Waterways Unit
Department of Natural Resources and Environment
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AN INDEX OF STREAM CONDITION: MANUAL FOR CATCHMENT MANAGER'S

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Other publications in this series:

- White, L.J., and Ladson, A.R., 1999, **An index of stream condition: Field manual,** Department of Natural Resources and Environment, Melbourne, April 1999.
- Ladson, A.R., and White, L.J., 1999, **An index of stream condition: Reference manual**, Department of Natural Resources and Environment, Melbourne, April 1999.
- White, L.J., and Ladson, A.R., 1999, **An index of stream condition: Applier's manual,** Department of Natural Resources and Environment, Melbourne (in press – due for release in August 1999).

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1. INTRODUCTION

1.1 Purpose of this manual

This manual is intended primarily for Catchment Management Authority board members, implementation committees, and staff (referred to in this manual globally as ‘CMAs’). It will also be used by the Department of Natural Resources and Environment (NRE), community members and others involved in waterway management.

The Index of Stream Condition (ISC) will be used to assess streams across Victoria in 1999. This manual explains how catchment managers can use the information generated from this ISC application. Following an ISC application, it is expected that catchment managers will find chapter 3 a valuable reference when developing waterway management plans.

This manual assumes that the reader has a basic understanding of the ISC structure (eg. ISC bar chart; sub-indices; indicators; rating tables; frame of reference of each indicator; lowland, and upland reaches). This basic understanding could have been obtained from a presentation on the ISC provided by the NRE, or from a review of the current ISC *Reference Manual* and *Applier’s manual.* A listing of the sub-indices and indicators in the ISC is provided in table 1.1. Some examples of ISC results are given in chapter 2.

Table 1.1 – List of indicators in the ISC

Sub-index	Indicators within sub-index
Hydrology	Amended Annual Proportional Flow Deviation
	Daily flow variation due to change of catchment permeability
	Daily flow variation due to peaking hydro electricity stations
Physical Form	Bank stability
	Bed stability
	Impact of artificial barriers on fish migration
	Instream physical habitat
Streamside Zone	Width of streamside zone
	Longitudinal continuity
	Structural intactness
	Cover of exotic vegetation
	Regeneration of indigenous woody vegetation
	Billabong condition
Water Quality	Total phosphorus
	Turbidity
	Electrical conductivity
	Alkalinity / acidity
Aquatic Life	SIGNAL
	AUSRIVAS

1.2 The need for the ISC

The objectives of waterway management in rural Victoria have evolved in the last few decades. The original objective of most river improvement trusts in the 1950s, 1960s and 1970s was primarily flood and erosion 'control'. The current waterway management objectives of the catchment managers are broader, and typically include the protection and management of the environmental condition (or 'health') of waterways and their surrounds.

To strategically manage waterways in the context of these broader objectives, catchment managers require integrated summary information on current stream condition. In the longer term, this information can be used to identify trends.

The ISC was developed as a mechanism to produce useful information for catchment managers on the environmental condition of streams, to support strategic waterway management. Catchment managers, depending on the objectives for a stream reach, may also require other information.

1.3 ISC objectives

The objectives of the ISC are to:

- benchmark stream condition;
- aid the setting of strategic waterway management objectives;
- provide feedback on the long term effectiveness of waterway management programs; and
- assist CMAs to meet statutory reporting requirements on environmental condition of streams.

To achieve these objectives, it is necessary that the ISC be straightforward and transparent. The ISC was developed to provide an appropriate balance between cost, speed of measurement, accuracy and scientific rigour.

1.4 ISC scope

The scope of the ISC is given below:

Scope of issues: The 19 indicators in the ISC were selected to be the key stream-related environmental parameters across Victoria.

It is expected that the ISC will fulfil one part of a catchment manager's information needs. Depending on regional issues, catchment managers may need to evaluate other indices or indicators:

- that allow the determination of trends relative to other types of objectives (eg. enhancement of recreational opportunities, protection of streamside assets); and
- that allow the determination of trends relative to other more specific environmental objectives (eg. protection of endangered fish species or vegetation associations).

Temporal scope: It is intended that the ISC be measured about every 5 years, except perhaps if there is a major event which causes a sudden and significant change to stream condition (eg. a major flood or a bushfire). The ISC can be used to flag trends in stream condition. There may be some waterway management issues that require a shorter period between measurements. An example of an issue that may require data collection at a different temporal scale to the ISC would be measurement of turbidity and suspended sediment during a flood.

Spatial scope: The ISC has been developed primarily for rural streams. For streams across the lowlands, the ISC is assessed for relatively homogenous reaches: typically 10 – 30 km long. Upland streams (particularly in uncleared areas) that are similar are often grouped together. The spatial scope is similar to *The Environmental Condition of Victorian Streams* (Mitchell, 1990).

Catchment managers may also require collection of data at a different spatial scale. An example of an issue that may require data collection at a different spatial scale would be the assessment of a revegetation program at a works site, or a detailed water quality program to determine the location of major sources of nutrients.

The differences between the ISC and short-term or local performance indicators is discussed in appendix 3.

1.5 Information contained within this manual

This manual contains:

- an example of the outputs from a hypothetical application of the ISC (chapter 2);
- a description of how to interpret and use ISC outputs in strategic waterway management (chapter 3);
- a listing of some waterway management strategies and techniques that could be used to rehabilitate the environmental condition of streams and hence increase ISC scores (appendix 1);
- a discussion of possible links between the Crown Water Frontage Review and the ISC (appendix 2);
- a discussion on the use of the ISC as a short term or local performance indicator (appendix 3); and
- the basis of a press release or brochure on ISC results (appendix 4).

2. OUTPUTS OF AN ISC APPLICATION

The standard outputs from an application of the ISC (at a point of time) are:
- ISC bar charts plotted onto a catchment map;
- a brief written discussion of the outputs;
- 6 photographs of each reach through a modified catchment or 2 photographs of each reach through an unmodified catchment;
- a summary of data gaps in each reach, and major changes in stream condition; and
- a list of other waterway management issues for each reach identified during field data collection.

Outputs from an ISC application for the **hypothetical** Grace River follow. These outputs are used in two examples on how ISC outputs can be used by catchment managers in strategic waterway management in chapter 3.

