Source: Hughey, K.F.D., Baker, M-A. (eds). (2010a). The River Values Assessment System: Volume 1: Overview of the Method, Guidelines for Use and Application to Recreational Values. LEaP Report No.24A, Lincoln University, New Zealand.

Chapter 2
Literature Review

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2.1 Introduction

This chapter summarises the relevant New Zealand and international literature regarding the methods used to assess river values. Throughout the chapter, this project is often referred to as 'the current project'.

The literature search was conducted in January 2009 and consisted of a thorough search of the Lincoln University library, online databases available at Lincoln University (namely *Web of Knowledge* and *Science Direct*), and the online search engine G*oogle Scholar*. Known websites that were likely to have relevant reports were also searched: *Environment Canterbury, National Institute of Water and Atmospheric Research (NIWA),* and *Ministry for the Environment.*

2.2 Purpose

The purpose of this chapter is threefold. Firstly, it identifies the literature which is of relevance to the River Values Assessment System (RiVAS) project. Secondly, it reports on the river values included in the literature and the ways in which these values are conceptualised in terms of attributes. For example, salmon angling includes attributes such as level of use, anticipated catch rate, water quality and perceptions of the quality of the angling experience. In addition to identifying the attributes of each value, indicators used to assess each attribute are included where they have been considered. Finally, the chapter outlines the ways in which these attributes and indicators have been evaluated, and whether or not greater importance is placed on particular attributes, by assigning weightings, for example.

2.3 Structure of the chapter

The remainder of the chapter which follows this introduction is structured into three sections. Section Two outlines the New Zealand and international literature relevant to the RiVAS project. This section is separated into six sub-sections; each addressing the river values stipulated by the project. These are:

1) Angling values,
2) Recreational values,
3) Scenic/landscape/natural values,
4) Tangata whenua values,
5) Wildlife/conservation/ecological values, and
6) Irrigation/hydro-electric development values.

This information is then summarised using a table format in Section Three. Section Four presents the conclusions of the chapter.

Several sources accessed for this chapter, outline a large number of attributes and/or indicators to assess one or more river values and, therefore, it was not feasible to reproduce them here. In such cases, the method has been described in as much detail as to give the reader a sufficient understanding to enable them to make an assessment as to whether they would like to view the original source.

2.4 Summary of the literature relating to assessment methods of river values

This section of the chapter outlines the literature accessed which was of relevance to the RiVAS project. It is separated into six sub-sections: 1) angling values, 2) recreational values, 3) landscape/scenic/natural values, 4) tangata whenua values, 5) wildlife/conservation/ecological values, and 6) irrigation and hydro-electric development values.

2.4.1 Angling values

New Zealand's first qualitative National Angling Survey was undertaken in 1980. It looked specifically at the relative rankings of several qualitative attributes for each water body used by freshwater anglers (see Teirney et al. 1982; Teirney & Richardson 1992). The survey also included a quantitative aspect, but the methodology was unsuitable for this purpose and these data have not been used for quantitative purposes.

The first rigorous and quantitative National Angling Survey for New Zealand was conducted between 1994 and 1996. This survey was subsequently repeated during the 2001/02 season (Unwin & Image, 2003). The purpose of this study was "to obtain consistent estimates of angler usage, for all New Zealand lake and river fisheries by New Zealand resident anglers" (p. 6). The results of the 2001/02 survey show that there were 1,111,000 ± 16,000 angler days. However, angling effort varied throughout the country, ranging from 1,870 ± 520 angler days in Northland to 229,500 ± 7600 angler days in the Eastern region. Based on these data alone, it might appear that rivers are valued more for the angling opportunities they offer in some areas when compared to other areas.

However, estimating the angling value of rivers on usage data alone has been suggested as being inadequate (Teirney, Richardson & Unwin, 1987). An alternative approach to investigate angling values was implemented in New Zealand during the 1980s, when a postal survey was conducted to gather information of anglers' use and perceptions of New Zealand rivers (Teirney et al., 1987; Teirney & Richardson, 1992). Two purposes of this study were 1) "to collect directly from the adult angling population of New Zealand, *quantitative and comparative* information on every river supporting a significant sports fishery," and 2) "to identify those attributes which characterise rivers of importance" (Teirney et al., 1987, p. 6, emphasis added). This work is particularly noteworthy because the researchers sought to determine the importance of rivers based on a variety of factors, rather than angling use alone. These factors were:

1) Distance from home;
2) Ease of access;
3) Area of fishable water;
4) Scenic beauty;
5) Peace and solitude;
6) Catch rate; and
7) Size of fish.

Each of these factors and the overall importance of the river was assessed using a five-point scale (1 = lowest, 5 = highest). An important point to note is that the factors which contributed to anglers' overall assessment of river importance differed depending on the type of fish sought: trout or salmon. The primary contributing factors for trout anglers were 1) catch rate, 2) scenic beauty, and 3) area of fishable water. In contrast, the primary factors for salmon anglers were 1) angler use and 2) fish size.

2.4.2 Recreational values

Rivers provide people with a myriad of recreational opportunities. The recreational value of rivers is considered widely throughout the available literature (see, for example, Daly, 2004; Griffin, 1975; Mosley, 2002; 2003; 2004; Sutherland-Downing & Elley, 2004), however, quantitative assessment of recreational value is more limited.

The first comprehensive attempt to assess the recreational value of New Zealand rivers for boating was *The New Zealand Recreational River Survey* conducted in the 1980s (Egarr & Egarr, 1981a; b; c). The applicability of this study to the current project is limited due to the largely qualitative nature of the study and subsequent changes in access, land use and boating techniques and equipment; nevertheless, the attributes used to assess recreational value might usefully be extended for use in a quantitative assessment. The following attributes were used by Egarr and Egarr: 1) suitability of use for each recreational group, 2) access, 3) problems and obstructions to use, 4) proximity to demand, and 5) skill or challenge factor. Through a qualitative assessment of these factors, rivers were categorised on the following scale of recreational value:

- Low = valueless & mediocre
- Intermediate = average
- High = popular
- Exceptional = extreme

The scenic value of each river was also assessed (see Section 2.3 below). The recreational and scenic assessments were then combined to categorise rivers. This categorisation and the descriptions for each are presented in Table 2-1 below.

Table 2-1
Categorisation of rivers as determined by their assessment of the recreational and scenic value of rivers in New Zealand

Category – a result of combining the recreational and scenic value of a river	Description
Category A	All rivers with exceptional recreational value and exceptional scenic value
Category B	All rivers with exceptional recreational value and impressive scenic value or high recreational value and exceptional scenic value
Category C	All rivers with exceptional recreational value and picturesque scenic value or high recreational value and impressive scenic value or high recreational value and picturesque scenic value or exceptional recreational value and moderate scenic value
Category D	All rivers with high recreational value and moderate scenic value or intermediate recreational value and exceptional scenic value or intermediate recreational value and impressive scenic value or intermediate recreational value and picturesque scenic value.

Source: Egarr and Egarr (1981a; b; c)

Another useful aspect of the study is a discussion which relates to the problems of trying to rank rivers based on their attributes (see p. 26 of original source). Egarr and Egarr (1981a) also highlight that weighting different attributes comprising recreational value is difficult due to the problems of finding a satisfactory formula to rank one attribute against another, particularly when trying to apply

this formula in different areas of the country. The authors conclude that "each river is a unique entity that cannot be compared to any other on exactly the same formula of comparison" (Egarr & Egarr, 1981a, p. 26).

Sutherland-Downing and Elley (2004) provide a comprehensive inventory of the recreation values for rivers and lakes in Canterbury, New Zealand. The recreation value of these waterways is separated into three types: recreation physical value, recreation use values, and recreation use types. Recreation physical value comprises water quality (high/moderate/low), scenic appeal (high/moderate/low), and natural appeal (high/moderate/low). Recreation use values comprise frequency of use (high/moderate/low) and intensity of use (high/moderate/low)[1]. The inventory also includes attributes used to describe the recreational potential of water bodies. The attributes used are[2]:

- Travel time (close/moderate/far)[3];
- Facilities (extensive/many/some/limited);
- Accommodation (camping/tramping hut/caravan/camper-van/crib or bach);
- Fishing and hunting abundance of target species (very common/common/uncommon – for each species);
- Channel features (shallows/waterfalls/shallow rock drops/rock obstacles/riffles/rapids/pools)
- flow strength (sluggish/moderate/strong/powerful)[4];
- Flow conditions supporting recreation (year-round/certain times of year);
- Obstructions (bank-side willows/bank or bed obstructions);
- Accessibility (along bank/bed = good/limited; road to & from water-body = good/moderate/private; boat = good/moderate/limited).

