develop spatial data layers for river integrity;
(v) Assess and prioritize estuaries;
(vi) Set quantitative biodiversity targets; and
(vii) Select and design areas for achieving biodiversity targets in both estuaries and rivers.

GENERAL DESCRIPTION OF THE STUDY AREA

The Fish-to-Tsitsikamma Water Management Area (WMA 15) is situated mainly in the Eastern Cape Province of South Africa, with small portions of its north-western part within the Northern and Western Cape Provinces. Six primary catchments occur within the Fish-to-Tsitsikamma Water Management Area: the Fish (Q-catchment), Sundays (N-catchment), Gamtoos (L-catchment), Algoa (M-catchment) and Bushmans (P-catchment) primary catchments occur completely within the Fish-to-Tsitsikamma Water Management Area, whilst the Tsitsikamma (K-catchment) occurs partially within the area. These primary catchments mark the delineations of sub-water management areas. Major rivers in the Fish-to-Tsitsikamma Water Management Area are the Fish, Kowie, Bushmans, Sundays, Gamtoos, Krom, Tsitsikamma and Groot rivers. A detailed account of the topography, climate, water use and availability characteristics of this water management area have been provided by Basson and Rossouw (2003).

The agencies responsible for implementation of biodiversity conservation and water resource protection, which were involved in the project include national and regional offices of DWAF as well as the bioregional coordination unit in the Eastern Cape.

MAPPING BIODIVERSITY PATTERN FOR RIVERS

Rivers were classified into 113 **river types** using a geomorphological and hydrological classification system (Dollar *et al.* in press). At the landscape level, rivers were classified according to geomorphic provinces (Partridge *et al.* in prep) and a hydrological index which characterizes flow variability (Hannart and Hughes 2003). A characterization of geomorphologic (longitudinal) zones at the level of individual streams was used to supplement these broad landscape-level descriptors of geomorphology and hydrology. Using this stream-level descriptor in conjunction with the landscape-level characterization of geomorphology and flow provides a finer-scale surrogate of the biotopes expected within the river reach, which in turn was used as a surrogate for biodiversity pattern within river ecosystems.

Future assessments should (i) evaluate whether each river type is a true reflection of river biodiversity or an artefact of combining the GIS layers for geomorphic province and hydrological index classes; and (ii) supplement these physical river types with aquatic species datasets that have been relatively comprehensively surveyed across the planning domain, e.g. fish databases.

INCORPORATING BIODIVERSITY PROCESSES

Four key principles were considered when incorporating biodiversity processes into this conservation plan. The first three of these principles require explicit consideration during the selection and design procedures; the last principle requires explicit mapping of large-scale biodiversity processes across the landscape.

Selecting ecosystems of high ecological integrity

Rivers that are currently considered to be of high integrity should ideally be selected for the purposes of conserving biodiversity, since these are the rivers that accurately represent the biodiversity of the region, and in which ecological and evolutionary processes operate within their natural ranges. Incorporating rivers of high integrity will therefore incorporate many small-scale biodiversity processes, such as localized nutrient cycling, sediment transport, inter- and intra-specific interactions. From a practical point of view, selecting rivers that are currently of high integrity also (i) facilitates operational management - since rivers operating close to natural conditions tend to be more self-sustaining and require less conservation management, and (ii) improves the cost efficiency of conservation management as no rehabilitation is required. For the purposes of this project, only rivers with a present ecological integrity of “Natural” or “Good” (equivalent to A or B class rivers; Roux 2004) were selected; and estuaries considered to be in a “Poor” state (Whitfield 2000) were excluded.

Ensuring connectivity

Longitudinal connectivity in the Fish-to-Tsitsikamma Water Management Area was maintained by incorporating, where possible, whole river systems in the conservation plan. It is often not possible to find whole systems that are currently in a consistently high present ecological state (i.e. where the river is Class A or B through its entire tertiary or primary length). Thus, rivers that were selected for conservation in a natural or good class (Class A or B) were connected through rivers that are only moderately used or impacted (Class C). Such connecting rivers were incorporated explicitly into the final conservation plan, with the recommendation that these should be maintained these in a state that retains longitudinal connectivity for its associated biodiversity.