As background, the catchment of Grace River is illustrated in figure 2.1, and described below.
- The Grace River flows across a floodplain downstream of Jean Dam. Upstream of Jean Dam are upland reaches of small tributaries. Dawn Creek is a lowland stream. Sykes Creek is an upland stream that flows through a narrow valley.
- The catchments of the Grace River downstream of Jean Dam, and Dawn Creek are cleared (figure 2.1). In addition, the local catchment of the downstream end of Sykes Creek (approximately the last two kilometres of stream) is cleared (including some of the streamside zone). The rest of the catchment is uncleared.
- There are no large towns or industrial plants in the catchment. There are a few hundred residents in the township of Mary. There is currently little tourism infrastructure on the river.
- There are two artificial barriers on the Grace River: Jean Dam and Margaret Weir. Jean Dam is operated to provide water to the irrigation districts downstream of Margaret Weir (figure 2.1). There are diversion channels from the Margaret Weir pool. Margaret Weir is typically drowned out at least once per year when the gates are left in during a flood, and the weir gates are removed from the river when irrigators do not require water: between mid autumn and early spring. The water level in Margaret weir pool is quite variable: it varies between 0.8 m and 3.0 m (gauge height) but is currently within the optimal range for boating (1.5 m to 2.0 m gauge height) for on average 20 weeks of the year.
- Because of flow travel time between Jean Dam and Margaret Weir, irrigators order water from Jean Dam about 3 days before they require it. Surplus diversions to the irrigation districts are returned to the lower reaches of Grace River.
- Farming practices in the irrigation district include the application of fertiliser. This has increased nutrient levels downstream of the irrigation districts.
- Although there are no artificial barriers on Dawn Creek, there are pumped diversions.
- Over recent years, the groundwater table has gradually risen in the irrigation districts. Saline groundwater occasionally seeps into channels that return surplus irrigation water to the Grace River.
- Extensive desnagging of the lowland reaches of the Grace River was undertaken by the local river improvement trust between 1950 and 1970 in an attempt to reduce ‘nuisance’ flooding of adjacent farms.

ISC outputs for the Grace River system in 1999 are provided in figures 2.2 and 2.3, box 2.1, and tables 2.1 and 2.2.

