E A R T H T E C H

Wimmera Catchment Management Authority

Geomorphic Categorisation and Stream Condition Assessment of the Wimmera River Catchment

Section Three: Stream Condition Assessment

Jobs 2901049.008 & 2901049.009

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Introduction

This purpose of this section of the report is to provide an understanding and summary of the current stream condition in the Wimmera River catchment. In order to create an overall picture, data used in this section is a combination of the 1999 Index of Stream Condition (ISC) assessment carried out by the Wimmera Catchment Management Authority (WCMA) and the 2002 ISC data collected by Earth Tech for this project. Aerial photographs of the catchment were also assessed, as detailed in the Approach section.

Approach

The approach to the project included analysis of aerial photographs of the catchment, a review of existing ISC information and completion of ISC assessments of 51 sites in the Wimmera River catchment.

Aerial photographs

Digital aerial photographs were provided by the Wimmera CMA for use in assessment of the geomorphic form and overstorey vegetation cover in selected waterways in the Wimmera River catchment. 3288 km of waterway of third order or greater was assessed for overstorey vegetation cover. Categories included sparse overstorey vegetation (<20%), patchy overstorey vegetation (20-80%) or continuous overstorey vegetation (>80% cover).

Existing information – 1999 ISC

Data from the 1999 assessments of 42 sites in the Wimmera River was provided by the Wimmera CMA for analysis in this project. After the data was assessed, 37 sites were found to have sufficient data for inclusion in this project.

Field assessments – 2002 ISC

Between Monday November 11th and Wednesday November 20th, 52 waterway sites of approximately 430 m were visited in the Wimmera River catchment. An ISC field assessment of the Streamside Zone and Physical Form sub-indices was carried out at each of these sites.

Aerial Photograph Interpretation of Overstorey Vegetation Cover

Background to Aerial Photograph Interpretation

The aerial photograph interpretation included an assessment of the percentage of overstorey vegetation cover along each waterway in the Wimmera River catchment of third order or greater. The three ratings were based on the ISC structural intactness classes, being <20% (sparse), 20-80% (patchy) and >80% (continuous) (Ladson & White 1999a, b & c). Where there was a dam, lake, reservoir or other waterbody, the overstorey vegetation cover was scored as 'Other'. The results of the assessment are shown in the map titled 'Overstorey Vegetation Cover and Index of Stream Condition Sites' in Appendix I.

The aerial photography for the Wimmera catchment existed in a digital format for the majority of the upper catchment (see Figure 2.1). The resolution of this digital imagery allowed the aerial photographs to be viewed at a scale of 1:5000 in the upper Wimmera catchment.

The lower part of the catchment was assessed using a variety of hard copy aerial photographs. The scale of these photographs varied, usually being at a scale of 1:20 000. The hard copy photographs were not available as stereo pairs, which limited the level of interpretation possible. This was particularly evident in the Wimmera River up- and downstream from Dimboola, where the Continuous Anabranching Fine Grained system included 94.9 km of anabranches to the main Wimmera River channel. These sections of waterway were not assessed for overstorey vegetation coverage and are marked on the map as 'Overstorey Vegetation Cover Not Assessed'.

Method of Aerial Photograph Interpretation

The three ratings used in aerial photograph interpretation of overstorey vegetation cover are summarised below. Assessment was based on the woody vegetation in both the riparian zone and floodplain of each reach.

Continuous Overstorey Vegetation

Figure 3.01 - Continuous Overstorey Vegetation (>80% Cover)

Table 3.01: Description of Continuous Vegetation

Longitudinal Continuity of woody vegetation	Width of woody vegetation	Percentage Cover of woody vegetation
>80% continuous woody vegetation in riparian zone	Riparian & Floodplain with continuous woody vegetation	>80% cover woody vegetation (continuous)

Patchy Overstorey Vegetation

Figure 3.02 - Patchy Overstorey Vegetation (20-80% Cover)

Figure 3.03 - Patchy Overstorey Vegetation (20-80%Cover)

Table 3.02: Description of Patchy (20-80%) Vegetation

Longitudinal Continuity of woody vegetation	Width of woody vegetation	Percentage Cover of woody vegetation
Vegetation limited to riparian zone and essentially continuous		
50-80% continuous vegetation in riparian zone	Streamside Zone width at least equal to baseflow width	50 – 80% cover woody vegetation (patchy)
Vegetation patchy and extends beyond riparian zone		
20-50% continuous vegetation in riparian zone	Riparian & Floodplain Streamside Zone width at least 3 times baseflow width	20-50% cover woody vegetation

Sparse Overstorey Vegetation

Figure 3.04: Sparse Overstorey Vegetation (<20% Cover)

Table 3.03 Description of Sparse Vegetation (<20%Cover)

Longitudinal Continuity of woody vegetation	Width of woody vegetation	Percentage cover of woody vegetation
Absent - 20% Continuous	Limited in Riparian zone, sparse in floodplain. Streamside Zone width narrower than baseflow width	<20% cover woody vegetation (sparse)

Using digital photographs provided by the Wimmera CMA in ArcMap 8.1 and hard copy aerial photos provided by the then Department of Natural Resources and Environment, Horsham, 3288 km of waterway in the Wimmera River catchment was assessed for overstorey vegetation coverage. This excluded first and second order streams. There were 6923 segments of waterway, ranging in length from 0.5 m (continuous anabranching fine grained section in the lower catchment) to 9.2 km (Natimuk Creek). The mean length of segments was 474.9 m.

Once each stream segment was assigned an overstorey vegetation coverage, an assessment of the proportion of the catchment within each range of vegetation coverage was carried out This was undertaken with the aid of ArcMap 8.1 and Excel. The results are presented in the next section.

Results of Aerial Photograph Interpretation

The 3288 km of waterway assessed in the aerial photograph interpretation was analysed and is summarised in Tables 3.04 and 3.05. The five categories are:

- Dams & Weirs
- Anabranching Fine Grained (lower catchment only)
- Continuous (>80%)
- Patchy (20-80%)
- Sparse (<20%)

Table 3.04: Summary of statistics of Stream Order vs Overstorey Vegetation Cover.