While these assessments are qualitative in nature, they provide a foundation for the attributes comprising recreational value and could potentially be converted to quantitative measurement[5].

Within the context of the current project, the inventory compiled by Sutherland-Downing and Elley is perhaps most useful due to their inclusion of desirable values and attributes for a wide range of recreational activities which can be undertaken on, in or near rivers[6]. For the lists of these values and attributes, readers are directed to the original report.

2.4.3 Scenic/landscape/natural values

Compared to the amount of work associated with angling and recreational values, a greater amount of work seems to have been done regarding the assessment of scenic, landscape or natural values relating to rivers. With this in mind, a point worth noting is that landscape values tend to overlap with other river values (Ministry for the Environment, 1998), thus work in this area might be usefully applied to assess other river values such as recreation or wildlife. Egarr and Egarr (1981a) reinforced this perspective when they noted that it is difficult to separate recreational use of a river from the

1 For a full description of the high/moderate/low assessments, readers are directed to the original report (pp. 10-13).
2 For a full description of the categories for each attribute, readers are directed to the original report (pp. 23-29).
3 While unstated in their report it is assumed to refer to travel time from home.
4 There is no explanation in the report about how this attribute applies for the context of a lake.
5 The data in the original report were not verified or field checked and attention should be given to the 'general terms and conditions' for using the information contained in the report (p. 1).
6 The recreation activities included in Sutherland-Downing and Elley's (2004) inventory are: passive (sightseeing, walking, tramping, picnicking/BBQ, camping, horse trekking, bird watching); contact (swimming, paddling/wading, diving); mechanised water craft (jet boating, water skiing, jet skiing, power boating); paddling and floating water craft (canoe/kayaking, rafting, floating, drift boating, rowing); sail water craft (sail boating, board sailing, kite sailing); fishing and hunting (salmon, trout, white-baiting, eeling, other fishing, waterfowl, small game, big game); off-road vehicles (four-wheel driving, trail biking, mounting biking, dune-buggies, land sailing); other (multi-sports, ice skating).

scenic qualities of a river, therefore their study also included an assessment of scenic value (see Section 2.2 and Table 2-2 the way in which recreational and scenic value were combined).

The way in which Egarr and Egarr assessed scenic value in *The New Zealand Recreational River Survey* was used previously in the now classic study titled *64 New Zealand Rivers* (Egarr, Egarr & MacKay, 1979). This study appears to be the first in New Zealand to respond to an observed need for an objective quantitative analysis of the scenic qualities (value) of New Zealand rivers. As was noted in Section 2.1 concerning angling values, Egarr et al. (1979) noted that a user numbers/cost-benefit analysis does not give a valid indication of the ways in which people value a given river. Consequently, they developed a five-point scale of qualitative distinctions that would allow "reasonably clear-cut judgements to be made" (p. 6). The scale (0 = dull, 1 = ordinary, 2 = interesting, 3 = impressive, 4 = exceptional) was used to evaluate seven factors which were selected as comprising the scenic quality of a river. These factors were:

1) Vegetation;,
2) Banks and riverbed;
3) Landscape;
4) Wilderness feeling;
5) Water quality;
6) Water movement; and
7) Other factors (see Table 2-2).

These attributes were each given equal weighting "not so much because we can make a case for them all to be equally important, but because we cannot make a convincing case that some are more important than others" (p. 11). Rivers were then divided into stretches and each stretch assessed according to the seven factors/attributes. Individual factor scores were then summed resulting in an overall scenic value score for each section of river. The overall scenic score was evaluated using the following scale: 0-3 = dull, 4-6 = ordinary, 7-9 = interesting, 10-15 = impressive, and over 16 = exceptional. An alternative way to designate categories is suggested by Mosley (2002): "if comparable features or values are ranked, 'outstanding' [for example] might be taken to equate to a given percentile range (e.g., the top 10%) of all cases" (p. 34).

A source which outlines a more complex quantitative assessment for the natural value of rivers is Collier's (1993) report *Towards a protocol for assessing the natural value of New Zealand rivers*[7]. Collier based the method on the South African River Conservation System reported in O'Keefe, Danilewitz & Bradshaw (1987). The five criteria for assessing the natural value of waterways were developed at a Limnological Society conference in 1987.

7 Another source addressing Collier's method is:
Collier, K.J., & McColl, R.H.S. (1992). Assessing the natural value of New Zealand rivers. In P.J. Boon, P. Calow, & G.E. Petts. (Eds.). River conservation and management, pp. 21-37. Chichester, UK: John Wiley & Sons.

Table 2-2
Factors (attributes) of the scenic value of rivers and the way in which they were evaluated in the *64 New Zealand Rivers study (*Egarr, Egarr & MacKay, 1979) and the New Zealand Recreational River Survey (Egarr & Egarr, 1981a; b; c)

Factors (attributes) comprising scenic quality/value	Indicators comprising the factors (attributes)	Method of evaluation
Vegetation	• Volume • Variety • Virginity	0 = dull (e.g., barren stopbanks, introduced grasses and weeds) 1 = ordinary (banks lined with a single introduced species, e.g., willow, broom, gorse, blackberry) 2 = interesting (a variety of vegetation types) 3 = impressive (e.g., mainly indigenous bush, or a variety of vegetation that fits particularly well into the landscape) 4 = exceptional (untouched native forest with a high density of tall trees and diversity of species)
Banks and riverbed	• Visible geological make up of the river environment	0 = dull (e.g., polluted mud) 1 = ordinary (e.g., shingle, sand, earth – underlying geological structure not evident) 2 = interesting (more varied riverbed, boulders, rocks) 3 = impressive (river in bedrock, interesting rock formations) 4 = exceptional (spectacular rock formations and cliffs)
Landscape	• The more distant views beyond the immediate banks and cliffs cut by the river itself.	0 = dull (flat, dull, developed country) 1 = ordinary (e.g., rolling, low-relief farmland, or landscape obscured altogether by banks or vegetation) 2 = interesting (e.g., close bush or tussock-covered hills, or a variety of short and long-range views of different landscape types) 3 = impressive (e.g., particularly beautiful developed country or high hills) 4 = exceptional (e.g., spectacular mountainous country)
Wilderness feeling	• Difficulty of access. • Distance from civilisation • Subjective feeling of wilderness	0 = dull (stopbanks dominant – visible development) 1 = ordinary (farming country largely obscured by bank vegetation) 2 = interesting (varied – river difficult to get to in places) 3 = impressive (mostly remote – access difficult and infrequent) 4 = exceptional (extremely remote – cross-country travel daunting)
Water quality	• Visual perception of water quality NB: a three-point scale was used	0 = dull (undrinkable, or permanently discoloured) 1 = ordinary (clear and apparently unpolluted) 2 = interesting (impressively pure and sparkling)
Water movement		0 = flat, without noticeable movement 1 = noticeably moving (includes Grade 1 rapids in shingle) 2 = significant rapids (attractive patterns or up to Grade 3) 3 = impressive rapids (in bedrock, or up to Grade 5) 4 = spectacular (very big water or high waterfalls)
Other factors		Including wildlife, historic sites, other scientific interest A three-point scale was used (0-2)

The criteria used in Collier's method were:

1) Ecological representativeness or rare type of ecosystem;
2) Diversity and pattern;
3) Rarity and unique features or species;
4) Long-term viability; and
5) Degree of modification.

The quantitative descriptors/indicators and weightings assigned to the criteria were developed through a questionnaire sent to 36 limnologists[8]. To combine the indicators used for each criterion/attribute, the values assigned were divided by the maximum score and then multiplied by the weighting. The sum of the indicator scores was then divided by the sum of the weightings for all indicators and multiplied by 100 (the score for the attribute 'degree of modification' was then subtracted from 100). Table 2-3 presents the calculation method adopted by Collier.

Table 2-3
Method of calculation used in Collier's protocol for assessing the natural value of New Zealand rivers (1993, p. 4)

Descriptor	Upper limit	Weight	Value
% catchment in native vegetation	≥ 80	+ 17.1	81
% length lined by native vegetation	100	+ 15.7	90
% base flow abstracted	≥ 60	- 15.4	50
No. exotic nuisance species	≥ 10	- 10.5	2
Sum of weighting factors		58.7	

NB: All factors are converted to positive values to calculate the sum of weightings.

Descriptor	calculation	Score
% catchment in native vegetation	80/80 x 17.1	17.1
% length lined by native vegetation	90/100 x 15.7	14.1
% base flow abstracted	50/60 x –15.4	(-12.8)* 2.6
No. exotic nuisance species	2/10 x -10.5	(-2.1)* 8.4
Sum of scores		42.2

* Where there are negative weights, scores calculated from the formula are subtracted from the weighting factor before being summed.