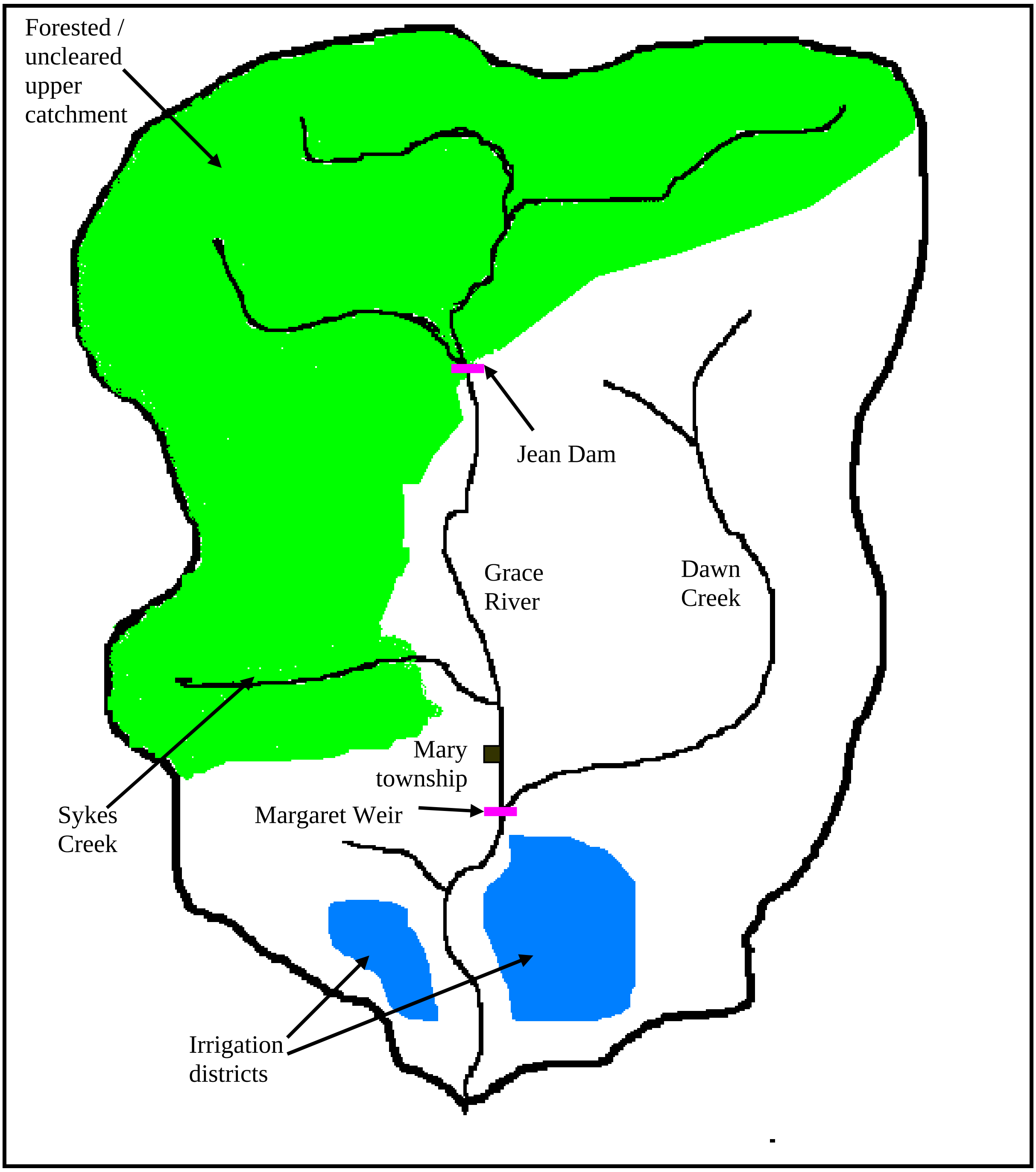

Figure 2.1 – The Grace River system

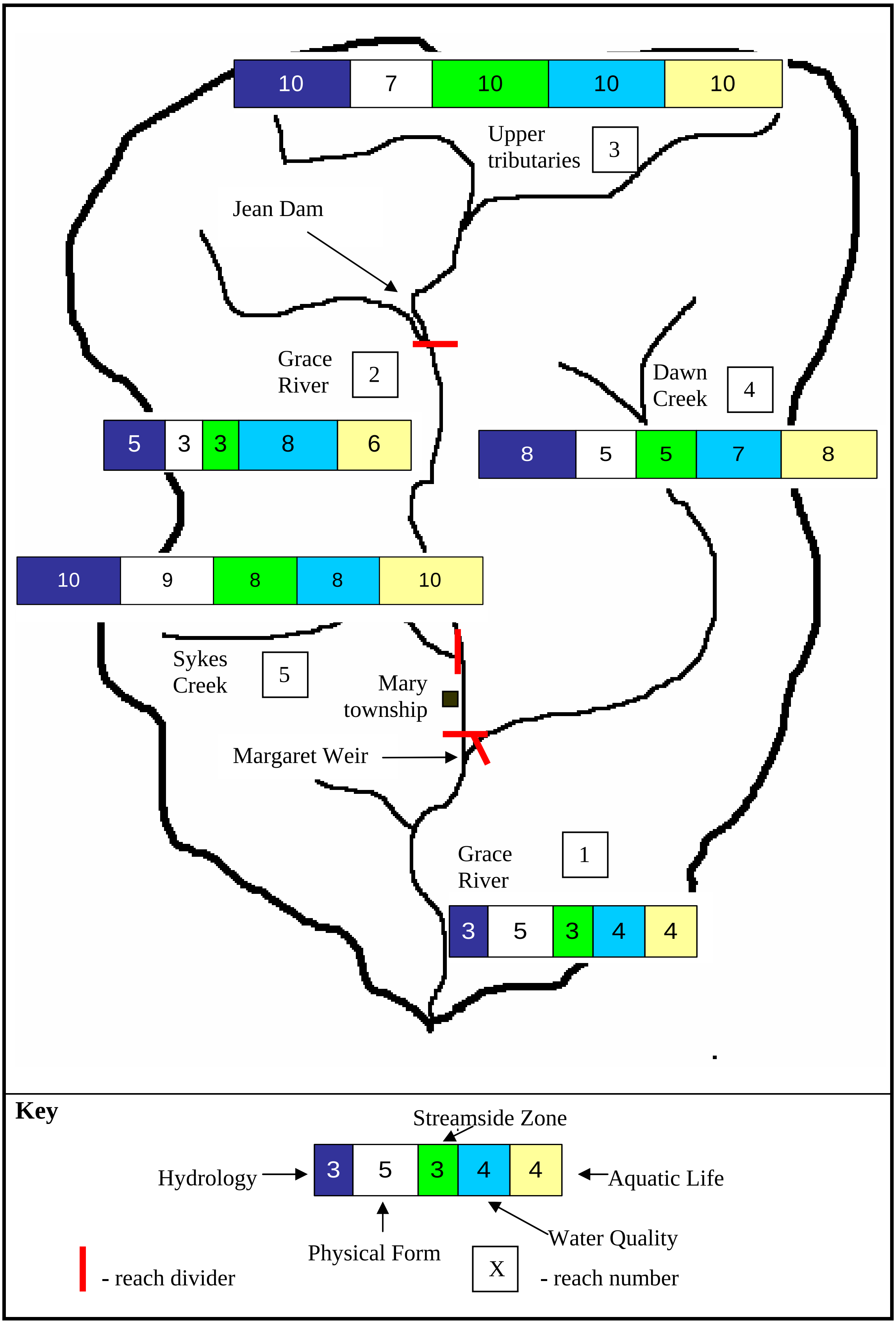

Figure 2.2 – ISC bar charts for Grace River system

Box 2.1 – Brief discussion of ISC outputs for the Grace River system

Data was available to assess every ISC indicator because of the planning of the local CMA two years prior to the ISC application.

For the 5 reaches of the Grace River system, the overall ISC scores ranged between 19 and 47 (ie. from poor to excellent). ISC scores for lowland reaches (1, 2 and 4) through cleared catchments were the lowest.

The **Hydrology Sub-index** was high for the Grace River upstream of Jean Dam, and Sykes Creek. The operation of Jean Dam affects the seasonality of flows in reaches 1 and 2. In addition, irrigation diversions from Margaret weir pool affect the total volume of flow in reach 1. The Hydrology Sub-index score for Dawn Creek was affected slightly by pumped diversions.

Compared to the other sub-indices, the **Physical Form Sub-index** was relatively low for most reaches in the Grace River system. In the upper reaches of Grace River, this is because of Jean Dam acting as an artificial barrier. Further downstream, the relatively low score is because of a combination of desnagging, some channel incision and bank erosion, and (for reaches 2, 3 and 5), that Margaret Weir acts as an artificial barrier to fish migration for some of the year.

Streamside Zone Sub-index scores were relatively low for streams through cleared catchments, and high for those through uncleared catchments. The randomly selected measuring sites for Sykes Creek were all located in uncleared sections of the catchment, which resulted in a high sub-index score. Exotic species (particularly willows) were prominent in the streamside zone of reaches 1 and 2.

The **Water Quality Sub-index** scores were relatively high for most reaches indicating excellent water quality. Water quality was lower for reach 1 than reach 2 because of the returns from irrigation districts containing relatively high concentrations of phosphorus and salinity.

The **Aquatic Life Sub-index** scores were relatively low for reaches 1 and 2, mainly because of a low rating for the AUSRIVAS indicator. As AUSRIVAS rating is (currently thought to be) strongly related to habitat for aquatic macroinvertebrates, these low ratings may be because of the reduction of physical habitat following past desnagging programs.

As explained in the *Field manual*, 2 photographs were taken at each measuring site. Photographs of the downstream reach of Grace River (reach 1) are in figure 2.3.

Figure 2.3 – Photographs of reach 2 of the Grace River

Table 2.1 - Stream management issues identified for the Grace River system during field data collection (see also table 2.2)

Reach	Other management issues observed
1	Cattle grazing on stream banks, black willow, blackberry
2	Cattle grazing on stream banks, black willow, blackberry, Cape Ivy
3	
4	Cape Ivy, blackberry
5	

Table 2.2 - Indicators suggesting a major or extreme difference from natural or ideal conditions, and data gaps, for the Grace River system (full names of indicators are given below the table)

		Hydrology			Physical form				Streamside zone						Water quality				Aquatic life	
Reach	u or l*	AmA PFD	% imp	Hydro-electric	Bank	Bed	Barrier	IPH	Width	LC	SI	Exotics	Regen	Bill.	P	Turb	EC	pH	SIG-NAL	AUS-RIVAS
1	l	■						■		■		■	■	■	■		■			■
2	l							■	■	■		■	■	■						■
3	u						■													
4	l				■															
5	v																			

* - upland or lowland reach

Full names of indicators: Hydrology Sub-index: Amended Annual Proportional Flow Deviation, daily flow variation because of urbanisation, daily flow variation because of peaking hydro-electric stations; **Physical Form Sub-index**: bank stability, bed stability, impact of artificial barriers on fish migration, instream physical habitat; **Streamside Zone Sub-index**: width of streamside zone, longitudinal continuity, structural intactness, cover of exotic vegetation, regeneration of indigenous woody vegetation, billabong condition; **Water Quality Sub-index**: total phosphorus concentration, turbidity, electrical conductivity, pH; **Aquatic Life Sub-index**: SIGNAL, AUSRIVAS

Key to table 2.2:

■ Indicator suggests major or extreme difference from reference conditions

▨ Inadequate data to evaluate indicator (because of the planning of the CMA, there were no data gaps in this particular case)

□ Adequate data to evaluate indicator, and rating indicates there is not a major or extreme difference from reference condition

3. USE OF ISC OUTPUTS BY CATCHMENT MANAGERS

The outputs of an ISC application can be used for:
- reporting stream condition; and
- aiding strategic waterway management.

Discussion of how the outputs from an ISC application (in this case, the hypothetical results for the Grace River system) can be used by catchment managers is provided in the following sections.

3.1 Reporting

A CMA can use ISC outputs to report to:
- the local community (including Landcare groups, angling clubs, environmental groups);
- project funders (eg. the National Heritage Trust); and
- the State Government (the Victorian Catchment Management Council has indicated its support for the ISC as the primary means for reporting stream condition in Victoria).

3.2 Aiding strategic waterway management

Strategically managing a stream reach is an iterative process involving:
1. obtaining of background information on stream condition;
2. developing a vision for the stream reach;
3. identifying broad objectives to achieve the vision for each part of stream system (eg. enhance terrestrial and aquatic habitat, increase stream stability, reduce the impact of point sources of pollution);
4. setting of measurable targets that will lead to the achievement of the objectives;
5. analysing the feasibility of strategies and techniques to meet the targets, and selection of preferred options;
6. designing, implementing and maintaining the preferred options; and, in future planning cycles; and
7. reviewing the performance of the implemented strategies and techniques.

The relationship between the stages is shown on figure 3.1.