Stream Order							
	Dams & Weirs	AFG	>80%	20-80%	<20%	Total Length (km)	Percentage
3	27.8	n/a	259.5	346.0	905.1	1538.4	46.8%
4	19.3	n/a	108.3	181.8	377.4	686.8	20.9%
5	8.4	n/a	41.1	168.8	196.5	414.9	12.6%
6	0	n/a	10.6	74.7	79.7	165.1	5.0%
7	3.5	n/a	10.2	36.8	33.9	84.5	2.6%
8	0	94.9	22.3	243.7	37.4	398.3	12.1%
Total Length (km)	59.0	94.9	452.2	1051.9	1630.0	**3288 km**	
Percentage length	1.8%	2.9%	13.8%	32.0%	49.6%		

*AFG is Stream Category 'Anabranching Chain of Ponds'.

The information in Table 3.04 provides an good summary of the vegetation coverage of waterways in the Wimmera River catchment. Of the 3288 km of waterways in the Wimmera River catchment that are of 3rd order or greater, only 13.8% have excellent (>80%) vegetation cover. In the catchment, approximately 32% of the total waterway length has moderate (20-80%) vegetation cover, whilst 49.6% of the 3rd order and greater waterways have poor (<20%) vegetation cover.

The third order streams make up almost half of the waterways in the catchment that are greater than second order. Importantly, 27.5% of the waterways of third order or greater are third order streams with <20% vegetation cover.

59 km (1.8%) of the length of waterway of the streams of 3rd order or greater were assigned as a weir or dam.

There is also 94.9 km (2.9%) of waterway in the lower Wimmera Catchment that is shown on the Vegetation Coverage map, Appendix I, as not having been assessed. This section of the Wimmera River catchment is located both upstream and downstream from Dimboola. These sections of waterway have been assigned a Stream Order of 8 and Stream Style of 'Anabranching Fine Grained' (AFG). The main Wimmera River channel was assessed for vegetation coverage with the aid of aerial photographs and field confirmation. However, as the aerial photographs were at a 1:20 000 scale, it was very difficult to also assess the vegetation cover in the numerous anabranching channels.

Table 3.05 (following page) shows the breakdown of waterway length in the Wimmera River catchment according to stream category. Of the length of waterways assessed as 3rd order or greater, 22.4% is intact valley fill and 22.0% is incised alluvial discontinuous. Of the length of waterway assessed as intact valley fill, 57.9% has an overstorey vegetation cover of <20%. This means that 13.0% of the Wimmera River catchment waterways of 3rd order or greater is intact valley fill with sparse vegetation coverage.

Table 3.05: Summary of statistics of Stream Style vs Overstorey Vegetation Cover.

	Stream Type	Constructed Feature	>80%	20 – 80%	<20%	AFG	TOTAL LENGTH (km)	%
Confined	Steep Headwater	0	6.8	0	0	0	6.8	**0.2%**
	Confined	0	136.6	13.3	6.8	0	156.7	**4.8%**
	Gorge	0	6.7	0	0	0	6.7	**0.2%**
Partly Confined	Partly Confined 1	0	15.8	15.3	0	0	31.1	**0.9%**
	Partly Confined 2	0	4.4	23.8	22.0	0	50.2	**1.5%**
	Partly Confined 3	0	7.0	42.2	82.1	0	131.3	**4.0%**
Alluvial Continuous	Alluvial Continuous 1	0	32.9	276.6	201.1	0	510.6	**15.5%**
	Alluvial Continuous 4	0	62.0	180.9	94.1	0	337	**10.2%**
	Alluvial Continuous 5	0	0.1	75.1	76.0	0	151.2	**4.6%**
	Anabranching Fine Grained	0	7.4	121.1	18.0	94.9	241.4	**7.3%**
	Cut & Fill	0	0.9	0.2	7.0	0	8.1	**0.2%**
Alluvial Discontinuous	Intact Valley Fill	0	166.3	144.0	427.0	0	737.3	**22.4%**
	Chain of Ponds	0	0	0.2	19.5	0	19.7	**0.6%**
	Floodout	0	0	0.5	10.4	0	10.9	**0.3%**
	Incised Alluvial Discontinuous	0	3.5	113.6	606.2	0	723.3	**22.0%**
	Discontinuous Anabranching Chain of Ponds	0	0	38.7	0	0	38.7	**1.2%**
Constructed Features	Dam	46.4	0	0.1	3.3	0	49.8	**1.5%**
	Weir	12.6	0	0.4	11.4	0	24.4	**0.7%**
	Constructed channel	0	1.9	5.8	43.3	0	51	**1.6%**
	Other	0	0	0	1.7	0	1.7	**0.1%**
	TOTAL LENGTH (km)	59.0	452.2	1051.9	0	94.9	**3288 km**	
	Percentage	**1.8%**	**13.8%**	**32.0%**	**49.6%**	**2.9%**		

The information in Table 3.05 shows that, in the Wimmera River Catchment, 5.2% of waterways are confined, 6.4 % are partly confined, 37.8% are Alluvial Continuous, 46.5% are Alluvial Discontinuous and 4.2% are Constructed features.

In the confined reaches, almost 90% of the length has >80% overstorey vegetation cover. In the partly confined reaches, almost 50% of the length has <20% overstorey vegetation cover and 38% has 20-80% overstorey vegetation cover. Just over 50% of the Alluvial Continuous waterways were assigned a vegetation cover rating of 20-80%. The Alluvial Discontinuous stream types were assessed using aerial photographs as having almost 70% of the overall length with overstorey vegetation cover <20%.