Final score on a scale of 0-100 is 42.2/58.7 x 100 = 71.9. This indicates the extent to which the river is unmodified. To indicate degree of modification the score is subtracted from 100 (NB: this is only done for the degree of modification attribute). Therefore, the score for degree of modification using the above indicators is 100 - 71.9 = 28.1.

An important point to note is that the scores derived from the criteria were not meant to be combined to produce an overall natural value score. Nevertheless, Collier concluded that the method appeared to render 'sensible' scores, but required further refinement (the weightings and descriptors in particular) before being applied more widely. Despite Collier viewing his work as a

8 Due to the number of descriptors and weightings, they are not reproduced here. Readers are directed to the original source.

starting point for developing a method for assessing the natural value of rivers, it appears that no further work has been undertaken to refine and adopt the method he proposed[9]. However, the method proposed could potentially be extended to the other values in the RiVAS project.

Another "attempt to quantify some elements of aesthetic appeal while eliminating, insofar as possible, value judgements or personal preferences" is Leopold's (1969, p. 1) *Quantitative comparison of some aesthetic factors among rivers*. He also adopted a five-point scale to assess 46 attributes relating to the aesthetic value of rivers[10], but rather than simply summing and averaging scores, he calculated what he termed uniqueness ratios after having scored each site under investigation according to the listed attributes. For example, if a site shares the same score for a given factor with seven other sites it is unique in the ratio 1 to 7 (0.14). If no other site shares the same score for a given factor then the site has a uniqueness ratio of 1:1 (1.0). Therefore, the uniqueness ratio is defined on a scale of 0-1.0. Uniqueness ratios from each attribute are summed for a given site to produce an overall uniqueness score, and then sites can be ranked according to their uniqueness scores. Leopold also undertakes further comparative analyses of selected factors (attributes) by which to evaluate different sites. These analyses appear to be unique and readers are directed to the original source to assess their merit.

In general, most sources assess only one river value (an exception is Egarr & Egarr, 1981a). One source which addresses *both* biological and aesthetic values is an assessment of islands and shoals around New York (Knutson, Leopold & Smardon, 1993). The purpose of the study was to develop a system with which small islands and shoals could be prioritised for conservation. This work is significant for two reasons. First, the researchers noted that most systems of categorisation at the time were based solely on biological factors; therefore they sought to combine both biological and aesthetic values. Second, the approach used adopts a system which is not based on a five-point scale. The biological quality score was determined by assessing five criteria: common tern nesting site, bald eagle winter feeding area, rare plant habitat, significant coastal wildlife habitat, and plant species richness. Each of these criteria was assigned a score from 1-10. A visual quality rating was determined by assessing four criteria: landform, vegetation, colour and cultural features. The subsequent visual quality score was then weighted on the basis of how visible the island or shoal was from popular scenic vantage points. Table 2-4 presents the method used to assess the biological and visual scores of each island or shoal.

An important feature of the method used by Knutson et al. (1993) is that the criteria for the biological and visual quality scores were not simply summed and then averaged. Instead, the researchers adopted a system of selecting either the highest or lowest score given to any one of the criteria (see original article for a full description of the method used). The authors also provide a brief, yet useful discussion of other ways in which criteria have been combined for given values. This article also refers to several other sources which might be useful to the current river values project.

9 Dunn (2004) refers extensively to Collier's proposed method and only cites the 1993 report.

10 Due to the large number of attributes and their associated indicators, the list will not be reproduced here. Readers are directed to the original article.

Table 2-4
Method used to derive a final score for each island from the determined attributes (Knutson, Leopold & Smardon, 1993, p. 202)

Category	Factors (a-e)	Max. factor score	Weighting (W)	Category score Range (1-10)	Final score Range (1-10)
Biological (B)	a) Common tern nesting	10	1	B = max (a-e)	Max (B, V)
	b) Bald eagle feeding	10	1		
	c) Rare plant habitat	7	1		
	d) Significant coastal wildlife habitat	6	1		
	e) Plant species richness	6	1		
Visual (V)	Visual quality rating	5	1, 1.5, or 2	V = Q x W	

2.4.4 Tangata whenua values

From a Maori perspective, water is considered an essential ingredient to life and is a priceless treasure left by ancestors (Waugh, 1992). Despite the importance placed on water sources by Maori, no studies were found which attempted a comprehensive quantitative assessment of tangata whenua values associated with rivers. This is perhaps unsurprising given the relatively recent acceptance of Maori perspectives and participation in managing waterways. Although literature containing reference to tangata whenua values of high relevance to the current project was scarce, a number of sources did include reference to the ways in which Tangata whenua value waterways (see, for example, Ministry for the Environment, 1998; Mosley, 2001; 2002; 2003; 2004; Tipa, 2001; Daly, 2004).

From the available literature, several attributes of tangata whenua values regarding rivers can be identified. These are mauri (Daly, 2004; Tipa & Teirney, 2003; Tipa, 2001; Te Runanga o Ngai Tahu, 1999), wahi tapu/taonga (Daly, 2004; Mosley, 2002; 2003; 2004), mahinga kai (Daly, 2004; Mosley, 2002; 2003; 2004; Tipa & Teirney, 2003), kaitiakitanga (Tipa & Teirney, 2003; Tipa, 2001; Te Runanga o Ngai Tahu, 1999), and consideration of the wider catchment or mountains to the sea philosophy (Tipa & Teirney, 2003; Tipa, 2001).

The best source of how these attributes might be conceptualised through set criteria is provided in the Te Runanga o Ngai Tahu *Freshwater Policy Statement* (1999). This statement identified several tangible attributes which can represent mauri. These are 1) aesthetic qualities (e.g., clarity, natural character and indigenous flora and fauna), 2) life-supporting capacity and ecosystem robustness, 3) depth and velocity of flow, 4) continuity of flow from the mountain source of a river to the sea, 5) fitness for cultural usage, and 6) productive capacity. A principal indicator used by Ngai Tahu to assess the mauri of a water body is the productivity of food and other resources sourced from it, however, no means by which this productivity might be assessed is provided.

In relation to kaitiakitanga, the following attributes are listed:

1) The role of particular waterways in unique tribal creation stories;,
2) The role of those waterways in historical accounts;
3) The proximity of important wahi tapu;
4) Settlement or other historical sites in or adjacent to specific waterways, the use of waterways as access routes or transport courses;
5) The value of waterways as traditional sources of mahinga kai food and other cultural materials and;
6) The continued capacity for future generations to access, use and protect the resource (Te Runanga o Ngai Tahu, 1999).

Other attributes of tangata whenua values that might be considered include place names and the presence of Maori trails (Tipa, 2001). Although Tipa's (2001) assessment of the tangata whenua values associated with the Rangitata River in Canterbury is largely descriptive and primarily sought to determine how these values could be negatively/positively affected by several proposed management options, the impacts on mauri and mahinga kai listed might be used in developing indicators for these attributes. Influences on mauri include inappropriate flow regime, channelisation/stopbanks/river protection, abstraction of water, drainage, dewatering, cross mixing of water, coastal environment health, catchment impacts, and water quality (p. 4). Characteristics affecting mahinga kai include:

1) Modifications to the waterways and the resultant loss of habitat;
2) Changing land use and the resultant loss of habitat;
3) The abundance and diversity of mahinga kai species has changed;
4) Health of fish has deteriorated;
5) Adverse effects are felt throughout the catchment; and
6) 6) There are problems with passage by fish throughout the system (p. 5).