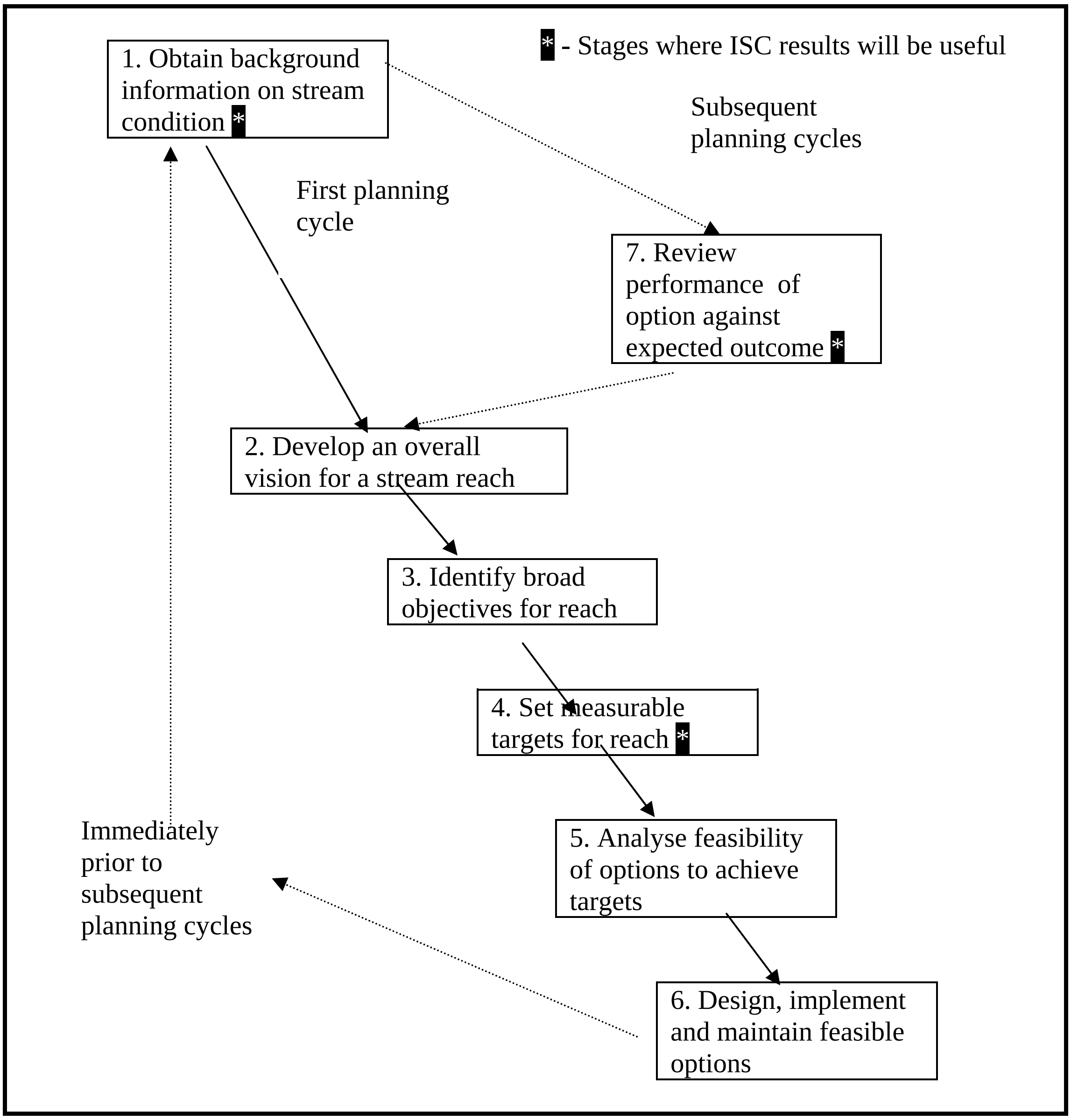

Figure 3.1 – A schematic of the stages of strategic waterway management for a planning cycle of about 5 years (see Lucas et al. 1999 and Ian Drummond and Associates 1995 for similar ideas on planning by catchment managers – full citations are given in the *Reference Manual*)

The role of the ISC in aiding strategic waterway management is to assist in primarily stages 1, 4 and 7 above by providing:

- broad background information on the environmental condition of streams (supplementary information and investigations may be required – depending on the waterway management objectives);
- a framework in which waterway management targets can be set (see box 3.1); and
- a basis for assessing the integrated effect of the implementation of waterway management strategies.

The ISC has been designed to help **flag** waterway management issues on a broad scale. For example, a low Physical Form Sub-index score could alert the catchment managers to a possible problem (eg. the movement of an erosion head along a stream). Catchment managers could then investigate the issue to try to identify the cause of the problem. If the investigation reveals that addressing the cause of the problem is necessary to achieve the vision for the waterway, then an assessment of the feasibility of strategies and techniques should take place.

The ISC was **not** developed to directly enable the identification of what stream management strategy or technique (if any) should be implemented. Therefore, in virtually all cases, further investigations will be required prior to selection of a strategy or technique to manage a stream. The nature of the investigation will be determined primarily by local factors. Selecting a stream management strategy or technique **solely** on ISC outputs and without a more detailed understanding of the issues and management options is generally **inappropriate**.

Some examples of the possible use of the ISC in objective setting are given in box 3.1, together with some other waterway management targets not linked to the ISC. Some other **important** considerations when using ISC outputs are given in box 3.2. Following these boxes are 2 examples of the use of ISC outputs in strategic waterway management:

- example A, where the primary objective is to enhance environmental values; and
- example B where the primary objective is to enhance recreational values.

Some of the strategies and techniques that could be used to rehabilitate streams and ultimately increase ISC sub-index scores in the long-run are given in appendix 1.

Box 3.1 – Some examples of waterway management targets

All **heritage rivers** in a basin shall have **all sub-indices** above 8 by 30 June 2004.^

All streams in a basin shall have a **Streamside Zone Sub-index** above 5 by 30 June 2004.^

All streams in a basin shall have **all sub-indices** above 4 by 30 June 2004.^

A **reach** shall have reduced concentrations of total phosphorus (a total phosphorus indicator rating above 3) by 30 June 2009.^

No streamside assets that conform to the catchment manager’s floodplain management plan will be damaged by stream erosion by 30 June 2004.

An average of 20 000 people per year will use a reach for recreation between 30 June 1999 and 30 June 2004.

Trout cod numbers in a reach will increase by 20% prior to 30 June 2004.

There will be no weed taxa present within 20 m of cultural heritage sites by 30 June 2004.

^ - Waterway management objective directly linked to the ISC.