Index of Stream Condition in the Wimmera River Catchment

Index of Stream Condition - Background

The Index of Stream Condition (ISC) was developed as a method for assessing the condition of streams in rural and bushland areas. The ISC was created to be a tool to:

- Benchmark stream condition, aiding objective setting and decision making by catchment managers and judging the long-term effectiveness of waterway management programs
- Be used by natural resource managers at local (e.g. CMA implementation groups, Landcare groups), regional (e.g. CMAs), state-wide and national levels

In the mid-'nineties, the State Government of Victoria decided a method was required to assess the overall health of waterways. The Catchment and Land Protection (CALP) Boards and River Management Authorities required a tool to assist with managing and reporting on waterway condition (Ladson *et al*., 1996). In response, the Index of Stream Condition (ISC) underwent its initial development in 1995. The following year saw the method tested on two catchments in eastern Victoria (Ladson *et al*., 1997). An expert panel was involved in the development and review of the method, which continues to undergo improvement (Ladson *et al*., 1997). In 1999, the ISC was applied Victoria-wide by Catchment Management Authorities (CMAs) to gain and combine valuable data about the health of the State's waterways (Batty, 1999).

The ISC is an integrated indicator that assesses a stream's overall condition (Ladson *et al.,* 1997). It involves both desk and field based data collection, which aims to give a reasonable quality, balanced outcome. Within the constraints of acceptable cost and time, it is expected that results satisfy appropriate levels of scientific rigour (Ladson *et al.,* 1999). The ISC consists of five sub-indices including: hydrology, physical form, streamside zone, water quality and aquatic life (Ladson *et al.,* 1996). In a practical sense, the objectives of the ISC are to:

- Report and benchmark the condition of streams in Victoria;
- Aid waterway managers with priority and objective setting in addition to decision making about waterway activities;
- Assist in judging the long-term effectiveness of rehabilitation programs and management intervention;
- Provide a tool for responses from Catchment Management Authorities, a management task necessary due to statutory requirements. (Ladson et al., 1996, 1997 & 1999).

Structure of the Index of Stream Condition

The overall ISC score lies between 0 and 50. A stream with a higher rating is considered more 'natural' or 'ideal' according to the best professional judgement of the panel of experts who designed the method (Ladson *et al.*, 1997 & 1999). The overall score is made up of five sub-indices. Each sub-index includes an array of indicators that are summed and scaled to ensure they each contribute a score out of ten (Ladson *et al.*, 1999). Following the Victorian State-wide application of the ISC during 1999, a verbal rating system was included, classifying each stream as being very poor, poor, moderate, good or very good in condition.

Limitations of the ISC

The Catchment Managers' Manual for the ISC (Ladson & White, 1999a) includes a section on limitations of the ISC. They include, amongst other points:

- The ISC has been developed to detect changes in the environmental condition of stream reaches typically 10 to 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.
- The ISC was primarily developed for rural streams. Therefore, it may be necessary to modify the ISC if it is to be applied for urban streams

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. (Ladson & White, 1999 a).

Index of Stream Condition, 1999

The Wimmera CMA provided the results of the 1999 ISC Assessment. Results for the Physical Form and Streamside Zone scores had been previously summarised for three sites within each reach. One site was selected out of each group of three to represent each reach. There was sufficient data for 37 ISC sites assessed in 1999.

The 1999 ISC results for the 37 selected sites are summarised in Appendix D.

Index of Stream Condition, 2002

Field Assessment

The 52 sites assessed in November 2002 are shown on the map titled *"Overstorey Vegetation Cover and Index of Stream Condition Sites"* , located in Appendix E. A summary of the site details is presented in the table titled *"Summary of ISC Site Locations visited in November 2002"*, (Table E1) located in Appendix E.

Factors of the waterways that contribute to the Physical Form Sub-index include:

- Bank Stability
- Bed Stability
- Instream Physical Habitat
- Impact of artificial barriers on fish migration (Ladson & White, 1999c).

Factors of the waterways that contribute to the Streamside Zone Sub-index include:

- Width of streamside zone
- Longitudinal continuity
- Structural intactness
- Cover of exotic vegetation
- Regeneration of indigenous woody vegetation
- Billabong condition (Ladson & White, 1999c).

Desktop Assessment

In addition to the data collected in the field, there is data required by the ISC method that must be obtained through desktop analysis. One set of data required is an estimation of the "Original Vegetation" structure that is used in a comparison with the current vegetation structure. The Reference Manual (Ladson & White, 1999c) states, "A general knowledge of the structure of the original vegetation community at a measuring site is necessary to evaluate the structural intactness indicator". The Wimmera CMA provided a digital layer of the pre-1750's vegetation community data (EVCs – Ecological Vegetation Communities) for this investigation. The Department of Sustainability and Environment provided detailed definitions of each EVC that were then summarised. Details on the method of assessment are in Appendix F.

The second set of data required is an estimation of the impact of artificial barriers on fish migration. Information was provided by the Wimmera CMA to determine the location of barriers to fish passage such as dams and weirs. However, as discussed in the Analysis of Results section, by the ISC definition all sites assessed had a barrier downstream in the catchment that would not be drowned out at least once per year.

Data from the field assessments and desktop assessments was entered into a Microsoft Access Database created by Melbourne Water Corporation (MWC) and the Department of Natural Resources and Environment (DNRE). The database was provided and approved for use by Paul Wilson at the DNRE in November 2002.

The ISC database generated Physical Form and Streamside Zone scores for each ISC site out of a total possible score of 10. These scores are summarised in Table H1, Appendix H.

Appendix G includes a Report Card for each of the 52 ISC sites assessed in November 200. The information was generated using the Microsoft Access ISC Database. Attached to each ISC site Report Card is a series of photographs that were taken at each site. Photographs were taken facing downstream.

ISC Sites with Poor Physical Form Sub-index Scores

The following photographs are taken facing downstream at four of the 52 ISC sites assessed in 2002. The Physical Form Sub-index scores, which are based on the bank stability, bed stability, instream physical habitat and potential affect of fish barriers, are between 0/10 and 3/10.

FS#30 – Unknown 6

Physical Form Score: 0/10

FS#31 – Unknown 7

Physical Form Score: 3/10

FS#48 – Unknown 12

Physical Form Score: 1/10

FS#51 – Wattle Creek Tributary

Physical Form Score: 1/10

Figure 3.05: Photographs of field sites with Poor Physical Form Sub-index scores

ISC Sites with Good Physical Form Sub-index Scores

The following photographs are taken facing downstream at four of the 52 ISC sites assessed in 2002. The Physical Form Sub-index scores are all 8/10.