Including rivers of sufficient size

Each river reach chosen for high protection status in the Fish-to-Tsitsikamma conservation plan was also evaluated in terms of its size and viability. With a few exceptions, only those reaches that were over 5 km long were chosen for conservation purposes. These exceptions mainly occurred in headwater streams, where the only option to conserve a representative stretch of river was in a reach that was shorter than 5 km in length, and which was connected to rivers of lower integrity (Classes C-F). Because headwaters are in reality relatively short stretches of river, and can be important and viable for specific aquatic biota despite their small size, it was decided that they should be included in the conservation plan ***provided*** that the length of river contributing to targets (i.e. in a Class A and B) did not fall below 17 % of the total length of river in that quaternary catchment. The threshold of 17 % was derived by assessing the cost of including quaternary catchments of low overall integrity versus the benefit of meeting targets in the overall plan.

Including additional large-scale biodiversity processes

The Fish-to-Tsistikamma Water Management Area contains many permanently open estuary mouths; these serve as large-scale migration routes for freshwater eels and the freshwater mullet, *Myxus capensis*. The desktop ecological importance and sensitivity scoring system (Kleynhans 2001) was used to identify quaternary catchments of national importance for migration - these quaternary catchments were then explicitly incorporated into the Fish-to-Tsistikamma conservation plan.

MAPPING ECOLOGICAL INTEGRITY OF RIVERS

Rivers that are currently of high ecological integrity should ideally be the first choice for biodiversity conservation. This requires a spatial depiction of the integrity of riverine ecosystems. Ecostatus determination techniques (Kleynhans *et al.* 2005) were used to assess the condition of rivers at the level of the landscape, and to derive a spatial depiction of river ecological integrity for the area. However, owing to limited time and inadequate reference site data, only the broadest level 1 ecostatus determination techniques were used; these focus on the derivation of an index of habitat integrity from physical drivers (as opposed to including response variables such as biotic indices). This process involved:

- Dividing the Fish-to-Tsitsikamma Water Management Area into assessment units, based on Level 1 ecoregions (Kleynhans *et al.* 2004), primary catchments, and land cover attributes;
- Scoring these assessment units according to the primary determinants of their in-stream and riparian ecological integrity in an expert workshop; and
- Assigning all rivers falling within the same assessment unit the same integrated index of habitat integrity.

Field verification of this desktop assessment was undertaken at 48 sites; these sites were located mainly in those areas that were not well known to experts. There were a number of sites (12 out of 48; 25 %) where there was a discrepancy between the desktop and field ecostatus scores. Of these 12 sites, some had an ecological integrity score at the landscape level that was better than at the site level, owing to localized impacts. In these cases, the desktop assessment was not changed. Not all of the discrepancies, however, were explained by localized site impacts. For example, on both the Groot and Klein Brak rivers, surveys were conducted along extensive sections of river and the discrepancies were not a result of localized site impacts. These discrepancies are more likely a consequence of poor resolution in the desktop analysis, resulting from the process of generalisation into broad assessment units. The river ecological integrity in these instances was corrected to derive a final map of ecological integrity of rivers.

Overall, rivers in the region are in relatively good condition compared to other areas of the country, with 46 % of the total river length in the Fish-to-Tsitsikamma Water Management Area in an A (natural) or B (largely natural) class, 42 % in a C class (moderately modified), and slightly over 12 % in D and E classes (largely to seriously modified).