One source which moves beyond simply identifying tangata whenua values and associated attributes is a tool developed by Tipa and Teirney (2003; 2006) called the Cultural Health Index. This was developed in order "to facilitate the input and participation of iwi into land and water management processes and decision making" (Tipa & Teirney, 2003, p. vii). Although this index only considers the health of waterways from an ecological perspective (in terms of mahinga kai species), it provides a useful example of quantitatively assessing water bodies in relation to tangata whenua values. The index has three components: status of the site, a mahinga kai measure and a cultural health stream measure. Table 2-5 summarises these components and the ways in which they are assessed and evaluated using the Cultural Health Index. Maori leaders were consulted to develop the indicators. The Cultural Health Index has recently been applied in the Motueka River Integrated Catchment Management project (see http://icm.landcareresearch.co.nz/ research/research.asp? theme_id=4&research_id=121) and in Te Waihora/Lake Ellesmere (Pauling & Arnold 2009),

Table 2-5
Components, attributes and scoring of the Cultural health index used to assess the health of streams and waterways
(Tipa & Teirney, 2006)

Components of cultural health index	Attributes	Evaluation indicators	Combining of scores
Component 1: Site status	1. Traditional/non-traditional site? 2. Would Tangata whenua use the site in the future?	A = traditional site B = non-traditional site 1 = tangata whenua would use site 2 = tangata whenua would not use site	
Component 2: Mahinga kai	1. Number of mahinga kai species present at the site today.	1 = 1-3 species present 2 = 4-7 species present 3 = 8-10 species present 4 = 11-14 species present 5 = 15+ species present	The four scores for the attributes of mahinga kai are totalled and then averaged. i.e., equal weight is given to each.
	2. Comparison of the number of mahinga kai species present today with historical indications	1 = non-traditional site 1 = none of the species recorded in the past are still present 2 = less than half present 3 = at least half present 4 = more than half present 5 = all species present	1 = poor mahinga kai values 2.5 = average mahinga kai values 5 = excellent mahinga kai values
	3. Accessibility of the site	1 = no access to the site 3 = either physical or legal barriers make access difficult 5 = Unimpeded easy access to the site	
	4. Whether tangata whenua would return to the site	1 = no, would not return for mahinga kai gathering 5 = yes, would return for mahingakai gathering	
Component 3: Cultural stream health	1. Catchment land use	1 = Land heavily modified, wetlands & marshes lost 5 = Appears unmodified	Multiple people evaluate a given site according to the 8 attributes. The scores for each attribute are totalled, then, averaged. Then, the average scores for each attribute are added and averaged giving an overall stream health score. i.e., equal weight is given to each attribute.
	2. Riparian vegetation	1 = Little or no vegetation, neither exotic or indigenous 5 = Complete cover of vegetation – mostly indigenous	
	3. Use of riparian margin	1 = Margins heavily modified 5 = Margins unmodified	1 = poor stream health 2.5 = average stream health

	4. Riverbed condition/sediment	1 = Covered by mud/sand/slime/weed 5 = Clear of mud/sand/sediment/weed	5 = excellent stream health
	5. Channel modification	1 = Evidence of modification, e.g., stopbanks, straightening, gravel, removal, shingle build up 5 = Appears unmodified	
	6. Water quality	1 = Appears polluted 5 = No pollution evident	
	7. Water clarity	1 = Water badly discoloured 5 = Water is clear	
	8. Flow and habitat variety	1 = Little or no current, uniform depth and limited variety of flow related habitats 5 = Current and depth varies, creating a variety of habitats	

2.4.5 Wildlife/conservation/ecological values

Much of the literature refers to the wildlife, conservation or ecological values of rivers (see, for example, Daly, 2004; Dunn, 2000; 2004; Knutson et al. 1993; Mosley 2002; 2003; 2004; O'Donnell 2000; O'Donnell and Moore 1983), but like many of the other values specified in the *Significance assessment for river values method* project, few sources utilise a quantitative assessment.

O'Donnell and Moore (1983) were amongst the first to use a criteria-based evaluation system to assign relative values to rivers, for birdlife on Canterbury's braided rivers. Their scoring system was based on Wildlife Service criteria for rating habitats for conservation values. In this application it led to rivers being rated as: outstanding, high, moderate-high, moderate or potential. The system continues to be used today and applied in a variety of one-off resource management contexts (e.g., resource consent or water conservation order processes). Table 2-6 lists the criteria used for scoring under this system.

Table 2-6
Wildlife Service Criteria for rating habitats for conservation values (O'Donnell & Moore 1983)

Outstanding	a) Presence of a breeding population of a highly endangered or rare endemic species. b) Presence of a population of an endemic species of very restricted distribution and which could become endangered. c) Areas essential to species from (a) and (b) for purposes other than breeding. d) Areas of vital importance to internationally uncommon species (breeding and/or migratory). e) Areas of vital importance to internally migratory species with very limited distribution or abundance. f) Largely unmodified ecosystem or example of original habitat type not represented elsewhere in the country, of large size and containing viable populations of all or almost all species which are typical of the ecosystem or habitat type.
High	a) Habitat containing an indigenous species which has declined significantly because of man's influence. b) One of few or the only breeding area for a non-endemic indigenous species of limited abundance.

	c) Habitat of an uncommon, discontinuously distributed species not adequately represented in the ecological region or only represented in a particular ecological region. d) Example of a largely unmodified habitat which is not represented to the same extent elsewhere in the ecological region and is used by most species which are typical of that habitat type for the region. e) Presence of a species of an endemic family which is of limited abundance throughout the country although adequately represented in one ecological region but whose habitat is at some risk.
Moderate-High	a) Presence of a species which is still quite widely distributed but whose habitat has been and still is being significantly reduced or modified because of man's influence. b) Areas containing high numbers of breeding or moulting birds or where breeding or moulting areas are of inter-regional significance to wildlife. c) A large and fairly unmodified habitat or ecosystem which is represented elsewhere in the ecological region and contains all or almost all species typical of that habitat type for a particular region. d) An area where any particular species is exceptional in terms of, say, abundance or behaviour but which is otherwise widespread.
Moderate	a) All habitats supporting good numbers of species which are typical of that particular habitat within an ecological region and which have not been heavily modified by man's influence.
Potential	a) All areas of some wildlife significance which are limited by size, heavy modification or other reasons, but are of potential wildlife value if left to generate or are managed or developed for wildlife. (May include habitat which functions as a corridor or is sub-optimal habitat which is necessary for maintaining genetic diversity.

O'Donnell (2000) developed a more robust and quantitative system than that used in O'Donnell and Moore (1983) and has applied this to a broader range of wetland habitat types, including the original set of braided rivers. His criteria (summarised in Table 2-7are based "on general conservation principles" (O'Donnell 2000, p. 17). Each habitat (or section thereof as decided) is scored against these criteria and then the total is simply the sum of these scores. The total score is then used (Table 2-8) to assign the site to one of six categories of significance. This is a simple, yet seemingly effective method of developing a comparative ranking index for rivers.

Table 2-7
Criteria for ranking habitat value to birds
(O'Donnell 2000)

Criteria	Sub criteria	Weighting scale range
A. Representativeness	Number of guilds present	1-7
	Level of endemism	1-3
	Quality of representation of habitat	1-3
B. Life supporting capacity	Habitat size	1-4
	Numbers	1-4
	Breeding guilds	0-7
	Feeding guilds	0-7
	Roosting guilds	0-7
C. Natural diversity	Within guilds	1-2
	Microhabitat diversity	1-10
	Number threatened species	0-7
D. Distinctiveness	Overwintering	0-1
	Migration stopover	0-1
	Significant breeding site	0-1
	Significant moulting site	0-1
	Only region typically supporting a particular species	0-1
	Habitat for specialist needs	0-1
	Habitat for species with special diet or foraging behaviour	0-1
E. Intactness/naturalness	Level of modification	1-4
F. Long term viability	Vulnerability to natural perturbations	1-3

Table 2-8
Habitat significance scores for wildlife
(O'Donnell 2000, p.21)

Rank	Score	Habitat significance
High 1	>50	National-International
High 2	40-49	National
High 3	30-39	Regional
Medium 1	20-29	Local
Medium 2	<20	Low

In Daly's (2004) inventory of in-stream values for Canterbury rivers and lakes aquatic ecological values are assessed according to the species present in the following categories: indigenous plants, indigenous invertebrates, indigenous birds, indigenous fish, salmonids and other. Other than species identification, no assessment criteria are provided. In Mosely's (2002; 2003; 2004) assessments of the natural character, amenity values and flow regimes of several Canterbury rivers, he adopts the term 'natural values' which comprises of the following attributes:

- Life-supporting capacity of water and associated aquatic and riparian ecosystems;
- Significant habitats of indigenous fauna and flora;
- Natural character;
- Habitat areas of braided river birds;
- Significant habitat of trout and salmon;
- Significant natural features and landscapes.

In contrast, Norton and Roper-Lindsay (2004) sought to develop an "ecologically sound and consistent approach that could be used throughout the country" (p. 298) to determine ecological significance. Although the approach used is not wholly quantitative, the criteria or attributes contributing to ecological significance are assessed as being either positive or negative. Four criteria/attributes to assess ecological significance were proposed: 1) rarity and distinctiveness, 2) representativeness, 3) ecological context and 4) sustainability. The first three pertain to a given site's current state and the sustainability criterion pertains to the future of the site. The authors concluded that these four criteria "provide sufficient information for assessment of the ecological values of terrestrial and freshwater sites in New Zealand" (p. 298). Table 2-9 presents the criteria used to assess ecological significance and the indicators for determining if a site is positive or negative.