FS#12 – Boggy Creek

Physical Form Score: 8/10

FS#14 – MacKenzie Creek

Physical Form Score: 8/10

FS#21 – Golton Creek

Physical Form Score: 8/10

FS#33 – Glenpatrick Creek

Physical Form Score: 8/10

Figure 3.06: Photographs of field sites with Good Physical Form Sub-index scores

ISC Sites with Poor Streamside Zone Sub-index scores

The following photographs are taken facing downstream at four of the 52 ISC sites assessed in 2002. The Streamside Zone Sub-index scores, which are based on the type, abundance and distribution of vegetation in the riparian zone, are all 3/10.

FS#30 – Unknown 6

Streamside Zone Score: 3/10

FS# – 36 – Nowhere Creek

Streamside Zone Score: 3/10

FS#44 – Unknown 11

Streamside Zone Score: 3/10

FS#49 – Unknown 13

Streamside Zone Score: 3/10

Figure 3.07: Photographs of field sites with Poor Streamside Zone Sub-index scores

ISC Sites with Good Streamside Zone Sub-index scores

The following photographs are taken facing downstream at four of the 52 ISC sites assessed in 2002. The Streamside Zone Sub-index scores, which are based on the type, abundance and distribution of vegetation in the riparian zone, are between 8/10 and 9/10.

FS#6 – MacKenzie Creek

Streamside Zone Score: 8/10

FS#17 – Seven Dial Creek

Streamside Zone Score: 9/10

FS#34 – Glenpatrick Creek

Streamside Zone Score: 9/10

FS#40 – Reservoir Creek

Streamside Zone Score: 8/10

Figure 3.08: Photographs of field sites with Good Streamside Zone Sub-index scores

Analysis of the 1999 and 2002 ISC Data

Of the sites assessed using the ISC method in 1999, 37 were selected for inclusion in this report. These are compared in Tables 3.06 and 3.07 to the 52 sites assessed in 2002. Table 3.06 is an overall comparison of the Physical Form Scores and Table 3.07 is a comparison of the Streamside Zone Scores.

Table 3.06: Comparison of the 1999 and 2002 Physical Form ISC scores

Physical Form Scores (/10	No. 1999 sites	% 1999 sites	No. 2002 sites	% 2002 sites	All Sites	% All Sites
0	0	0%	1	1.9%	1	1.1%
1	2	5.4%	3	5.8%	5	5.6%
2	1	2.7%	4	7.7%	5	5.6%
3	6	**16.2%**	3	5.8%	9	**10.1%**
4	10	**27.0%**	5	9.6%	15	**16.9%**
5	9	**24.3%**	8	**15.4%**	17	**19.1%**
6	7	**18.9%**	11	**21.2%**	18	**20.2%**
7	2	5.4%	6	**11.5%**	8	9.0%
8	0	0%	11	**21.2%**	11	12.4%
9	0	0%	0	0%	0	0%
10	0	0%	0	0%	0	0%

There is an overall shift in the Physical Form Sub-index scores from the 1999 and 2002 ISC assessments. In 1999, 66.4% of sites received a Physical Form Sub-index score between 3/10 and 6/10, inclusive. In 2002, 69.3% of sites received a Physical Form Sub-index score between 5/10 and 8/10. When the sites are combined, 66.3% received a Physical Form Sub-index score between 3/10 and 6/10.

Assessment of the 2002 results showed that the median score for both the Streamside Zone and Physical Form Sub-indices is 6/10. The average Physical Form score is 5.3/10 and the average Streamside Zone score is 5.8/10.

Table 3.07: Comparison of the 1999 and 2002 Streamside Zone ISC scores

Streamside Zone Scores (/10)	No. 1999 sites	% 1999 sites	No. 2002 sites	% 2002 sites	All Sites	%All Sites
0	0	0%	0	0%	0	0%
1	0	0%	0	0%	0	0%
2	0	0%	0	0%	0	0%
3	3	8.1%	9	**17.3%**	12	13.5%
4	5	13.5%	8	**15.4%**	13	14.6%
5	11	**29.7%**	8	**15.4%**	19	**21.3%**
6	5	**13.5%**	6	**11.5%**	11	**12.4%**
7	12	**32.4%**	9	**17.3%**	21	**23.6%**
8	1	2.7%	7	13.5%	8	9.0%
9	0	0%	5	9.6%	5	5.6%
10	0	0%	0	0%	0	0%

The majority (75.6%) of the 37 ISC sites assessed in 1999 received Streamside Zone scores between 5/10 and 7/10. In 2002, the results were more evenly spread, with the majority (76.6%) of sites receiving Streamside Zone scores between 3/10 and 7/10. Of the 52 sites assessed, 17.3% received 3/10 and the same percentage received a score of 7/10. The combined scores show that 57.3% of sites received a score between 5/10 and 7/10 for the Streamside Zone sub-index score.

The comparison of the 1999 and 2002 ISC shows that overall there has been very little change in the condition of the catchment. The Physical Form Sub-index scores improved slightly between the two series of assessments, whilst the Streamside Zone Sub-index scores did not change significantly. The comparison was based on limited data and confirms that the Streamside Zone and Physical Form condition of many waterways in the Wimmera River catchment is poor to marginal.