SETTING QUANTITATIVE BIODIVERSITY TARGETS FOR RIVERS

Biodiversity targets (also referred to as conservation targets) set out the minimum, quantitative requirements for biodiversity conservation in order to: allow an evaluation of whether or not existing conservation efforts adequately represent the biodiversity of a region; provide guidance for planners who have to balance a number of competing demands for natural resources in a region; and provide water resource management and biodiversity conservation agencies with common quantitative measures or targets to aim for (Groves 2003).

The recommendations arising from the national cross-sectoral policy process (Roux *et al.* 2006), currently underway as a parallel Water Research Commission project (Project K8/642), were adopted for setting targets for rivers in the area. This process has put together recommended operational policy objectives and guiding principles to advance the practical conservation of inland water biodiversity across multiple sectors and spheres of government. These objectives and guidelines are the culmination of analysis, consultation and deliberation amongst the primary agencies responsible for conservation of inland water biodiversity in South Africa. Translating these recommendations to the Fish-to-Tsitsikamma conservation plan, biodiversity targets were calculated as 20 % of the total length of each Level 3 river type. These targets should only be achieved within river reaches that have a present ecological integrity class of “Natural” or “Good” (i.e. Class A or B rivers) - any river reach that is in a class that is lower than A or B class, and which is required for maintaining longitudinal connectivity, should be included explicitly in the plan, but should not contribute towards achieving this 20 % biodiversity target.

There are 37 river types which cannot achieve their biodiversity target in river reaches of an A or B class, i.e. the combined length of their A or B class segments has fallen below 20 % of the total length of that river type in the area. Options for rehabilitating examples of these river types within the Fish-to-Tsitsikamma Water Management Area were explored within the context of the potential opportunity for conserving these river types elsewhere in the country. This assessment of rehabilitation potential divided these 37 river types into four categories:

(i) Rehabilitation is feasible - quaternary catchments containing good examples of these river types have been flagged for rehabilitation in the subsequent conservation plan.

(ii) Best conserved elsewhere - areas which could adopt the targets for the Fish-to-Tsitsikamma Water Management Area were identified.

(iii) Rehabilitation is not feasible and conservation opportunities elsewhere also look bleak - an assessment at the national level should be undertaken to identify where it would be best to rehabilitate these river types.

(iv) Rehabilitation is not feasible and cannot be conserved elsewhere (unique to study area) - these river types are now under-represented in the country (i.e. have failed to meet the national target).

ESTUARY ASSESSMENT AND SELECTION

Estuaries in the Fish-to-Tsitsikamma Water Management Area were assessed with the aim of selecting a representative set of estuaries to conserve threatened species, maintain viable populations of all estuarine species, and to maintain in their reference state, or where necessary, to rehabilitate the estuary to a condition where it achieves the above aims. Like rivers, it is envisaged that all estuaries should enjoy some level of protection, being assigned to three protection categories, listed in decreasing order of their level of protection as: Estuarine Protected Areas, Estuarine Conservation Areas and Estuarine Management Areas. This project focuses on identifying estuaries to be earmarked as Estuarine Protected Areas and Estuarine Conservation Areas.

Estuarine biodiversity pattern and process

There are a total of 30 estuaries in the Fish-to-Tsitsikamma Water Management Area, and all fall within the Warm Temperate biogeographical zone (Harrison 2004). The Whitfield (1992) classification was used to further classify **estuary types;** these were used as the physical surrogate to depict the biodiversity pattern of estuaries in the area. This divided the Fish-to-Tsitsikamma estuaries into eight permanently open estuaries; 17 temporarily open estuaries; and five river mouths. Only 18 % of South Africa's estuaries are permanently open and therefore this area is particularly important in terms of estuarine biodiversity and conservation importance. For example, the importance of this area for large-scale migration of freshwater eel and freshwater mullet are a result of the many permanently open estuaries.

Additionally, the national conservation importance rating of each estuary was used to help choose between estuaries of similar types. This rating was based on quantitative and semi-quantitative biodiversity data for plants, invertebrates, fish and birds, as well as estuarine type and its rarity within each biogeographical zone, and overall estuary size.