Table 2-9
Criteria/attributes and the indicators used to assess ecological value and site significance
(Norton & Roper-Lindsay, 2004)

Criteria/attributes for assessing site significance	Indicators used to determine if site is positive or negative
Rarity and distinctiveness (site criterion)	A site is positive if it is known to support a species: • That is listed acutely threatened on the New Zealand Threat Classification system • That is at a national distributional limit • Only occurs in that area, or is particularly uncommon in the study area.
Representativeness (site criterion)	A site is positive if it: • Supports an ecosystem that is now at less than *c.*10% of its former extent in the ecological district • Supports a high quality example of an ecosystem that is now less than *c.*20% of its former extent in the ecological district.

Ecological context (site criterion)	An area is positive if it: • Enhances connectivity between patches • Buffers or similarly enhances the ecological values of a specific site of value • Provides seasonal or "core" habitat for specific indigenous species.
Sustainability (future criterion)	A site is considered positive if: • Key ecological processes remain viable or still influence the site • The key ecosystem within the site are known to be or are likely to be resilient to existing or potential threats under some realistic level of management activity • Existing of potential land and water uses in the area around the site could be feasibly modified to protect ecological values.

Using the above assessment, if a site is positive for a site criterion and positive for sustainability, the site is considered 'significant'. If the site has no positive site criteria, or it has a positive site criteria but is negative in terms of sustainability then the site is not considered to be a 'significant natural area'[11].

Internationally, researchers in Britain and Australia have attempted to standardise attributes relating to the ecological or conservation value of rivers (Boon, Wilkinson & Martin, 1998; Boon, Holmes, Maitland & Fozzard, 2002; Dunn, 2000; 2003; 2004). In Britain during the 1990s, a system for evaluating the conservation values of rivers was developed: 'System for Evaluating Rivers for Conservation' (SERCON) (Boon et al., 1998). Although this system only considers conservation value, the method developed could potentially be extended to the other values included in the current project. SERCON utilises a wide variety of information to generate scores (on a scale of 0-5) for six attributes:

1) Physical diversity;
2) Naturalness;
3) Representativeness;
4) Rarity;
5) Species richness; and
6) 'Special features'.

Each of these attributes has a number of indicators (see Table 2-10).

Table 2-10
List of attributes and indicators used in the System for Evaluating Rivers for Conservation SERCON) (Boon et al. 1998)

Attribute	Indicators	Attribute	Indicators
1. Physical diversity	1. Substrates 2. Fluvial features 3. Structure of aquatic vegetation	**2. Naturalness**	1. Channel naturalness 2. Physical features of the bank 3. Plant assemblages on the bank 4. Riparian zone 5. Aquatic and marginal macrophytes 6. Aquatic invertebrates 7. Fish 8. Breeding birds

11 The term 'significant' is used in this study according to the definition given in the Resource Management Act 1991.

3. Representativeness	1. Substrate diversity 2. Fluvial features 3. Aquatic macrophytes 4. Aquatic invertebrates 5. Fish 6. Breeding birds	**4. Rarity**	1. Habitats Directive/Bern Convention species (+ rare in UK) 2. Scheduled species 3. Habitats Directive species (but not rare in UK) 4. Red Data Book/Nationally scarce macrophyte species 5. Red Data Book/Nationally scarce macrophyte species
5. Richness	1. Aquatic and marginal macrophytes 2. Aquatic invertebrates 3. Fish 4. Breeding birds	**6. Special features**	1. Influence of natural on-line lakes 2. Extent and character of riparian zone 3. Floodplain: recreatable water-dependent habitats 4. Floodplain: unrecreatable water-dependent habitats 5. Invertebrates of river margins and banks 6. Amphibians 7. Wintering birds on floodplain 8. Mammals

Attribute scores are weighted and combined to produce a series of conservation and impact indices. During 1999, a review of SERCON was undertaken and improvements made (Boon et al., 2002). SERCON appears to be a sophisticated and well-developed method for evaluating the conservation value of rivers. It incorporates a weighting system which many of the other methods lack. The weights used in SERCON were determined through extensive consultation with experts.

Drawing from SERCON and work by Collier (1993), Dunn (2000; 2004) implemented a survey of Australian river scientists and managers to determine the particular values and attributes that describe conservation significance of Australian rivers. The survey consisted of a series of attributes associated with conservation values relating to rivers and respondents were asked to indicate the importance of each attribute. Five criteria were determined:

1) Naturalness;
2) Representativeness;
3) Diversity and richness;
4) Rarity;
5) Special features[12].

The survey results revealed that there were 47 attributes which indicated high ecological value[13]. It is important to note, however, that the results from this survey were simply to provide a foundation from which an assessment tool might be developed (Dunn, 2004).

Dunn's (2000) report of this process *Identifying and protecting rivers of high ecological value* might be particularly useful to the current project. Dunn identified three elements which were necessary to achieving an assessment method; two of which bear much resemblance to the RiVAS project. The first is "definition – laying out those criteria and attributes which define ecological value", and the second is "evaluation – specifying the basis on which comparisons will be made and making judgements" (p, 23). In addition, Dunn extensively reviews models and approaches which have been used to assess rivers in Australia and internationally. She includes much information about the

12 These criteria were based on the SERCON tool developed in Britain, and Collier's (1993) work.
13 See original sources for the list of attributes defined.

criteria and attributes used in the different assessment methods, but little on what indicators were used and how they were measured. One method included in Dunn's review is the 'draft framework for conservation and sustainability' developed by the *Environment Protection Agency (Queensland)* (see pages 14 & 33 in Dunn, 2000). Little detail is provided, but this approach uses a weighting system to evaluate the attributes and obtaining the original source might reveal an appropriate method which could be adapted for the purposes of the current project.

2.4.6 Irrigation/hydro-electric development values

When compared with the other values included in the *Significance assessment for river values* project, few sources that were directly relevant were found concerning industrial values such as irrigation or hydro-electricity. In addition, the methods which have been used for assessing industrial values depart from the approaches described above. In New Zealand, water is not commonly traded; therefore, it is difficult to place a monetary value on water resources especially with regard to irrigation and hydro-electric development (Waugh, 1992). Despite this characteristic of industrial water use in New Zealand, those sources that were found considered these values from an economic perspective (Grimes & Aitken, 2008; Ministry of Agriculture and Forestry, 2004).

One such method is the hedonic property value approach to water valuation used by Grimes and Aitken (2008). This method uses sales prices and valuation data together with resource consent data and the value of farm improvements to calculate the net economic contribution of irrigation water. Characteristics of individual farms, such as slope, drainage, rainfall and distance to nearest towns/cities, must also be controlled for to allow comparisons of irrigation value. This method is appropriate in the New Zealand context because legal rights (via consents) to abstract water from waterways are not transferable; they remain with the farm when it is sold. Grimes and Aitken concluded that for the Mackenzie District, where they applied this approach, water and the right to abstract water was a valuable commodity. However, water was more highly valued in areas which were more suitable for water-intensive land uses and these areas could be determined through particular farm characteristics (e.g., slope, drainage, rainfall, or distance to nearest town). Such characteristics might usefully be converted to attributes by which irrigation values could be assessed.

Another method applied in New Zealand to value irrigation is the adjusted gross margin (GM) method which utilised a "with minus without" irrigation approach (Ministry for Agriculture and Forestry, 2004). The resultant formula used was:

Farm gate GDP due to irrigation = GDP with irrigation – GDP without irrigation

GDP with irrigation = (irrigated land use mix X (irrigated GM – fixed costs))

GDP without irrigation = (dryland use mix X (dryland GM – fixed costs)

The purpose of the study was to assess the economic value to New Zealand of water use through irrigation. The results of this work showed that in 2002/2003 the net contribution of irrigation to GDP at the farm gate was approximately $920 million. This is equivalent to 11% of total GDP at the farm gate for the same period. While this report only addressed the socio-economic value of irrigation to New Zealand, the intention of the report was that it would be used in conjunction with work being done involving other water values such as recreational, cultural and conservation values.

2.5 Table summary of the sourced literature

A summary of the sources reviewed in this chapter is given in Table 2-11. The table is organised according to the relevancy (high, medium or low) of each source to the current project (the final column) and then within each relevancy classification, sources are listed in alphabetical order by author/s.

Sources which have been categorised as highly relevant are those sources which include quantitative assessment and evaluation of river values (or values associated with the landscape setting under investigation). Sources of medium relevancy provide information regarding multiple river values and their associated attributes, but lack quantitative assessment. Sources of low relevancy include those sources which provide more general information relating to the ways in which rivers are valued.