Table 3.08: The Distribution and Median Physical Form and Streamside Zone ISC Scores for each Stream Type

	Stream Type	Physical Form Scores	Median Score	Streamside Zone Scores	Median Score
Confined	Steep Headwater	7, 8	**7.5**	7, 9	**8**
	Confined	6, 8, 8	**8**	3, 4, 9	**4**
	Gorge	8, 8	**8**	7, 9	**8**
Partly Confined	Partly Confined 1	2, 5, 7, 7, 7, 8	**7**	5, 6, 7, 7, 7, 7	**7**
	Partly Confined 2	4, 6, 8, 8	**7**	5, 6, 6, 8	**6**
	Partly Confined 3	3, 4, 4, 5, 6, 6, 8	**5**	3, 3, 5, 5, 5, 6, 9	**5**
Alluvial Continuous	Alluvial Continuous 1	3, 4, 4, 5, 5, 5, 5, 5, 5, 5, 5, 6, 6, 6, 7, 8	**5**	3, 4, 4, 4, 5, 5, 6, 6, 6, 6, 7, 7, 7, 7, 7, 8, 8	**6**
	Alluvial Continuous 4	1, 3, 4, 4, 5, 6, 6, 6	**4.5**	4, 5, 5, 6, 6, 7, 7, 7	**6**
	Alluvial Continuous 5	1, 4, 6	**4**	4, 4, 7	**4**
	Anabranching Fine Grained	4, 5, 6, 6, 6, 7	**6**	5, 5, 7, 7, 7, 8	**7**
	Cut & Fill	3, 3	**3**	6, 7	**6.5**
Alluvial Discontinuous	Intact Valley Fill	4, 5, 5, 6	**5**	3, 3, 8, 9	**5.5**
	Chain of Ponds	4, 6, 6	**6**	3, 5, 5	**5**
	Floodout	5	**5**	3	**3**
	Incised Alluvial Discontinuous	0, 1, 1, 1, 2, 2, 2, 2, 3, 3, 3, 3, 4, 4, 4, 4, 5, 7	**3**	3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 4, 5, 5, 5, 5, 5, 5, 8	**4**
	Discontinuous Anabranching Chain of Ponds	6, 7, 8	**7**	7, 7, 8	**7**

Table 3.08 shows the median Physical Form and Streamside Zone Sub-index scores for the 89 ISC sites. With the exception of the Discontinuous Anabranching Chain of Ponds, the Physical Form Median score generally decreases from the confined waterways to the alluvial waterways. Incised Alluvial Discontinuous waterways have a median Physical Form score of only 2.5/10. Cut and Fill waterways have a median Physical Form score of 3/10, whilst Alluvial continuous 5 waterways score 4/10 for Physical Form.

The stream types of Steep Headwater, Gorge, Partly Confined 1, Anabranching Fine Grained and Discontinuous Anabranching Chain of Ponds have high median Streamside Zone scores. Floodouts have a Streamside Zone median score of 3/10 and Incised Alluvial Discontinuous is 4/10.

Distribution of ISC Sites in the Wimmera River catchment

A total of 89 ISC sites have been used in this analysis. The ISC Catchment Managers' Manual (Ladson & White 1999a) states that:

"The ISC has been developed to detect changes in the environmental condition of stream reaches typically 10 – 30 km long …"

This assessment has covered 3288 km of waterways in the Wimmera River catchment of 3rd order or greater. That means that there is, on average, one ISC site per 37 km in the catchment. With the addition of the ISC sites visited in 1999 for which sufficient data was not available, this distance would be further reduced. Table 3.09 is a summary of the distribution of ISC sites within the catchment.

Table 3.09: The distribution of ISC sites within each Geomorphic Style

	Stream Type	No. sites	TOTAL LENGTH (km)	No. sites per km
Confined	Steep Headwater	2	6.8	**3.4**
	Confined	3	156.7	**52.2**
	Gorge	2	6.7	**3.4**
Partly Confined	Partly Confined 1	6	31.1	**5.2**
	Partly Confined 2	4	50.2	**12.6**
	Partly Confined 3	7	131.3	**18.8**
Alluvial Continuous	Alluvial Continuous 1	17	510.6	**30.0**
	Alluvial Continuous 4	8	337	**42.1**
	Alluvial Continuous 5	3	151.2	**50.4**
	Anabranching Fine Grained	6	241.4	**40.2**
	Cut & Fill	2	8.1	**4.1**
Alluvial Discontinuous	Intact Valley Fill	4	737.3	**184.3**
	Chain of Ponds	3	19.7	**6.6**
	Floodout	1	10.9	**10.9**
	Incised Alluvial Discontinuous	18	723.3	**40.2**
	Discontinuous Anabranching Chain of Ponds	3	38.7	**12.9**
Constructed Features	Dam	0	49.8	**0**
	Weir	0	24.4	**0**
	Constructed channel	0	51	**0**
	Other	0	1.7	**0**
	TOTAL	89	**3288 km**	AVERAGE **36.9**

Discussion of ISC site distribution

Table 3.09 shows the distribution of ISC sites used in this project. Of the 16 Geomorphic Stream Types used, 10 have an ISC site more frequently than the 30 km defined by the method (Ladson & White, 1999a). Five stream types, being Confined, Alluvial Continuous 4, Alluvial Continuous 5, Anabranching Fine Grained and Incised Alluvial Discontinuous, have an average of one ISC site per 40 to 50 km of waterway.

The only stream type with a low frequency of sites per kilometre of waterway is Intact Valley Fill. There is one ISC site per 184.3 km of waterway defined as Intact Valley Fill. The two main reasons for this are in the limitations of the original aerial photograph interpretation.

- Due to the continuous coverage of overstorey vegetation in areas such as the Grampians National Park and the Pyrenees Region, much of the waterway length was attributed a stream type of Intact Valley Fill, as no channel could be seen
- The digital photographs provided were viewed at a 1:5000 scale. In some cases, this was not a fine enough scale to pick out the difference between an Intact Valley Fill waterway and one that has become an Incised Alluvial Discontinuous waterway

Although the aerial photograph interpretation is an excellent method of assessing an extensive length (3288 km) of the geomorphic type and overstorey vegetation cover of waterways in a catchment, there are limitations.

Limitations of the aerial photograph interpretation

Three ISC sites were assigned a stream type of Intact Valley Fill by the aerial photograph interpretation, but were confirmed in the field investigations to have a different stream type. This is due to the difficulty of determining the geomorphic type of a waterway through either patchy (20-80%) or continuous (>80%) overstorey vegetation cover.