Estuarine ecological integrity

Whitfield (2000) conducted an assessment on the ecological integrity of estuaries, which has recently been slightly refined where regional experts deemed it necessary (Turpie 2004b). This classified estuaries broadly as "Excellent", "Good", "Fair", or "Poor". Only two of the permanently open estuaries in the Fish-to-Tsitsikamma Water Management Area are in a "Good" condition, whilst the remaining permanently open estuaries are rated in a "Fair" state. Nine of the 17 temporarily open estuaries are in a ""Excellent" or Good" state, while three are in a "Fair" state and the remaining five are in a "Poor" state. The ecological state of the estuaries selected for inclusion in the conservation plan should be given attention to ensure that biodiversity within these estuaries is maintained.

Current protection status

The current status of protection was derived from the Whitfield (2000) classification system, and shows that the present system of formal protection is biased. All five river mouths qualify as Estuarine Protected Areas, there is one temporary estuary (the Tsitsikamma) that qualifies as an Estuarine Conservation Area, and the remaining three are co-managed as Estuarine Management Areas. There are no permanent estuaries that receive Estuarine Protection or Conservation status. The conservation plan should aim to correct this bias.

Current protection status was also taken into account, in terms of their practical feasibility for protection, in the selection of estuaries for inclusion in the conservation plan.

Setting quantitative biodiversity targets for estuaries

Targets for estuaries were based on methods used in the assessment of estuaries on the Wild Coast (Turpie and Van Niekerk 2004), in which the targets used were set as 20 % of estuaries allocated to Estuarine Protected Areas and 30 % of estuaries allocated to Estuarine Conservation Areas.

Selecting estuaries for inclusion in the conservation plan

Seven Estuarine Protected Areas and nine Estuarine Conservation Areas were selected based on the following selection protocol to satisfy the biodiversity targets:

(i) Estuaries in “Excellent”, “Good” or “Fair” condition were deemed suitable for selection. Estuaries in “Poor” condition were excluded from selection options.

(ii) Estuaries that already have high protection status (Estuarine Protected Areas) were chosen first to satisfy targets. Estuaries with lower protection status (Estuarine Conservation Areas or Estuarine Management Areas) were favoured, but not necessarily chosen over other more suitable estuaries.

(iii) Spatial distribution was then taken into account, making sure that estuaries are more or less evenly dispersed along the coastline.

(iv) A national importance rating was used to decide between estuaries of the same type and condition that are located no more than 200 km (most often less than this) from each other.

(v) Estuarine Protected Areas were selected based on the feasibility of pure protection. In cases where high protection is not considered feasible, but where the estuary qualifies on the above selections, the estuary was assigned to Estuarine Conservation Area status. This feasibility assessment included criteria such as:
   - Current levels of terrestrial and coastal protection in the area. Areas in close proximity to existing protected areas were favoured;
   - Current socio-economic activities associated with the estuary; and
   - Quality of the river flowing into the river. Rivers with an ecological integrity of A, B or C were favoured over rivers with a lower ecological integrity (D, E or F).

CONSERVATION DESIGN FOR RIVERS, CATCHMENTS AND ESTUARIES

The aim of this stage in the conservation planning process is to locate a set of catchments and estuaries that will achieve riverine and estuarine biodiversity targets. It should be noted that conservation planning should be seen as a process of iterative improvement – ground truthing should be undertaken in selected catchments to verify that they contain the biodiversity features for which they were selected, and this should be fed back into the planning process so that plans can be revised appropriately.