Table 2-11
Summary table of relevant literature relating to the RiVAS project
Note that literature is organised according to a subjective assessment of relevancy to this research project (far right column) and author (far left column)

Author/s	Title	Location	Values identified	Attributes identified	Means of combining and evaluating attributes	Relevancy to project (high, medium, low)
Collier (1993) Collier & McColl (1992)	Towards a protocol for assessing the natural value of new Zealand rivers Assessing the natural value of New Zealand rivers.	New Zealand	1. Natural values	1. Ecological representativeness or rare type of ecosystem 2. Degree of modification 3. Diversity and pattern 4. Rarity and unique species or features 5. Long-term viability	Descriptors and weightings (in terms of importance) were determined through expert opinion collected via surveys. Due to the number of descriptors and weightings, they are not reproduced here (see original report). To combine the indicators used for each criterion/attribute the values assigned were divided by the maximum score, and then multiplied by the weighting. The sum of the indicator scores was then divided by the sum of the weightings for all indicators and multiplied by 100 (the score for the attribute, degree of modification, was then subtracted from 100). This method could potentially be extended to the other values in the RiVAS project.	High
Boon, Wilkinson & Martin (1998) Boon, Holmes, Maitland & Fozzard (2002)	The application of SERCON (System for Evaluating Rivers for Conservation) to a selection of rivers in Britain Developing a new version of SERCON (System for Evaluating Rivers for	Britain	1. Conservation values	1. Physical diversity 2. Naturalness 3. Representativeness 4. Rarity 5. Species richness 6. Special features 7. Additional features (this criterion does not contribute to the calculation of the conservation indices) 34 indicators are used to measure these attributes which are presented in Table 2-10. Readers are also directed to the original source for more information.	Data are gathered via a field survey of the river corridor and other data on physical, biological and chemical features of the river is gathered from other sources. These data are then converted into a series of scores on a 0-5 scale for each of the identified attributes. Scores are weighted and combined to produce separate indices of conservation value (0-100) for the 6 criteria.	High

	Conservation)				Data are given a quality score of A (high), B (medium) or C (low) confidence in the data. This aids in data interpretation and appropriate caution can be taken for particularly poor quality data.	
Dunn (2000) Dunn (2004)	Identifying and protecting rivers of high ecological value Defining the ecological values of rivers: The views of Australian river scientists and managers	Australia	1. Aquatic biodiversity/conservation/ecological values	1. Naturalness 2. Representativeness 3. Diversity and richness 4. Rarity 5. Special features Taken from survey of Australian river scientists and managers	A survey of river scientists and managers was implemented to determine the attributes of rivers with high ecological value. The survey was a foundation to the development of assessment tools.	High (Although this source does not include any quantitative assessment of river values, it has been rated as having 'high relevancy' because the report bears much resemblance to the current project and includes a comprehensive review of the ways in which rivers (and other ecosystems) have been assessed according to conservation or ecological values)
Egarr, Egarr & MacKay (1979)	64 New Zealand Rivers: A scenic evaluation	New Zealand – nationwide	1. Scenic values	1. Vegetation 2. Banks and riverbed 3. Landscape 4. Wilderness feeling 5. Water quality 6. Water movement 7. Other factors	Each attribute was evaluated on a five-point scale (with the exception of water quality and other factors). Rivers in the study were divided into stretches. Each stretch was evaluated for each attribute and then the scores summed. All attributes were given equal significance.	High

Knutson, Leopold & Smardon (1993)	Selecting islands and shoals based for conservation based on biological and aesthetic criteria	America	1. Biological 2. Aesthetic/visual	Biological 1. Common tern nesting site 2. Bald eagle winter use area 3. Rare plant habitat 4. Significant coastal wildlife habitat 5. Plant species richness Scores for each biological criteria potentially ranged from 1-10 (see original article for the ways in which these scores were assigned). Visual/aesthetic 1. Landform 2. Vegetation 3. Colour 4. Cultural features Each visual criterion was assessed as being Distinctive (5), Average (3), or Minimal (1). (See original article for a table detailing the ways in which these assessments were made).	"The maximum of the biological and the visual scores becomes the final rating for an individual island. This assures a high ranking for any island important in either one of these categories" (p. 201). Visual quality score weighted on the basis of the visibility of the island or shoal from scenic vantage points.	High
Leopold (1969)	Quantitative comparison of some aesthetic factors among rivers	United States – Idaho	1. Landscape/aesthetic/scenic values	46 factors/attributes are included in this assessment. Due to the large number of factors they are not listed here (see original article). The factors are grouped into three broad categories: 1. Physical features 2. Biological features 3. Human interest features Each factor/attribute is evaluated on a 1-5 scale (see original report for this scaling system).	Ranking schemes – between sites a uniqueness ratio is calculated. For example, if a site shares the same score for a given factor with 7 other sites it is unique in the ratio 1 to 7 (0.14). If no other site shares the same score for a given factor then the site has a uniqueness ratio of 1:1 (1.0). The uniqueness ratio is defined on a scale of 0-1.0. Uniqueness ratios are then summed to give an overall uniqueness score and subtotals for each of the 3 categories (physical, biological & human interest). Sites can then be ranked according to these scores. Leopold also undertakes a comparative analysis of selected factors by which to evaluate the different sites. He presents these analyses in a series of figures (see original article).	High
O'Donnell & Moore (1983)	The wildlife and conservation of braided river systems in Canterbury	New Zealand, Canterbury	1. Wildlife	Using O'Donnell (2000): 1. Representativeness 2. Life supporting capacity 3. Natural diversity	Many criteria have multiple sub criteria. These are all weighted on scales of 0-1 (No or Yes), or 0-'x' (depending on the number of sub criteria) and then scored accordingly.	High

O'Donnell (2000)	The wildlife and conservation of braided river systems in Canterbury			4. Distinctiveness 5. Intactness/naturalness 6. Long term viability	The overall score is the sum of this evaluation. Habitat significance is then comparatively evaluated on a 5-tiered scale from High 1 (= National-International significance) to Medium 2 (= Low significance).	
Teirney & Richardson (1992) Teirney, Richardson & Unwin (1987)	Attributes that characterize angling rivers of importance in New Zealand, based on angler use and perceptions The relative value of North Canterbury rivers to New Zealand anglers (NB: This is a regional report of the nationwide study reported in the 1992 article above.)	New Zealand – nationwide New Zealand – Canterbury	1. Angling values	1. Distance from home (1 = remote, 5 = close) 2. Ease of access (1 = difficult, 5 = easy) 3. Area of fishable water (1 = restricted, 5 = extensive) 4. Scenic beauty (1 = low, 5 = high) 5. Peace and solitude (1 = low, 5 = high) 6. Catch rate (1 = low, 5 = high) 7. Size of fish (1 = small, 5 = large)	Using a 1 (lowest) to 5 (highest) scale, respondents rated each attribute and the overall importance of the river. Spearman rank correlations and stepwise regressions were used to determine which attributes were most closely associated with anglers' perceptions of overall importance.	High
Tipa & Teirney (2006)	Using the cultural health index: How to assess the health of streams and waterways	New Zealand	1. Tangata whenua/Maori/Cultural values	Status of site 1. Traditional/non-traditional site 2. Future use Mahinga kai 1. Number of mahinga kai species 2. Historical comparison 3. Accessibility 4. Would tangata whenua gather mahinga kai in the future Cultural stream health 1. Catchment land use 2. Riparian vegetation 3. Use of Riparian margin 4. Riverbed condition/sediment 5. Channel modification 6. Water quality 7. Water clarity 8. Flow and habitat variation	Mahinga kai and cultural stream health attributes were evaluated using a 1-5 scale. Scores were then totalled and average giving equal weight to each attribute.	High
Bergmann,	Valuing the attributes	Scotland	1. Renewable energy	1. Impacts on the landscape	The Choice Experiment method was used.	Medium