Box 3.2 – Important considerations when using the ISC in strategic waterway management

Issues to do with the scope of the ISC

1. The ISC has been developed to detect changes in the environmental condition of stream reaches typically 10 – 30 km long over a time period of approximately 5 years. The ISC may not be sensitive enough, or may indeed be overly sensitive, for considerably longer or shorter reaches or for shorter time periods. Other indicators will generally be required to assess the local effectiveness of works in the short term. For further information on this point, please see appendix 3.
2. The focus of the ISC is on major **Victoria-wide** environmental values – other environmental issues may be the most important locally for some reaches (eg. water temperature, pesticide concentrations, acidic drainage). Some other local indicators may be required to complement the ISC outputs.
3. The focus of the ISC is on **environmental** values of waterways: catchment managers may have other objectives of waterway management that need to be considered when developing holistic waterway management programs (eg. recreational access, flood management, protection of some key streamside assets from erosion). Catchment managers may select other indicators to measure performance relative to these other objectives.
4. The ISC provides base information – it does not prioritise waterway management projects – although ISC outputs can be used as input into a prioritisation process. (For example, Melbourne Water Corporation is doing this – S. Heron, pers. comm.).
5. The ISC was primarily developed for rural streams: it will be necessary to modify the ISC if it is to be applied for urban streams.
6. Care should be taken when extrapolating and comparing ISC outputs – for example when comparing ISC outputs for streams in different catchments, or comparing streams of different geometry or character.

Issue to do with the use of indices in general

1. Like other indices (eg. Consumer Price Index), or statistics (eg. the unemployment rate), without a sufficient understanding of the ISC, the outputs can be interpreted in a number of ways by a range of stakeholders, and possibly mis-used. Catchment managers should take due care and ask NRE if in doubt. (Contact Paul Wilson on (03) 9412 4324.)

Cost issues

1. Care has been taken to achieve a satisfactory and useful quality of outputs from the ISC application whilst constraining the overall cost. To ensure satisfactory outputs, an ISC quality assurance and control plan is being implemented (see the *Applier's manual*).
2. The cost of increasing a sub-index score by one point will typically not be the same as the cost to increase the **same** sub-index by a further one point. For example, to increase the Physical Form Sub-index, construction of a fishway over an artificial barrier may cost say $200 000 per point, whereas rock bank stabilisation works may cost millions per point.
3. The cost of increasing each of the 5 **different** sub-indexes by a point will typically not be the same. For example, the cost of increasing the Hydrology Sub-index by one (by, say, purchasing some diversion licences to return water to the environment) will typically be different to the cost of increasing the Physical Form Sub-index by one point (by, say, returning large woody debris to a reach).

Example A: Environmental targets set using ISC

The ISC outputs for the hypothetical Grace River are given in chapter 2. Based on these outputs and its regional catchment strategy, the local CMA developed the vision to manage reach 2 of the Grace River with the primary objective of enhancing its **environmental** values. This vision is articulated in box 3.3.

Box 3.3 –Vision for reach 2 of the Grace River

The reach 2 of the Grace that we envision for the future is a revitalized rural river, flowing with life-sustaining water through regenerated natural habitats, farmland and Mary township. In its upper reaches, sparkling creeks and deep forest pools will flash with fish. Downstream through the farmed lowland, the Grace will meander gently under shade trees, and merge during floods into wetlands alive with waterfowl. As the Grace's water becomes ever cleaner, and snags and riparian vegetation are replenished, many species of fish, mammals, birds and other wild life will return to find their niches within its varied, connected habitats. The community, too, will visit the Grace often to experience its environmental values, through improved access and trails, and will develop a catchment consciousness. The community will feel responsible for the part of the Grace closest to home, while appreciating its living connections to the catchment as a whole.

(Adapted from Metropolitan Toronto and Region Conservation Authority, 1994, *Forty steps to a new Don: The report of the Don Watershed Task Force*, Toronto).

Based on figure 3.1, the 7 stages of strategic waterway management follow.

1. Background information

Between 1950 and 1970, reach 2 (figure 2.2) of the Grace River downstream of Jean Dam was systematically desnagged, to increase channel capacity and opportunities for boating. The streamside zone was also cleared for farming during this period.

ISC outputs show that for reach 2 of the Grace River:

- the instream physical habitat indicator rating is 0 (out of 4);
- the AUSRIVAS indicator rating is 1 (out of 4); and
- the longitudinal continuity and cover of exotic vegetation indicator ratings are 2 (out of 4), so natural replenishment rates of large woody debris are expected to be low.

A detailed investigation by an aquatic biologist has shown that the absence of large woody debris is limiting the abundance and species diversity of the aquatic biota (particularly indigenous fish and macroinvertebrates) of reach 2.

2. Vision

The overall vision for reach 2 is given in box 3.3.

3. Objectives

From box 3.3, the vision for reach 2 of the Grace River is that it be full of indigenous fish, mammals and other wildlife. Subsequently, one of the objectives that the CMA set for the Grace River was 'to restore complexity to instream physical habitat', and decided to use the instream physical habitat and AUSRIVAS indicators in the ISC as measures.

4. Targets

By 31 December 2000: reach 2 of the Grace River system will have a rating for both the instream physical habitat and AUSRIVAS indicators greater than 1 (out of 4).
By 31 December 2010: reach 2 of the Grace River system will have a rating for both the instream physical habitat and the AUSRIVAS indicators greater than 2 (out of 4).
By 31 December 2050: reach 2 of the Grace River system will have rating for both the instream physical habitat and AUSRIVAS indicators greater than 3, and ratings for both the longitudinal continuity and cover of exotic vegetation indicators greater than 2 (out of 4).

5. Assessment of the feasibility of strategies and techniques

A number of techniques exist for artificially replenishing large woody debris. It is not clear which of these techniques is the most appropriate for the Grace River at this time.

In the lowland reaches, the streamside zone currently has inadequate suitable indigenous vegetation to significantly replenish the instream large woody debris. However, if regeneration of indigenous tree species was encouraged, it is likely that natural replenishment of large woody debris to the streams would occur within 50 years.

6. Design, implement and maintain feasible options

The feasible options selected for implementation are listed below.

i) Review literature on reinstating large woody debris in streams, and obtain information from interviews of other stream managers on large woody debris replacement projects in other streams in Australia.
ii) Determine whether fish are prepared to live near artificially reconstructed habitat.
iii) Trial a range of techniques for placing large woody debris in a reach 2 by 31 December 2000.
iv) Select the most efficient method to achieve an ISC rating of 2 (out of 4) for the instream physical habitat in reach 2 of the Grace, and implement the method progressively from 31 December 2000.
v) Work with landholders to create continuous buffers of indigenous tree species to naturally replenish instream large woody debris progressively from 31 December 2000.

7. Review performance of option against expected outcome

Review progress towards the achievement of the objectives when the ISC is implemented (about every 5 years).

Example B: Environmental safeguards set using ISC

The ISC outputs for the hypothetical Grace River are given in chapter 2. Based on a different (hypothetical) regional catchment strategy to that in example A, the local CMA developed the vision to manage reach 2 of the Grace River by enhancing its **recreational** values whilst maintaining a minimum environmental condition expressed in terms of the ISC. This alternative vision for reach 2 is given in box 3.4.

Box 3.4 – An alternative vision for reach 2 of the Grace River

The reach 2 of the Grace that we envision for the future is a very popular and aesthetic river. Mary township will become known as the best boating and fishing resort throughout the year in our part of Victoria. This reach will have many facilities along it, including boat ramps, paddlesteamers and a small marina. The adjacent floodplain will also have many popular facilities, including many open parks, golf courses and lawn tennis courts. To maximise the enjoyment of these facilities, the water level within reach 2 of the Grace River will be maintained within a narrow range by Margaret Weir. The banks of the river will be stable (particularly near boat ramps and jetties) and lined with shady, safe and beautiful weeping willows. Indigenous fish of legal size will be caught in the river at all times of the year.