The following steps were used, in the order in which they are listed below, to select rivers and quaternary catchments for inclusion in the Fish-to-Tsitsikamma conservation plan:

1. Use conservation planning decision support software to assist with the derivation of an initial plan that takes into account the following multiple criteria:
    - Complementarity and efficiency in achieving biodiversity targets;
    - Building in longitudinal connectivity ;
    - Where a choice must be made between quaternary catchments with similar biodiversity components, in order of appearance below:
        - Choose rivers located near to or flowing through terrestrial protected areas;
        - Choose rivers that are adjacent to quaternary catchments that are flagged for river rehabilitation.
2. Add in additional quaternary catchments needed for rehabilitation.
3. Add in additional quaternary catchments required for large-scale species migration routes.
4. Build in large-scale connectivity where it is still needed.
5. Remove short stretches of river reach that are deemed too small to be viable.
6. Investigate the removal of marginal quaternary catchments, defined as those quaternary catchments where the percentage length of A or B class rivers is very low compared to the total length of river in that catchment.

This produced a river conservation design that contained quaternary catchments and rivers that are required for:

- Representation/target achievement. Any river selected should maintain its A or B present ecological integrity class.
- Rehabilitation to an A or B ecological integrity status to help achieve biodiversity targets.

- Large-scale migration routes. Catchments selected must be managed in an ecological integrity class that supports connectivity, preferably no lower that a C class.
- Upstream connectivity of river reaches. Catchments need not be in an A or B ecological integrity class, but they need to be managed to facilitate connectivity, preferably no lower than a C class.

The conservation plan requires 55 (27 %) quaternary catchments in the Fish-to-Tsitsikamma Water Management Area to achieve the biodiversity targets for Level 3 river types. This translates to 29 % of the total river length in the water management area. A further 27 (13 %) of the quaternary catchments in the area (translating to an additional 13 % of the total river length in the area) are required to maintain upstream and downstream connectivity. These catchments need not be in an A or B ecological integrity class, but will need to be maintained in a state that permits connectivity, ideally these should be no lower than a C state.

The proposed river selections would achieve the biodiversity targets of 76 (67 %) river types in the Fish-to-Tsitsikamma Water Management Area. If the proposed quaternary catchments and rivers are rehabilitated, then 14 (12 %) additional river types will meet their biodiversity targets. Thus, with feasible rehabilitation, 80 % of the river types can meet their targets in the Fish-to-Tsitsikamma Water Management Area. It is not possible to meet biodiversity targets of the remaining 23 (21 %) river types, as rehabilitation of examples of these river types is not feasible in this water management area.

CONCLUSIONS

Lessons learnt

Conservation planning for inland waters is a new and rapidly evolving field. The Fish-to-Tsitsikamma is the first river conservation plan to be devised for a water management area in South Africa (though some estuarine conservation plans have already been developed, e.g. Turpie and Van Niekerk 2004). Lessons from this planning exercise are already being applied in new conservation planning projects underway in the Crocodile (West) and Marico, and Olifants/Doorn Water Management Areas. Key lessons from this study include:

(i) <u>*National context*</u>: There is a need to consider the national context within which plans at the water management area level are undertaken, particularly when assessing river types that cannot meet conservation targets. A national process is underway to cascade national targets differentially across South Africa, based on a national conservation assessment of biodiversity. Currently, an assessment of the national context is constrained by data limitations: the assessment requires consideration of the distribution of biodiversity at a national level, combined with the ecological integrity of this biodiversity. Level 3 river types have not yet been developed at a national level as this requires constructing longitudinal zones for at least all 1:500 000 rivers in South Africa, an activity that is currently being undertaken by the Department of Water Affairs and Forestry. Ecological integrity has also not yet been developed for all 1:500 000 rivers, although the Department of Water Affairs and Forestry is currently attempting to initiate a national ecostatus determination process to derive these data. This is a time-consuming process and it is recommended that a suitable model be developed to predict river ecological integrity at finer scales.