Hanley, Wright (2006)	for renewable energy investments		– including hydro electric schemes	2. Impacts on wildlife 3. Impacts on pollution levels, in particular air pollution 4. Creation of long-term employment opportunities 5. Potential increases in electricity prices to pay for renewable sources		
Egarr & Egarr (1981a; b; c)	New Zealand recreational river survey	New Zealand – nationwide	1. Recreational values/potential	1. Suitability of use for each recreational group 2. Access 3. Problems and obstructions to use 4. Proximity to demand 5. Skill or challenge factor Consideration of these factors leads to categorising rivers according to the following scale of recreational value. 1. Low (valueless & mediocre) 2. Intermediate (average) 3. High (popular) 4. Exceptional (extreme)	Difficult to find satisfactory formula to rank one attribute against another, especially when trying to apply this formula in different areas of the country. Combining the recreational and scenic values assigned to each river. Category A: all rivers with exceptional recreational value and exceptional scenic value Category B: all rivers with exceptional recreational value and impressive scenic value or high recreational value and exceptional scenic value Category C: all rivers with exceptional recreational value and picturesque scenic value or high recreational value and impressive scenic value or high recreational value and picturesque scenic value or exceptional recreational value and moderate scenic value Category D: all rivers with high recreational value and moderate scenic value or intermediate recreational value and exceptional scenic value or intermediate recreational value and impressive scenic value or intermediate recreational value and picturesque scenic value.	Medium
			Scenic value	1. Vegetation (volume, variety & virginity) 2. Geological makeup 3. Vista 4. Wilderness or naturalness 5. Water quality 6. Water movement 7. Utilities 8. Wildlife Consideration of these attributes lead to evaluating each river on the following six-point scale. 1. Dull 2. Uninspiring 3. Moderate 4. Picturesque 5. Impressive 6. Exceptional		
Daly (2004)	Inventory of instream values for rivers and lakes of Canterbury New Zealand	New Zealand – Canterbury	1. Landscape values	1. Natural character = high/moderately high/moderate/moderately low/low 2. Outstanding natural features and landscapes = high (outstanding)/moderately high/ moderate (significant)/moderately low/low (unremarkable)	Evaluations for the attributes comprising 'landscape' and 'visual amenity and recreational' values have associated indicators and numerical scores. These have been taken from a report prepared for Environment Canterbury by Boffa and Miskell (2001). In most cases a 1-5 scale was used	Medium
			2. Aquatic Ecological	1. Indigenous plants		

			values	2. Indigenous invertebrates 3. Indigenous birds 4. Indigenous fish 5. Salmonids 6. Other Lists of appropriate species obtained from Department of Conservation documents	and scores summed to provide score categories of high/moderate/low etc. Indicators are not weighted.	
			3. Visual amenity and recreational values	1. Visual amenity (wild and scenic) = high/moderate/low 2. Recreation (frequency of use) = high/moderate/low		
			4. Education, scientific and heritage values	1. Importance = international/national/regional Determined from New Zealand Geological Society geo-preservation sites inventories and classifications.		
			5. Tangata whenua values	1. Mauri 2. Mahinga kai 3. Wahi tapu		
Grimes & Aitken (2008)	Water, water somewhere: The value of water in a drought-prone farming region	New Zealand – Mackenzie Country	1. Industrial values (irrigation)	1. Farm sale prices 2. Land values assessed by an independent body 3. Value of improvements to the property	Hedonic property value approach to water valuation Statistical analyses using farm sale prices, land valuation data, and resource consent data. Farm Characteristics such as value of improvements, slope, drainage, rainfall and distance to towns, are controlled for. (See original source for equations).	Medium
Ministry of Agriculture and Forestry (2004)	The economic value of irrigation in New Zealand	New Zealand	1. Industrial values (irrigation)	1. GDP with irrigation 2. GDP without irrigation	The gross margin method was used which utilised a "with minus without" irrigation approach. (See Section 2.6 for the formula used).	Medium
Ministry for the Environment (1998)	Flow guidelines for instream values – volume A	New Zealand	Report is organised according to the following: 1. Ecological values 2. Landscape values 3. Recreational values 4. Maori values		These river values are considered and discussed within the context of the Resource Management Act 1991. No quantitative assessment is made.	Medium

			The report also separates river values into 'in-stream values' and 'out-of-stream values'. In-stream values 1. Ecological values 2. Aesthetic values (recreation & landscape) 3. Maori cultural and traditional values Out-of-stream values 1. Abstraction of water 2. Diversion of water into or out of rivers 3. Damming 4. Changing land use patterns			
Ministry for the Environment. (2004)	Water bodies of national importance: Potential water bodies of national importance for recreation value.	New Zealand	Part of the *Water Programme of Action* which seeks to identify water bodies of national importance for a range of values: 1. Natural heritage 2. Recreation 3. Cultural and historic heritage 4. Irrigation 5. Energy industry 6. Domestic use 7. Tourism This report seeks to develop methodology for determining water	Two primary reasons for assessing water bodies of national importance in terms of recreational value were identified. 1. Location 2. Type of water body.	Three methods were employed. An internet survey, a telephone survey, and a literature review	Medium

			bodies of national importance for recreation value.			
Mosley (1989)	Perceptions of New Zealand river scenery	New Zealand	1. Scenic 2. Recreational	43 primary variables or characteristics of rivers were selected to describe the river scapes. Due to the high number of factors, they have not been reproduced here. The variables were measured in a variety of different ways. For example, percentage of native forest, five-point scales (e.g., velocity class of river), distance to farthest point visible in photograph. See original source for a full list of variables and the measurements used.	A series of statistical analyses were used to determine the variables influencing people's perceptions the most.	Medium
Mosley (1999)	Natural character and amenity values of rivers and lakes	New Zealand	1. Natural character 2. Amenity values	This report "does not specify the particular measurements that are required to describe the attributes…. Nor does it include protocols for carrying out the measurements…… This task would be a major exercise, although a considerable amount of guidance already is available in documents such as the *Lake Managers Handbook* (Vant, 1987) and *A procedure for characterising river channels* (Mosley, 1982). In terms of evaluating the degree of natural character of a locality, however, a simple ranking of the degree of naturalness of a particular attribute would be more economical than carrying out a full quantitative survey" (p. 23).	Includes discussion of the ways in which amenity values and natural character are defined in legislation and regional policies.	Medium
Mosley, (2002) Mosley (2003) Mosley (2001)	Hurunui River: In-stream values and flow regime Waipara River: In-stream values and flow regime Rangitata River: natural character, amenity values and flow regime (NB: this report adopts a slightly different format to the above three, however includes discussion of	New Zealand – Canterbury	1. Natural values 2. Cultural values 3. Heritage values 4. Amenity values 5. Recreational values	Natural values 1. Life-supporting capacity of water and associated aquatic and riparian ecosystems 2. Significant habitats of indigenous fauna and flora 3. Natural character 4. Habitat areas of braided river beds 5. Significant habitat of trout and salmon 6. Significant natural features and landscapes Cultural values 1. Mahinga kai areas 2. Wahi tapu and other wahi taonga	Values of the specified river are considered within particular flow regimes.	Medium

	the same values.)					
Mosley (2004)	Waiau River: In-stream values and flow regime	New Zealand – Canterbury	NB: Owing to the multiple number of values identified in this reference, the attributes comprising each value have been listed under according to each. 1. Landscape values • Natural character • Outstanding natural features and landscapes 2. Aquatic Ecosystem values • Indigenous plants • Indigenous fauna (birds, fish, other) • Salmonids 3. Visual amenity (wild and scenic and recreation values 4. Educational scientific heritage values tangata whenua values			Medium
Norton, & Roper-Lindsay (2004)	Assessing significance for biodiversity conservation on private land in New Zealand	New Zealand	1. Ecological/conservation/indigenous biodiversity values	Site criteria/attributes 1. Rarity and distinctiveness 2. Representativeness 3. Ecological context Future viability of site criterion 4. Sustainability Each criterion is assessed as being positive or negative. The original article includes the descriptions necessary to determine if a site is positive or negative for each criterion. Two stage assessment process. 1. Site criterion assessed. If any one is positive then: 2. Assessed against the sustainability criterion.	If a site is positive for a site criterion and positive for sustainability, the site is considered 'significant'. If the site has no positive site criteria, or it has a positive site criteria but is negative in terms of sustainability then the site is not considered to be a 'significant natural area' (in terms of the RMA).	Medium
Rob Greenaway and Associates (2003b)	Waitaki River recreation survey	New Zealand – Waitaki River	1. Recreational values	1. Fish 2. Peacefulness 3. Quality of the water 4. Accessibility 5. Size of the river 6. The landscape 7. Other people you meet		Medium
Sutherland-	Inventory of	New Zealand	1. Recreational value	1. Travel time (close/ moderate/far)	Document is simply a descriptive inventory,	Medium