1. Background information

As shown on figure 2.2, Jean Dam is as the upstream end of reach 2, and Margaret Weir is at the downstream end. The water level at the township of Mary is responsive to gate settings at Margaret Weir, releases from Jean Dam, evaporation from the Margaret Weir pool and irrigation diversions. Often during hot weather, the water level in Margaret Weir is drawn down below levels that are needed for easy access to the marina. The gates of Margaret Weir are removed when irrigators are not diverting water.

ISC outputs show that for reach 2 of the Grace River the instream physical habitat indicator rating is 0 (out of 4), and the Hydrology Sub-index score is 5 (out of 10).

2. Vision

From box 3.4, that this reach of the Grace be utilised extensively by recreationists, particularly fishers and boaters.

3. Objectives

Based on this vision, two of the targets that the local CMA set for reach 2 of the Grace River were:

- to maintain the water level for the Grace River at the township of Mary between 1.5 m and 2.0 m gauge height for the whole year; and
- to improve fish habitat by increasing the instream physical habitat indicator to 2 (out of 4) (without increasing the risk of damage to boats).

Other targets that the local CMA set for reach 2 include environmental safeguards expressed in terms of the ISC,

- to maintain the Hydrology Sub-index at greater or equal to 3 (out of 10); and
- to maintain the impact of artificial barriers on fish migration indicator at greater than or equal to 2 (out of 4).

4. Targets

By 31 December, 2000: That the water level at Mary be maintained within 1.0 m and 2.5 m for an average of 40 weeks per year whilst satisfying environmental safeguards.
By 31 December, 2010: That the water level at Mary be maintained within 1.3 m and 2.2 m for an average of 45 weeks per year, and that the instream physical habitat indicator will be 1 whilst satisfying environmental safeguards.
By 31 December, 2050: That the water level at Mary be maintained within 1.5 m and 2.0 m for an average of 50 weeks per year, and that the instream physical habitat indicator will be 2 (out of 4) whilst satisfying environmental safeguards.

5. Assessment of the feasibility of strategies and techniques

The strategies and techniques considered by the CMA are summarised below.

i. **Change rules for operation of Jean Dam.** If more airspace was maintained in Jean Dam, then the frequency of flooding of the floodplain recreational facilities would be reduced. More uniform releases from Jean Dam would also make it easier to maintain the water level at Mary township within the target range. However, increased airspace in Jean Dam would mean less security of supply for irrigators – which is likely to meet resistance from local irrigator groups. A water allocation process would be required to change the current rules for airspace in, and release from Jean Dam. As a Bulk Water Entitlements process has recently been concluded, it is unlikely that a new process could be instigated in the short term.

   Detailed hydrologic modelling analysis indicated that changing the operating rules of Jean Dam to increase airspace and make releases more uniform would reduce the Hydrology Sub-index below 3 unless two Spring floods (which generally last less than a week in the Grace River system) were passed per annum.

ii **Change rules for operation of Margaret Weir**. At present, the weir gates are removed for some of the year, and the weir is drowned out at other times of the year. An alternative operating rule would be that the gates were left in except when floods are being passed from Jean Dam. Although this alternative operating rule would reduce the opportunities for fish passage, it would not reduce the impact of artificial barriers on fish migration indicator score as fish passage would still be provided for some of the year during floods (the current indicator rating is 2. This option is feasible.

iii) **Reduce diversions when evaporation is high**. Normally, the demand for irrigation water is highest when the temperature is hot and evaporation is high. To maintain an adequate water level for the recreationists, diversions could be restricted during hot weather. This strategy is likely to be unpopular as irrigators order water with the expectation they will receive it on time. This option is unlikely to feasible.

iv) **Fish habitat enhancement using large woody debris.** Removal of large woody debris has significantly reduced the risk of damage to boats and recreationists (particularly water skiers). If any large woody debris were put back, it would either have to be visible under all conditions to boaters or be deep enough so as not to be a threat to boats. This option is unlikely to be feasible.

v) **Artificial fish habitat enhancement.** Artificial habitat enhancement (perhaps using concrete pipes) has the advantage over large woody debris that it is easier to ensure all of the habitat is lower than the bottom of boats. As the materials used could be denser than wood, it is also less likely to get washed away in floods. However, it would be necessary to determine whether the fish were prepared to use this artificial habitat.

6. Design, implement and maintain feasible options

The local CMA chose to implement the following strategies:

i) To construct an effective fishway on Margaret Weir, so the changes to operation of Margaret Weir would not hinder fish migration.

ii) To lobby for a review of the operating rules of Jean Dam and Margaret Weir by a committee comprising representatives of the CMA, Mary Township Tourism Association, the local rural water authority, environmentalists, irrigators and recreationists.

iii) To trial placement of artificial habitat, and to measure its durability and the response of fish to it over three years.

7. Review

The CMA will review progress towards the achievement of the targets each 5 years using the ISC and the other indicators for which targets were specified (eg. number of weeks that water level at Mary township is within the target range).

APPENDIX 1 – SOME WATERWAY MANAGEMENT STRATEGIES AND TECHNIQUES THAT COULD BE USED TO INCREASE ISC SCORES

Some strategies and techniques that could be used to rehabilitate streams and hence increase ISC scores related to the:

- Hydrology Sub-index are given in box A1.1;
- Physical Form Sub-index are given in box A1.2;
- Streamside Zone Sub-index are given in box A1.3;
- Water Quality Sub-index are given in box A1.4; and
- Aquatic Life Sub-index are given in box A1.5.

It is important that catchment managers realise that these strategies and techniques should not be implemented just on the basis of ISC outputs. These ISC results just flag that there may be stream management issues, they do not indicate their cause. Further investigations will be required to identify why the condition of a stream is degrading and to assess the feasibility of options for management.

Box A1.1 – Some strategies and techniques related to Hydrology Sub-index that could rehabilitate streams

Increasing the Hydrology Sub-index score would involve modifying the quantity and timing of the existing flow regime to closer to the natural flow regime.

1. For regulated streams, increase the **quantity** of water available to the environment by:
- participating in the bulk water entitlements process and undertaking the development of water allocation plans;
- purchasing water entitlements; and
- lobbying Government to increase allocations to the environment.

2. For regulated streams, make the **timing** of release more consistent with the natural flow regime by:
- encouraging irrigators to not to divert during some periods;
- changing release rules (eg. ‘transparent / translucent dam operations’);
- changing pricing: investigate the feasibility of developing a pricing regime for water that provides incentives for irrigators at the downstream end of a stream to use a greater quantity of water in Spring, and less in Summer and Autumn. This pricing regime may stimulate research into suitable crops for this watering regime; and
- changing delivery times: investigate the feasibility of implementing a policy limiting the proportion of each irrigator’s allocation that can be provided in Summer and Autumn.