(ii) <u>*Choosing which rivers to assess*</u>: Careful consideration needs to be given to choosing which rivers to assess in the conservation plan (i.e. which rivers data layer to use). River data layers for South Africa are available at scales of 1:500 000; 1:250 000 and 1:50 000. The 1:500 000 data layer is based on 1:500 000 topographical maps, but has been refined to include alignment of the rivers to within 50 m of 1:50 000 topographical maps. This is a marked improvement on the 1:250 000 rivers data layer which, although it contains more rivers, consists simply of the blue plates from 1:250 000 topological maps that have not been cleaned or hydrologically corrected. Rivers at the

1:50 000 scale have been hydrologically corrected and coded and may seem ideal; however: (i) using 1:50 000 rivers can lead to selecting streams that are of too small a size to satisfy biodiversity targets; and (ii) constructing longitudinal zones for all 1:50 000 rivers (required for Level 3 river typing) would also be an immense task. Using the 1:500 000 rivers as a base data layer and augmenting this with any other significant river reaches from the 1:50 000 data layer (identified by regional experts) seems to be a good compromise for planning at the level of a water management area.

(iii) *Using sub-quaternary catchments*: The conservation plan for the Fish-to-Tsitsikamma Water Management Area uses quaternary catchments as the basic units for selection, or planning units. Modelling smaller sub-quaternary catchments would produce a more efficient conservation plan, as this would incorporate specific rivers. This lesson has been carried forward to the Crocodile (West) and Marico conservation plan with some success, and it would be ideal to develop a data layer of such sub-quaternary catchments at a national level.

(iv) *Assessing ecological integrity at the level of river reach*: Conservation plans for river biodiversity are often constrained by a shortage of river ecological integrity information across a planning region, particularly in areas where many rivers are in a poor condition. Two methods are commonly used in South Africa to derive ecological integrity at a landscape level, namely present ecological status (Kleynhans 2000) or ecostatus determination approaches (Kleynhans *et al.* 2005). Both of these methods aggregate rivers into broad-scale assessment units. All rivers in the assessment unit are then assumed to have the same generalized ecological integrity class. This ignores the possibility that, at a finer scale within the broad assessment unit, there may be some rivers that are in better condition than others, and therefore limits the options for achieving biodiversity targets. Modelling river ecological integrity at the level of each individual river reach (e.g. reaches between river confluences) would enable a better assessment of options across the landscape.

(v) *Using preliminary conservation plans to guide field verification*: Conservation plans are dependent on the data that are used to derive them. Since ecological integrity data are extremely limited in the Fish-to-Tsitsikamma Water Management Area, a desktop ecological integrity score was derived using ecostatus determination techniques (Kleynhans *et al.* 2005). There was a need to undertake field verification in order to test the accuracy of these data before using these in the conservation planning exercise. Field sites were chosen mainly in areas where expert knowledge was lacking, so as to get a more consistent coverage of the landscape. However, in retrospect, to utilize resources most effectively, it would have been better to undertake a desktop conservation plan with preliminary data and then to visit the priority areas emanating from this process to verify that they do, in reality, contain the biodiversity components for which they were selected. Initially, this was not done so as not to bias the conservation plan.

(vi) *Preparation of the spatial data layers*: This is a time consuming process, but it is critical that sufficient time is spent making sure that these data layers are of high quality and contain no errors and data artefacts (e.g. slivers produced from spatial overlays may produce false river types).

(vii) *Hydrological index*: Great care must be taken when hydrological index classes are lumped together without a strong rationale for doing so. Initially, it appeared that it would be easier to deal with only three levels of flow variability. However, on closer inspection of the hydrological index data with regional experts, it seemed the hydrological index classes separated out true river types.

(viii) *Best Attainable Ecological Management Class*: These data (Kleynhans 2000) are broad-scale and outdated (assembled between 1996 and 1998), and should thus be applied with caution when assessing the rehabilitation potential of rivers. The available data tend to suggest that a river can be returned to a higher ecological integrity class than that which is currently deemed feasible by experts.