As a result, the stream types of several ISC sites originally considered Intact Valley Fill, were changed after field inspections. This meant that the original number of ISC sites allocated to Intact Valley Fill was reduced, as was the average length per ISC site. It also means that there were more Partly Confined 1 and Incised Alluvial Discontinuous ISC sites than originally determined, bringing the averages for these two stream types down to one ISC site per 5.2 km and 40.2 km respectively. Refer Figure 3.09 and Table 3.09.

FS#19 – Unknown 2

Aerial Interpretation – Intact Valley Fill

Field Confirmation – Incised Alluvial Discontinuous

FS#32 – Unknown 8

Aerial Interpretation – Intact Valley Fill

Field Confirmation – Partly Confined 1

Figure 3.09:Two sites that were assigned the incorrect Stream Type using aerial photograph interpretation.

Assessment of the Stream Condition Method

Applicability of the ISC in the Wimmera

There are certain stream types in the Wimmera River catchment for which the ISC method is not appropriate. Although the ISC takes into account most general characteristics of waterways in rural Victoria, it does not factor in some of the stream types that are found in the northwest of the state. For example, stream types such as Chains of Ponds and Intact Valley Fills, where there is no defined channel, are difficult to assess with the standard ISC method. The following photographs show stream types that are found in the Wimmera River catchment that may not be accurately assessed by the current ISC method.

Four ISC sites assessed in 2002 were assessed in the aerial photograph interpretation as being Intact Valley Fills. They are known as Unknown 1, 3, 5 and 8. There were 2 sites on Glenlofty Creek that were defined as Chains of Ponds systems, being field sites 38 and 39.

FS#4 – Unknown 1

Intact Valley Fill

FS#22 – Unknown 3

Intact Valley Fill

FS#38 – Glenlofty Creek

Chain of Ponds

FS#39 – Glenlofty Creek

Chain of Ponds

Figure 3.10: Stream types in the Wimmera that are difficult to assess with the current ISC

Discussion of Applicability

The limitations of the ISC should be recognised in the analysis of results in this investigation. Although the ISC was designed to be a Victorian, statewide assessment, it does not take into account the difference in Geomorphic Categories. For example, the Discontinuous stream categories such as Intact Valley Fill, Chain of Ponds and Floodouts do not have defined channels as used in the ISC. The results of the ISC assessments at these sites should be considered with recognition of their limitations. Further investigation could include the development of an ISC-type assessment specifically focussed on discontinuous systems.

Impact of artificial barriers on fish migration

The ISC Reference Manual (Ladson & White, 1999a) has three ratings as shown in Table 3.10.

Table 3.10: ISC Ratings for the impact of artificial barriers score.

Category	Rating
In a typical year, no artificial barriers in the basin downstream of the reach interfere with the migration of any indigenous fish species endemic to the stream.	4
In a typical year, at least one artificial barrier in the basin downstream of the reach completely blocks the migration of indigenous fish species.	0
Situations where there are artificial barriers in the basin downstream of the reach that do not fit into the above two categories.	2

Source: (Ladson & White, 1999c)

A digital map was created using GIS to show the location of the ISC sites and significant fish barriers in the Wimmera River catchment. The ISC Reference Manual states that the barriers can affect fish passage from any point in the Basin downstream from the site. The 1999 Wimmera ISC data was accessed through the Victorian Water Data Warehouse and the "Impact of artificial barriers on fish migration" score was 0/4 for all sites except Outlet Creek and Natimuk Creek, where the score was 4/4. To remain consistent with the 1999 ISC, the "Impact of artificial barriers on fish migration" scores for the 2002 sites were assigned 0/4.

As stated in the ISC Reference Manual, the Rating Table above:

"…may be refined as the results of further research into the influence of artificial barriers on fish migration become available and the Victorian fish barriers database is developed further" (Ladson & White 1999a).

There are no indigenous native fish species that are migratory in the Wimmera River catchment (Koster & Close, 2001). Therefore, the "Impact of artificial barriers on fish migration" score should technically be 4/4 for all ISC sites. However, there are migratory native fish in the Wimmera River catchment, which are not indigenous to the region, which would be affected by the fish barriers. Whether the score is 0/4 or 4/4 is dependent upon whether the native indigenous or native non-indigenous fish species are considered a priority. If the Wimmera CMA decides to manage the Wimmera River catchment for native indigenous fish species only, the ISC fish migration score should be 4/4. If native non-indigenous fish species are to be included in the management priorities, the ISC score should be 0/4 for fish migration. For consistency in this project, a score of 0/4 was adopted for the fish migration score.

Benefits of the ISC Assessment

One aim of this investigation is to increase the information that the Wimmera CMA holds about the type and condition of its waterways. The ISC data is used by CMAs to populate the recently developed RIVERS database, a program to assist in priority setting. This information is then used in publications such as the Victorian River Health Strategy and the Regional River Health Strategies, which are vital components of the way in which our waterways are managed. With an addition of 52 sites, the Wimmera CMA now has an increased number of ISC sites from which to draw information about the condition of the catchment.

In 2004, the next statewide assessment of the ISC will take place. The Wimmera CMA may use the 2004 ISC results to indicate whether there has been a general change in the condition of the catchment. However, it is more likely that the additional sites assessed in 2004 will further build on the important information that was collected in 1999 and 2002. Such ISC information can be used as a benchmark to define the condition of the Wimmera River catchment.

Hydrologic Assessment

As a broad scale analysis, the Wimmera River catchment can be divided into three hydrologic fields. The aim of the classifications is to identify the systems affected by water harvesting, the natural channels that are used as conduits for the transit of irrigation water and systems unaffected by water harvesting or by the associated distributary systems. The classification system has not attempted to assess the changes in flow regime brought about by changes in land use, vegetation and incision within the catchment.

Three categories have been adopted for this investigation:

Stream hydrologically affected – water extracted for the Wimmera Mallee Stock and Domestic Supply System

Stream hydrology has been changed in a significant way due to water harvesting for irrigation and / or domestic supplies.