3. For unregulated streams affected by diversions bring flows more in lie with natural regime by:
- being involved in the development of a streamflow management plan;
- changing water extraction timing to protect low flows ie. encouraging high flow diversions on limits on extraction during low flows;
- ensuring that water trading leads to reductions in water extraction in overallocated or ‘stressed’ streams;
- measuring and controlling diversions; and
- ensuring that a stream is not over allocated.

4. *(For peaking hydro stations)* re-negotiate hydro power station agreements so that pulsing of release does not occur during any day. (Some compensation to hydro power station owners may be required.)

Box A1.2 – Some strategies and techniques related to Physical Form Sub-index that could rehabilitate streams

1. Develop bed and bank management strategies in the context of a geomorphic understanding of a stream. (Without an understanding of the geomorphic context, implementation of bed and bank stabilisation strategies is risky.) Implement bed and bank stabilisation strategies (including engineering works, revegetation) using current design guidelines.

2. Exclude stock from streams in nearly all circumstances. (The only exception may be if stock are necessary in weed control – and the grazing is very light.)

3. Construct, operate and maintain effective fishways.

4. Replenish large woody debris in streams using indigenous species.

5. Limit the number of avulsions (breakaways) that occur.

6. Limit the maximum rate of drawdown downstream of headworks (eg. dams).

7. Reduce the total stream power acting on a river channel during a year.

Box A1.3 - Some strategies and techniques related to Streamside Zone Sub-index that could rehabilitate streams

1. Exclude stock totally from the waterway in nearly all circumstances. Use appropriate fencing (taking into account the amount of work required to restore the fence following a flood).

2. Construct stock watering points that will be stable in the long-run (eg. not on the outside of meander bends). Ensure that the width of watering points is less than that of a 'significant gap' as defined in the ISC (10 m).

3. Ensure appropriate management of Crown water frontages.

4. Develop and implement strategies to control noxious and environmental weeds along Crown water frontages.

5. Increase the quantity of indigenous species of vegetation in the streamside zone by using techniques appropriate for the local conditions, perhaps in accordance with a riparian revegetation strategy. Specific techniques may include:
   - planting seedlings;
   - fostering natural regeneration: creating conditions where indigenous species can out compete exotic species (eg. weed control); and
   - direct seeding (where there a seedbed of indigenous species is not present).

6. Increase the width and quality of fringing vegetation around wetlands.

7. Reduce pollutants (eg. effluent from dairy sheds) entering wetlands.

Box A1.4 – Some strategies and techniques related to Water Quality Sub-index that could rehabilitate streams

1. Undertake phosphorus and sediment monitoring programs to detect sources of nutrients and turbidity (eg. in conjunction with Waterwatch).

2. Treat, or encourage other stakeholders to treat, **point** sources of nutrients and sediment, eg.
   - sewage treatment plants (eg. by building additional treatment ponds);
   - drains and returns from irrigation diversions (eg. by constructing small wetlands near the downstream end of drains to polish' nutrients and catch sediment);
   - roads (eg. by sealing roads); and
   - bed and bank erosion (by implementing appropriate bed and bank stabilisation methods).

3. Treat, or encourage other stakeholders to treat, **diffuse** sources of nutrients of sediment, eg.
   - farms (by increasing the width of riparian buffer strips, particularly along drainage lines lateral to the main stream, encouraging farmers to implement practices that retain nutrients and soil on their farms; and
   - forestry operations (eg. by ensuring that the Code of Forest Practices or Regional Forest Agreements are implemented).

4. Operate salinity mitigation schemes so that saline water does not return to the river as frequently.

Box A1.5 – Some strategies and techniques related to Aquatic Life Sub-index that could rehabilitate streams

Implementation of the activities to improve other Sub-index scores may also improve the Aquatic Life Sub-index score. In addition, those activities listed below specifically relate to improving the Aquatic Life Sub-index score.

1. Develop an aquatic biota management strategy with input from aquatic ecologists.

2. Ensure that the water temperature is not significantly different to that under natural conditions (particularly downstream of thermal power stations or deep reservoirs).

3. Ensure that concentrations of pollutants are not above critical levels.

APPENDIX 2 – LINKS BETWEEN CROWN FRONTAGE REVIEW AND THE ISC

In 1998, each CMA was assigned the task of undertaking a Crown Water Frontage Review (CWFR) throughout its district. This CWFR would give regard to 'attributes' of frontages, some which are similar to ISC indicators. By December 1999, the Index of Stream Condition (ISC) will be applied across Victoria. It is possible that some links could be established between these two projects based on regional needs. This appendix has been prepared for the CMAs to provide some thoughts on possible links between the projects.

The objectives of CWFR and ISC projects are listed in box A2.1. There are some significant differences. The remaining sections of this paper are:

- an overview of key similarities and differences between the two projects (section A2.1); and
- identification of some possible links between the projects (section 2.2).

Box A2.1 - Objectives of the CWFR and ISC

The objectives of the CWFR are to:

- identify and categorise the values associated with Crown water frontages in the region and assess the condition of the frontages in strategic terms;
- identify land uses and/or management practices of Crown water frontages and abutting land which threaten the identified values and uses;
- assess the effectiveness of management practices including licensing arrangements in protecting these values; and
- where appropriate, recommend changes to current management practices and/or licensing arrangements and conditions to achieve the sustainable use and management of Crown water frontages and the protection of their conservation, recreation, cultural and other values and uses.

The objectives of ISC project are to:

- benchmark stream condition;
- aid in objective setting for catchment management;
- judge the effectiveness of management intervention, in the long term, in managing and rehabilitating stream condition;
- provide feedback to catchment managers as part of an adaptive management process; and
- indicate long term performance by catchment managers.

A2.1 Overview of key similarities and differences between the CWFR and ISC

An overview of the key similarities and differences between the CWFR and ISC is given in the following sections:

- scope of issues;
- temporal scale;
- spatial scale; and
- field sampling protocol.

Scope of issues. The scope of the CWFR is broader than the ISC. The CWFR involves measurement of stream condition, assessment of a range of values (including environmental, recreational, cultural, landscape values), identification of threats to the values, and an assessment of the effectiveness of different management options aimed at protecting the values. The ISC involves an assessment of stream condition (not values, threats etc) associated with environmental value (not other values: cultural, recreational, landscape etc).

Temporal scale. The temporal scale of the CWFR and ISC are the same. The CWFR and ISC will each take place about every 5 years.

Spatial scale. The spatial scale of the ISC is broader than the CWFR. The CWFR predominantly focuses on streamside land, to a level of detail of individual licenses. The ISC focuses on the condition of the stream, streamside land, and (to a limited extent) the catchment (both laterally across the floodplain and longitudinally along the valley) for reaches typically 10 – 30 km in length. For example, measures of change to hydrology and water quality are included in the ISC but are unlikely to be considered in a CWFR. However, as shown in table A2.1, there is a lot of commonality between some attributes of the CWFR and the Physical Form and Streamside Zone sub-indices of the ISC.

Field sampling protocol. The CWFR process includes a ground truthing stage, during which a representative sample of frontages is selected. The SRG have decided to randomly select field measuring sites rather than to attempt to select ‘representative’ measuring sites. This decision was based on statistical analysis that showed that values of indicators assessed at measuring sites thought to be representative could actually be considerably different from the average indicator values for the reach (see appendix 3 of the *Reference Manual*).