Future research and monitoring to support implementation of the conservation plan

The future research needs identified below would all feed into developing a national biodiversity assessment and conservation strategy, which is critical to provide context for conservation planning at a sub-national level:

(i) *Collecting and verifying primary data*: Conservation planning outputs are highly dependent on biodiversity pattern and ecological integrity data layers. These data layers have their limitations, and require both expert and field verification. In addition, research on how best to supplement conservation plans with species data should be initiated, e.g. freshwater fish distribution data. Collecting high quality primary data for a region, or at a national scale, is well worth the investment because experience in terrestrial conservation planning (already over a decade old in this country; Driver *et al.* 2003) suggests that the primary data have a much longer life span than the conservation plan itself.

(ii) *Developing a model to predict ecological integrity, using existing data on land cover, dams and surface run-off*: A model has been developed for Australian rivers (Stein *et al.* 2002), which could be used as a basis for South African rivers. This model would need to be verified, a process which could be done together with the regional ecostatus determination due to be launched in the next year.

(iii) *Modelling sub-quaternary catchments*: Techniques have already been pioneered in the conservation plan for the Crocodile (West) and Marico Water Management Area, which is currently underway, and this would need to be extended to the entire country. Extending it to the entire country, rather than generating sub-quaternary catchments on a piece-meal basis, would facilitate synergy and alignment of the sub-quaternary catchments used. It would also facilitate efficiency in developing a national biodiversity assessment and conservation strategy.

(iv) *Incorporating wetlands*: There are a number of projects under way to promote the inventorying and classification of wetlands in South Africa. These are challenging in their own right, but once the spatial products are available, wetlands could be relatively easily incorporated into biodiversity pattern targets. The m ain challenges, related to future research for wetlands with regard to conservation planning, include: deriving wetland condition at a landscape level; incorporating the functional importance of wetlands; and setting biodiversity targets for wetland types. Some of these aspects are being pioneered at a very basic level in the conservation plan for the Crocodile (West) and Marico Water Management Area.

(v) *Incorporating ground water*: Research is required on how best to incorporate ground water into conservation planning. Whilst many research projects currently target management of groundwater, research focussed on mapping ground water processes is limited. Efforts currently being applied in the Crocodile (West) and Marico conservation plan focus on identifying rivers that are highly dependent on ground water and areas important for ground water recharge. Although there are also preliminary maps of ground water dependent ecosystems, the areas that need managing in order to maintain these can be great distances away - maps of the actual areas that support ground water dependent ecosystems therefore need to be developed.

(vi) Setting more ecologically meaningful targets for aquatic biodiversity: It is recognised that the biodiversity target of 20 % is arbitrary and not based on a sound scientific understanding of limits of acceptable change and other ecological thresholds. These targets may also differ for different ecosystem types (some may require a larger proportion than others in order to enjoy an adequate level of protection). Scientific research around ecological thresholds should therefore be undertaken to inform the setting of biodiversity targets.

Management actions

The maintenance of ecological integrity in selected river reaches is critical, and these reaches should be connected within the selected quaternary catchments via rivers that facilitate upstream and downstream connectivity. Selected estuaries should be afforded the appropriate level of protection, as suggested by their status as either an Estuarine Protected Area or an Estuarine Conservation Area. They should also have accompanying management plans, and a comprehensive estuary reserve assessment should be undertaken and implemented. Linking selected rivers and estuaries with the national water resource classification process is essential, as well as setting Resource Quality Objectives for all selected rivers and quaternary catchments.