Stream hydrologically affected – used for water transfer

Stream hydrology is severely affected due to the stream channel being used to distribute water for irrigation, domestic supplies and environmental flows. The use of natural stream channels usually involves a reversal of flows, with high flows during summer and low flows during winter. Flows are also often at bank full levels for extended periods without natural fluctuations, some channels in the Wimmera catchment have also been deepened to allow greater flows down the channel.

Stream not hydrologically affected by the Wimmera Mallee Stock and Domestic Supply System

Stream hydrology is not affected by water harvesting on a large scale for either irrigation or reticulated supplies. If the catchment of these streams is being used as farmland there is a high probability that water harvesting for stock and domestic purposes will be occurring. In uncleared catchments, there maybe some minor water harvesting for fire dams.

Hydrology Results

Streams affected by water harvesting and the distribution of water for stock and domestic water are generally higher order streams that are exclusively continuous in nature. The continuous streams may be Confined, Partly Confined or Alluvial Continuous, depending on their location within the catchment.

As shown in Figures 3.11, 3.12 & 3.13, both the harvesting of runoff and the use of natural streams as distribution channels affect streams as low as 3rd order in the Wimmera Catchment. The length of stream affected generally increases with increasing stream order. This varies from 10% of 3rd order streams being affected to 83% of 8th order streams. There is an average of 8% of waterway length affected across the entire Wimmera Catchment. This assessment does not consider changes to catchment hydrology brought about by changes in land use, clearing and loss of water to farm dams.

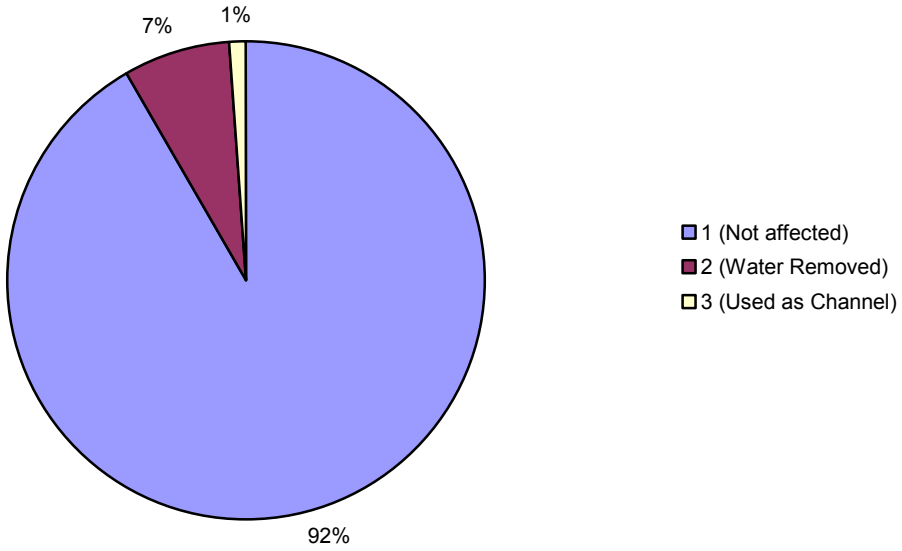

Figure 3.11: The total affected streams within the entire Wimmera catchment.

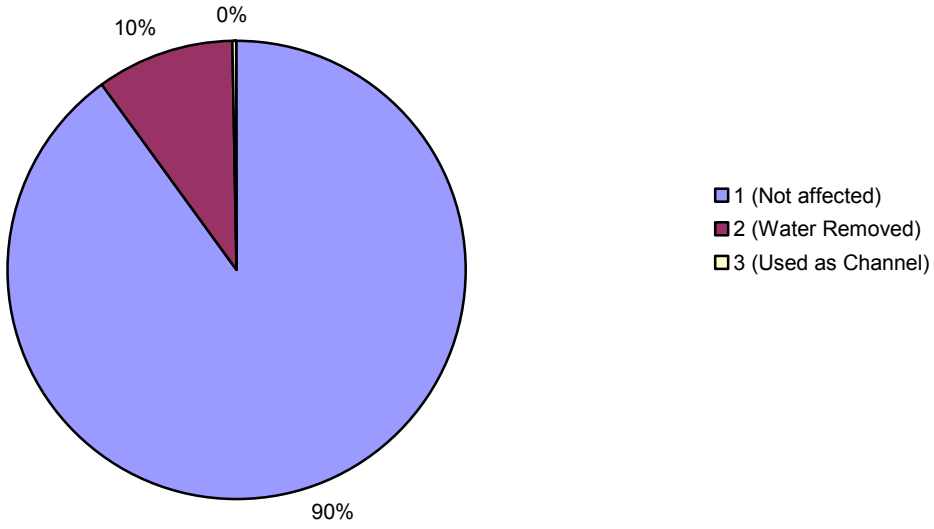

Figure 3.12: The affected streams within 3rd order streams within the Wimmera catchment

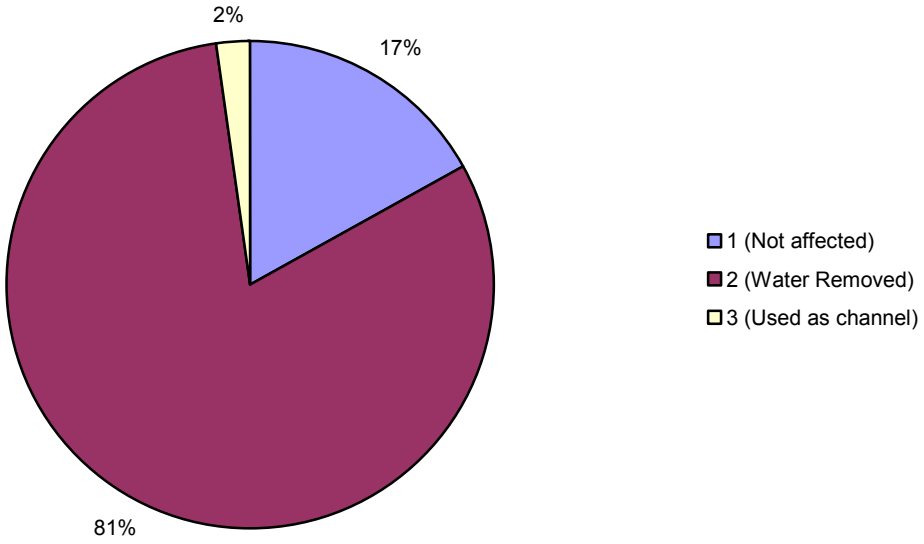

Figure 3.13: The affected break down of the 8th order streams within the Wimmera catchment.