Downing & Elley (2004)	recreation values for rivers and lakes of Canterbury New Zealand	– Canterbury	This is broken down into sub-values 1. Recreation physical value • water quality = high/moderate/low • natural appeal = high/moderate/low • scenic appeal = high/moderate/low 2. Recreation use values Frequency = high/moderate/low Intensity = high/moderate/low 3. Recreation use types	2. Facilities (Extensive/many/ some/limited) 3. Accommodation (Camping/ Tramping hut/caravan/ campervan/crib or batch) 4. Fishing and hunting abundance of target species (very common/ common/ uncommon – for each species) 5. Channel features (Shallows/ waterfalls/shallow rock drops/rock obstacles/ riffles/ rapids/pools) 6. Flow strength (Sluggish/ moderate/strong/ powerful) 7. Flow conditions supporting recreation (Year-round/ certain times of year) 8. Obstructions (Bank-side willows/bank or bed obstructions) 9. Accessibility (Along bank/bed = good/limited; Road to & from water-body = good/moderate/ private; Boat = good/ moderate/ limited)	i.e., no quantitative evaluation is undertaken. Descriptions for each evaluation are given in the report. An evaluation of the desirable values and attributes for a number of different types of recreation is also provided. The recording sheets are contained as an appendix to the report.	
Te Runanga o Ngai Tahu (1999)	Te Runanga o Ngai Tahu: Freshwater policy statement	Ngai Tahu – South Island, NZ	1. Tangata whenua/Maori/cultural values – mauri and kaitiakitanga	Mauri 1. Aesthetic qualities, e.g., clarity, natural character and indigenous flora and fauna 2. Life-supporting capacity and ecosystem robustness 3. Depth and velocity of flow 4. Continuity of flow from the mountain source of a river to the sea 5. Fitness for cultural usage 6. Productive capacity Kaitiakitanga 1. Role of particular waterways in unique tribal creation stories 2. Role of those waterways in historical accounts 3. Proximity of important wahi tapu, settlement or other historical sites in or adjacent to specific waterways 4. Use of waterways as access routes or transport courses 5. Value of waterways as traditional sources of mahinga kai food and other cultural materials; and 6. Continued capacity for future generations to access, use and protect the resource	This source is a policy statement, rather than a method of assessment.	Medium

Tipa (2001)	Rangitata River: Tangata Whenua values	New Zealand – Canterbury	1. Tangata whenua/Maori/Cultural values	1. Place names 2. The wider catchment 3. Mauri 4. Waahi tapu/taonga (sites of significance access to areas), mahinga kai (resource use), Trails 5. Kaitiakitanga.	Primarily descriptive and qualitative	Medium
Dunn (2003)	Can conservation assessment criteria developed for terrestrial systems be applied to riverine systems	Australia	1. Conservation values		Useful discussion of the applicability of assessment criteria developed for terrestrial systems to riverine systems.	Low
Grindell & Guest (1986) – cited in Mosley (2002)	A list of rivers and lakes deserving inclusion in a schedule of protected waters		1. Wild values 2. Scenic values 3. Recreational values 4. Fisheries values 5. Wildlife habitat values 6. Flora values 7. Scientific values 8. Educational values 9. Cultural values 10. Other amenity values			
Griffin (1975)	A comprehensive study of the Styx River and river catchment	New Zealand – Christchurch	2. Recreational	1. Geology 2. Soils 3. Relief 4. Climate 5. Visual aspects of land use 6. Emergent features 7. Ecology 8. Zoning 9. Roading 10. Landscape character 11. Access and availability if the river to the public 12. Present uses 13. Associated problems	A qualitative assessment of the recreational value of the Styx River in Christchurch, New Zealand. However, this source has been included here because Griffin considers a range of factors/criteria which influence recreational value.	Low
Jowett (1992)	River hydraulics and instream habitat modelling for river biota	New Zealand	1. Wildlife/biota (trout)	1. Adult trout habitat 2. Food production 3. In-stream cover 4. Water temperature	No numerical assessment of these criteria. Source is about the relationship between river flows and amount of suitable habitat for wildlife.	Low

				5. Substrate		
Kingston Reynolds Tom and Allardice Limited., & Kearsley (1982)	Ministry of Works and Development for New Zealand electricity (a division of Ministry of Energy): Upper Clutha Development Kawarau River recreation study.	New Zealand – Kawarau River	1. Recreational Value 2. Scenic value	In terms of scenic value, the survey implemented in this study requested respondents to indicate what was the most visually appealing feature of the Kawarau Gorge from the following list: 1. Outcrops of bare rock 2. Type of vegetation 3. The narrow road 4. Movement of the river 5. The steep slopes 6. Absence of habitation 7. The historic context 8. Colour of the river 9. Height of the road 10. The power of the river 11. The wildlife 12. The power station	Questionnaire Primarily descriptive analyses	Low
Phillips & Joy (2002)	State of the environment report: Native fish in the Manawatu-Wanganui region	Manawatu-Wanganui region	1. Wildlife – native fish values	1. Presence or absence of different species of fish	Multivariate statistical analyses were used to develop relationships between the areas where fish were present and the associated habitat characteristics	Low
Unwin & Image (2003)	Angler usage of lake and river fisheries managed by Fish and Game New Zealand: Results from the 2001/02 national angling survey	New Zealand - nationwide	1. Angling values	1. Angler usage	Calculated as number of angler days. NB: Other studies have suggested that angler days are not an adequate indication of the true value of a river in terms of its angling opportunities.	Low

2.6 Conclusions

This chapter has described and analysed the available New Zealand and international literature addressing the ways in which rivers might be classified according to their associated values. It has shown that while much is known about the ways in which rivers are valued, less work has been done which incorporates these values in such a way that rivers can be compared and subsequently classified. Consequently, none of the sources outlined in this chapter appears to offer a method which is directly applicable to the RiVAS.

The most highly relevant sources for the current project are those which quantitatively assess the river values with which they are concerned. To date, most quantitative assessment work and, consequently, that which is directly relevant to the current project, assesses scenic/landscape/natural and wildlife/conservation/ecological values. Work assessing the other values appears to be less common. Moreover, the approaches used to assess angling, recreational, scenic/landscape/natural, tangata whenua, and wildlife/conservation/ecological values are broadly similar in that they identify appropriate attributes and indicators (in some cases attempting quantitative assessment). However, methods used to assess irrigation values are more economic in nature. Also, with the exception of Egarr and Egarr (1981a) and Knutson et al. (1993), most of the literature employing quantitative assessment methods considers just a single value.

Many of these quantitative assessments adopt an arbitrary five-point scale and denote descriptors to each end of the scale (see, for example, Egarr & Eggar, 1981a; b; c; Egarr, Egarr & MacKay, 1979; Teirney & Richardson, 1992; Tipa & Teirney, 2006). The number of studies which assign weightings denoting relative importance to attributes is small though. As identified by Egarr and Egarr (1981a) developing a rational argument for allotting greater importance to particular attributes will be difficult. Even within a given value (e.g., angling), there will be differences in the importance placed on different attributes by different types of anglers (see, for example, Ferrer, Montano, Dibble, Jackson & Rundle, 2005). This point was also highlighted by Teirney and Richardson (1992) when they found that the factors influencing the importance anglers placed on rivers differed depending on the type of fish caught.

Several sources, however, offer approaches that warrant consideration during the development of the current project. These most highly relevant sources are:

- The System for Evaluating Rivers for Conservation (SERCON) developed in Britain (Boon, Wilkinson & Martin, 1998; Boon, Holmes, Maitland & Fozzard, 2002)
- Collier's (1993) Towards a protocol for assessing the natural value of New Zealand rivers
- Knutson, Leopold and Smardon's (1993) Selecting islands and shoals based for conservation based on biological and aesthetic criteria
- Leopold's (1969) Quantitative comparison of some aesthetic factors among rivers

In addition, Dunn's (2000) report *Identifying and protecting rivers of high ecological value* also warrants attention, primarily because the purposes of her study regarding the ecological value of Australian rivers bears much resemblance to those of the current project. Further investigations could be made as to whether an assessment tool has been developed as a result of the process used to define attributes of ecological value undertaken by Dunn.

While these sources appear to offer the current project some direction, Dunn (2000) issued an appropriate caution for the development of river value assessment tools when she posed the question "Are the kinds of values reflected in river assessment protocols developed overseas relevant and adequate for Australian [or New Zealand] rivers?" (Dunn, 2004, p. 417).

Much of the work outlined in this chapter is descriptive and qualitative in nature, lacking any quantitative assessment. However, the ways in which values are discussed and the attributes listed in these sources could provide a useful foundation for the current project and further quantitative assessment. Specifically, Sutherland-Downing & Elley's (2004) inventory of recreational values associated with Canterbury waterways seems particularly useful due to their inclusion of lists of values and desirable attributes associated with a wide range of recreational activities undertaken in riverine environments.

While there is some consistency regarding the attributes which constitute different values, there is also much diversity, which is probably a reflection of the ad hoc nature of the body of literature concerning river value assessment. Perhaps the soundest approach for standardising attributes for given river values is that employed by Boon et al. (1998; 2002), Collier (1993), Dunn (2000; 2004) and Tipa & Teirney (2003; 2006), consultation with experts in the relevant field.

By way of a final point, a factor influencing the ways in which rivers are valued that seems to be absent from the literature is place attachment or sense of place. Although a central premise of the angling survey conducted in the 1980s (Teirney et al., 1987; Teirney & Richardson, 1992) was that visitation alone could not adequately indicate the true value of a given river, none of the other factors included in the study addressed the ways in which people value rivers as a result of place attachment. This factor would be particularly applicable for angling and other recreational values.

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