Saunders *et al.* (2002) list the three primary causes of biodiversity loss in inland water systems: (i) land-use disturbances; (ii) altered hydrological regimes; and (iii) alien invasive species. This concurs with the findings of river health surveys in South Africa, where the destruction of riparian zones, flow regulation and alien species (including terrestrial and riparian flora as well as aquatic biota) are typically found to be the main factors having adverse impacts on river health. From these primary impacts, Roux *et al*. (2006) suggest three basic management actions that would go a long way to conserving inland water biodiversity. These are outlined below, with specific recommendations regarding the Fish-to-Tsitsikamma Water Management Area:

(i) Negate effects of deleterious land-use activities:

This would include:

- Conserving whole catchments if at all feasible. Where this is not possible, catchment zoning, (where the most deleterious activities for the resource are relegated to the part of the catchment furthest away from the river), should be used as a management option. Where the former options are not available, intact riparian buffer strips may be used to reduce the effects of deleterious land-use practices. Widths of 10-50 m have been found to be effective in maintaining ambient stream temperatures and retaining sediments and nutrients. The effective width of a riparian buffer strip should be determined on a site-specific basis, considering factors such as varying vegetation types channel form, and slope.
- Improving or re-instating extension in agricultural landscapes.
- Avoiding road crossings in selected rivers. Where they are necessary, ensure that their impacts are minimized. For example, bridges are better than causeways – where causeways have to be built, build a reasonable number culverts into the causeway so that water can flow freely in the active channel; build retaining walls for roads next to rivers (especially gravel roads).

(ii) *<u>Retain natural flow regimes</u>*:

This would include:

- Understanding the in-stream flow requirements of rivers.
- Managing the primary drivers of in-stream ecological integrity, i.e. in-stream water abstraction, flow modification, bed modification, channel modification, water quality and inundation.
- Developing a water release plan for dammed rivers that is suited to maintaining the river in the desired ecological integrity (A or B class for rivers required to meet targets; preferably a C class for rivers required for maintaining connectivity).
- Building fishways in rivers required for connectivity. NOTE: alien infestations may need to be managed before this is done.
- Removing non-functional weirs, a common occurrence in the Fish-to-Tsitsikamma Water Management Area, particularly in the more arid inland areas of the region. NOTE: alien infestations may need to be managed before this is done.

(iii) *<u>Exclude alien species:</u>*

All selected catchments should have an alien organism management plan, which includes a monitoring component.

Identify a champion institution to coordinate implementation of this plan

Implementation of this conservation plan will require an effective integrated management approach where water resource management, land-use management, and biodiversity conservation are managed in a coordinated manner that aims to achieve ecological and socio-economic sustainability. To achieve this coordination, it is important to identify a regional champion institution to take responsibility for driving this plan forward. Importantly, conservation of inland water biodiversity is a cross-sectoral responsibility and the two departments with the most direct line responsibility are the departments of Water Affairs and Forestry, and Environmental Affairs and Tourism. However, to make cooperative implementation work in practice, one of these departments should take the lead.

The most appropriate framework within which to operate would be the Catchment Management Agencies under the auspices of the Department of Water Affairs and Forestry; however, it may take several years before all of these these agencies are fully functional. In the interim, the most appropriated champion institution is the Resource Directed Measures and Water Resources Planning Directorates of the regional and national offices of the Department of Water Affairs and Forestry. This department should develop an implementation strategy and action plan with significant involvement of the provincial Department of Economic Affairs, Environment and Tourism and the Bioregional Coordination Unit (under the auspices of the South African National Biodiversity Institute). Other key stakeholders in the region to include in the implementation are presented in, but the list should be extended to include local and district municipalities and agriculture.

The implementation strategy and action plan should give due attention to the various roles and responsibilities in this complex cross-sector environment. Aspects that should receive attention in the implementation strategy include:

- Development of a cooperative governance framework which would form the building block for the implementation of the conservation plan for the region;
- Capacity (skills and knowledge) required to implement conservation action and to “do the right thing”;
- Financial resource requirements;
- Providing clear definition of roles and responsibilities, and possibly of required institutional and functional design aspects that are currently lacking;
- Problem-solving, negotiation and conflict management skills (this is an inevitable requirement where overlapping responsibilities and conflict of interests are realities); and
- Developing a monitoring and evaluation system, not only for achievement and revision of ecological and conservation targets or objectives, but also for institutional and individual performance measurements.