The effects of changes in the Wimmera Catchment brought about by the harvesting and distribution of water are important. Refer to Appendix J for a detailed description and analysis of changes in hydrology within the Wimmera Catchment.

The streams that are required to carry water for irrigation and domestic supplies will adapt to greater flows by increasing channel size and changes in stream alignment at a faster rate than their natural process. The greater flows may have a detrimental effect on stream ecology through:

- The release of cold water
- The removal of in-stream features such as bars and LWD
- Creating areas in the channel of low velocity flow, such as pools, when they are not part of the natural channel character

The length of streams that have been affected by water diversions and used as conduits is quite significant when considered in terms of overall higher order stream length. This is due to water being harvested from lower order streams, which are generally upstream from higher order streams. Extensive harvesting and diversion of water within the Wimmera catchment has left the majority of the lower Wimmera river and its significant tributaries, such as the MacKenzie and Mt William Creek, with low and restricted flows.

Streams with affected hydrological regimes

The streams of the Wimmera River catchment that have undergone significant change in hydrology, due to water harvesting and distribution, since European settlement are summarised in Table 3.11.

These streams are of a generally continuous nature and represent a significant proportion of the larger streams within the catchment. The majority of channel length that has been affected is due to flows being significantly reduced. However, many streams are used at different times of the year to supplement the distribution channel network. Refer to Appendix J for a map of affected streams within the Wimmera River catchment.

The general implications of this assessment are that the lower Wimmera has been severely affected by changes in stream hydrology, the reduction of flows and the upper Wimmera Catchment has been significantly damaged by incision and channelisation (pers comm. Hardie, 2002)

Table 3.11: Streams in the Wimmera River catchment with affected hydrology

Waterway	Way in which waterway is affected
Upper Fyans Creek	Water diverted by WMW (Wimmera Mallee Water) from the headwater streams to the Wannon River
Fyans Creek	Dammed at Lake Bellfield and the stream channel below the dam is used for water distribution
Fyans Creek Diversion	Diverts water to a defined stream below Halls Gap to prevent it bypassing Lake Lonsdale
Mt William Creek	Affected below Lake Lonsdale through the restriction of flow
Sheepwash Creek	Occasionally used to carry regulated flows by WMW
Wimmera River	Used to carry water from Glenorchy to Huddlestones Weir
Wimmera River below Huddlestones Weir	Restricted flows. All water up to 1600ML/day is regulated into the Wimmera Inlet Channel
MacKenzie River	Flows are regulated between the Wartook Reservoir and the MacKenzie Distribution Heads
MacKenzie River below the Distribution Heads	Restricted to between 5 and 10 ML / day of environmental flows. 5 ML/day is a insufficient amount for the river to be fully wetted during the summer month
Potters Creek	Used as a channel for distributing stock and water supplies during the summer as well as for water for Horsham urban storages
Burnt Creek – Distribution Heads to Toolondo Channel	Flows are restricted and environmental flows are not always available during summer periods
Burnt Creek – Toolondo Channel to Wimmera River	Used a distribute water during the summer for dam filling operations
Bungalally Creek	Used as a distribution channel for irrigation water. Stock and Domestic supplies and the lower part of the stream is used to carry Wimmera River environmental flows from Pine Lake to the Wimmera River
Parts of Yarriambiack Creek	Formerly used to carry irrigation water, WMW supplies some water to weir pools at some towns for recreational purposes
Parts of Dunmunkle Creek	Used to carry irrigation as well as stock and domestic water. It has also been excavated in some places for use as a channel or drain for excess irrigation water

Summary of the Stream Condition Assessment

The stream condition assessment has included aerial photograph interpretation, ISC assessments and a review of the hydrology in the Wimmera River catchment.

The aerial photograph interpretation has shown that there are almost 50% of the 3288 km of waterways in the Wimmera River catchment, of 3rd order or greater, with less than 20% overstorey vegetation cover. Only 13.8 % of the waterway length has overstorey vegetation cover of greater than 80%, mostly located in the Grampians National Park, Pyrenees region or the Heritage River section of the Wimmera River.

Waterways which have been identified as Intact Valley Fill make up 22.4% of the total stream length and Incised Alluvial Discontinuous constitute 22.0%. A significant majority of the length of these two types of waterways have overstorey vegetation cover of less than 20%. This means that over 30% of the length of 3rd order streams or greater in the Wimmera River catchment is Intact Valley Fill or Incised Alluvial Continuous with less than 20% overstorey vegetation cover.

The 1999 and 2002 ISC scores were combined to create a set of 89 ISC sites for assessment. The median Physical Form and Streamside Zone scores ranged from 2.5/10 to 8/10. The Confined and Partly Confined systems generally received higher ISC scores than the Alluvial systems. This may be due to the location of the Confined and Partly Confined systems in National Parks and other such protected areas, whilst the Alluvial systems are generally located in agricultural and privately owned areas.

The range of ISC scores may also be affected by the limitations of applying the ISC in the Wimmera River catchment. As discussed in this section, the ISC does not incorporate the unique features of discontinuous systems such as Chain of Ponds or Intact Valley Fill. Analysis of the ISC results for these stream types should consider these limitations.

The Hydrology investigation showed that the majority of waterway length in the entire Wimmera River catchment is not affected hydrologically by the Wimmera Mallee Stock and Domestic Supply System. However, over 80% of the length of 8th order waterways in the catchment is directly affected by water being harvested for irrigation and / or domestic supplies.

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Acknowledgments:

Land Victoria Horsham provided access to the aerial photographs for the part of the catchment that wasn't covered by the digital imagery.

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