Table A2.1 – Similar ISC indicators to attributes of the Crown Water Frontage Review

Core attribute, or regional attributes selected by Wimmera CMA (shaded)	Similar Index of Stream Condition indicators (comments)
Vegetation along stream	Width of streamside zone (which extends to the next land-use – which may be within or beyond the border of the Crown water frontage. For example, in the ISC the width of streamside zone in an uncleared catchment with 1 km from the stream to the ridge with a frontage 20 m wide would be 1 km).
Links with areas of native vegetation	Width of streamside zone (see comment above).
Remnant native vegetation	Structural intactness, cover of exotic vegetation and regeneration of indigenous woody vegetation. (In the ISC, remnant and revegetated streamside zones would be assessed in the same way.)
Species or communities listed under the Flora and Fauna Guarantee Act	-
Species listed as vulnerable, rare or endangered	-
Sites of Botanical Significance	-
Heritage River Status	-
Site of Cultural Significance	-
Site of Geomorphological Significance	-
Linked or adjacent wetlands	Billabong condition (which is assessed for the catchment associated with a reach)
Level of weed infestation	Cover of exotic vegetation
Bank stability and bank erosion levels	Bank stability (Also bed condition could be incorporated)
Longitudinal vegetation profiles	Longitudinal continuity
Presence of major evidence of intervention	-

A2.2 Identification of some possible links between the CWFR and ISC

Some of the possible links between the CWFR and ISC projects are listed below.

1. Some of the ISC indicators and data could be used in the assessment of some of the attributes in the CWFR (particularly those in table A2.1.)
2. In the ISC methodology, reach selection involves dividing streams into relatively homogeneous reaches (although there will be typically be some variability of Physical Form and Streamside Zone Sub-indices within a reach). In the CWFR process, the ISC reach selection could be referred to when deciding where the representative sites should take place.
3. There may be an opportunity to collect additional field data for use in the CWFR during the field data collection phase the statewide ISC application.
4. Some resources could be shared between both projects (eg. staff for data analysis, GPS, GIS, digital camera).
5. In the long run, ISC results could be used to assess the effectiveness of alternative frontage management strategies at a broad scale.

APPENDIX 3 – THE USE OF THE ISC AS A SHORT TERM OR LOCAL PERFORMANCE INDICATOR

Some catchment managers have inquired as to whether ISC results could be used as a short-term or local performance indicator. Some thoughts on this issue are provided in this appendix.

The ISC provides a broad measure of the environmental condition of reaches of stream 10 – 30 km long. It will be used as a performance indicator at a long term strategic level. Most indicators in the ISC may not be an effective measure of management performance in the short term (annual time periods) nor of local programs due to differences in objectives. Differences between annual performance measures and the ISC are discussed in table A3.1.

In general, the ISC should not be used as an ‘off the shelf’ short term or local performance index. Specific performance indicators that are more detailed may be required to replace or supplement the ISC.

As an example, the East Gippsland Catchment Management Authority is currently undertaking a large program of stream management works following the severe June 1998 floods. The EGCMA has decided to use a subset of ISC indicators and some additional indicators to assess the short-term environmental response to the works (R. Candy, pers. comm.). The ISC indicators that are being used are: bank stability, bed stability, instream physical habitat, width of streamside zone, longitudinal continuity, cover of exotic vegetation, structural intactness, and regeneration of indigenous vegetation. The supplementary indicators that are being used include: height of bare bank, length of unstable bank, number of trees planted, and quantity of rock placed.

CMAs can access more ideas on indicators from a report titled *Planning and Reporting Framework* (Ian Drummond and Associates, 1995). A copy of this report is available through the NRE.

Table A3.1 - Differences between annual performance measures and the ISC

ISC	Annual performance indicators	Comment
An absolute measure is important. The objective of the sum of the measurements is to accurately define the current condition of the stream.	Absolute values of an indicator are not as important as relative values. Measurement of change is the objective. It is better to know the magnitude and direction of change than to find out accurately current stream condition.	Measures of change need to be more sensitive than measures of condition. This applies at a spatial and temporal scale.
Measures departure of stream condition from some defined reference state (natural or ideal).	Should provide a measure that is closely linked to targets of managers. There is no point measuring something that is unimportant to managers.	Condition is only one aspect that managers consider when setting objectives. Management effectiveness should be judged against management intention.
Measurements are required over large spatial scales to assess *statewide* condition.	For annual performance indicators measurements should be at approximately the same spatial scales as the management targets or actions.	The spatial scale of performance indicators needs to match the spatial scale of the management targets. For more ‘strategic’ or ‘outcome’ performance indicators larger scale measurements are appropriate. These performance indicators are reported over longer time scales.
Statewide assessment requires large space scales. This means larger time scales (> 1 year) are generally required before management induced changes are seen.	Annual performance indicators should be focused on annual targets.	The time scale of performance indicators needs to match the time scale of the management targets. Longer term measurements are appropriate for longer term targets.

APPENDIX 4 – BASIS OF A PRESS RELEASE OR BROCHURE ON ISC RESULTS

A press release or brochure on ISC results could be prepared to:

- report that an ISC application has recently been undertaken;
- state what the ISC is;
- summarise the results;
- give an example of how the results will be used in strategic waterway management; and
- let the reader know how to access more information.

An example of a press release based on the Grace River example is given in box A4.1.

Figures that could accompany the text in the press release or brochure could show:

- the CMA district;
- photographs of a reach, and ISC scores for the reach;
- summary charts of results over the whole CMA district, or over Victoria.

Box A4.1 – Example of a press release referring to ISC results

The report card on the condition of the Grace: it's a mixed bag

The Newton CMA has recently completed a survey of the health of streams in the Grace River catchment. This survey was conducted using the innovative Index of Stream Condition approach.

> Report than an ISC application has been undertaken

The CMA board chair, Ms. Jenny Jones, said 'the Index of Stream Condition is a newbroad-scaled stream assessment tool. It summarises the condition of a stream reach with regard to flow, erosion, habitat for fish, streamside vegetation, water quality and aquatic bugs'.

> State what the ISC is

The results for the Grace River system show that the current environmental condition of the:

- Grace River upstream of Jean Dam and Sykes Creek is excellent;
- Dawn Creek and the Grace River between Jean Dam and Margaret Weir is marginal; and
- Grace River downstream of Margaret Weir is poor.

> Summarise the results

Ms. Jones went on to discuss how the survey results will be used by the Newton CMA. 'The survey will provide important information on which to base future waterway management plans. As an example, the survey highlighted that the instream physical habitat (which is predominantly snags) in the Grace River between Jean Dam and Margaret Weir is highly disturbed and is unlikely to be naturally replenished by streamside vegetation. This loss of habitat may be a major contributor to the dramatic decline of the endangered Grace cod in this stream reach. Rectifying this situation will now be a priority in the forthcoming Grace River management plan. Community input during the development of this plan is invited.'

> Give an example of how the results will be used in strategic waterway management

Further information on the survey results or the Grace River management plan can be obtained by contacting John Citizen on (03) 5555 5555, or by visiting the catchment managers web site *(address would be provided).*

> Let the reader know how to access more information