A FRAMEWORK FOR THE NATURAL VALUES OF CANADIAN HERITAGE RIVERS

Second Edition

March 2001

PREFACE

This second edition of what is commonly referred to as the *CHRS Natural Heritage Framework*, represents the final stage of work begun in 1992. The first edition, completed in March 1998, was applied to CHRS nomination documents and other studies and plans for three years. The effectiveness of the themes, sub-themes and elements of the framework were evaluated during this period and this second edition is the result. The six themes and eighteen sub-themes that comprise the framework attempt to encompass, and indeed define, the breadth of Canada's natural river heritage in a rational and comprehensive manner.

While the reader and user may judge how well this goal has been accomplished, it is believed that this framework will provide a common tool for planning staff in government agencies participating in the Canadian Heritage Rivers System (CHRS). For these agencies it can, and *should* according to the Board's guidelines, be applied to CHRS research studies, river nominations, and management strategies. For government managers, it is a tool that can help direct resources to rivers and river values of national concern. For the CHR Board, and for commentators on the program, the framework will allow measurement of the status of the System, identification of its strengths and of gaps in its representation of Canada's river heritage. For non-government agencies and individuals interested in the program, it will facilitate more effective participation, particularly in making the argument for inclusion of rivers in the System and in preparing management strategies for rivers that are included.

It is believed that the framework is an advancement in the general, if small, cause of classifying and defining river heritage from a global perspective. By academic standards the categorization of river features in the framework may seem simplistic and sub-themes and elements defined too generally. It is important to realize that the framework is intended to be easily understood and applied widely. It must be applied by planners without training in fluvial processes, and understood by the CHR Board and the program's public constituency. It must be sufficiently general to be applicable in all jurisdictions in a country with an enormous diversity of river forms. It must also address all aspects of rivers including not only fluvial morphology, but also hydrology and biological aspects of rivers.

The 1998 version varies from this second edition in several ways. The six basic themes remain unchanged and the number, if not the content, of sub-themes is also unchanged. However, among sub-theme and elements there are some significant changes.

Two sub-themes of *Theme 1: Hydrology* were re-sequenced and some significant modifications have been made to elements of many of the sub-themes. There are also some conceptual changes to sub-themes. For example, stream order is now included as part of *Sub-theme 1.1: Drainage Basins* instead of *Sub-theme 1.4: River Size*. The latter now addresses total river length as

well as volume. For two of these sub-themes, elements are now defined according to "classes" of values, defined according to a matrix of two variables.

Fewer changes have been made to *Theme 2: Physiography*. Two sub-themes were re-sequenced and *Sub-theme 2.4: Topography* now addresses height above sea level instead of types of river sections, which are addressed in *Sub-theme 3.2: River Profile*.

The first three sub-themes of *Theme 3: River Morphology* have been modified to include not only their previous content but also elements reflecting horizontal and vertical aspects of channel patterns. Two sub-themes have been re-named: Lakes and ponds are now part of *Sub-theme 3.2: Channel Pattern* and rapids and waterfalls are now included under *Sub-theme 3.3: River Profile*. The *Fluvial Landforms* sub-theme is adjusted to include more features.

Theme 4: Biotic Environments is virtually unchanged, but elements of both *Theme 5: Vegetation* and *Theme 6: Fauna* have been changed to more directly address the association of species relative to rivers as well as to include species that are judged rare according to provincial and territorial lists.

These modifications have made the framework more sound both theoretically and in application. With them, the framework can now be said to be a reasonably accurate definition of what is meant by "Canada's natural river heritage".

ACKNOWLEDGEMENTS

This framework was initiated in 1992 by Nick Coomber, Chief of Cooperative Heritage Planning in Parks Canada, in support of the federal leadership role of Parks Canada within the Canadian Heritage Rivers System. Along with the cultural framework counterpart initiated in 1994, this framework was intended to enable the Canadian Heritage Rivers Board to take a national perspective on the development and management of the System.

Considerable effort was expended over 1992-94 by Dr. John Marsh, of Trent University, Peterborough, Ontario, in an attempt to develop "river regions", that could be used to provide a framework for classifying the natural values of Canadian heritage rivers. Dr. Marsh concluded, however, that a regional approach was impractical and probably invalid, and recommended a thematic approach similar to that then underway for the cultural framework.

The current framework owes much to the first attempt to develop a thematic approach by Mr. Gregg Sheehy, environmental consultant, in 1996. Mr. Sheehy developed a hierarchical set of themes, sub-themes and elements that was valuable in gathering input from many areas of expertise over the following two years.

Numerous comments were received on drafts from Parks Canada staff and staff of provincial and territorial agencies, and other interested individuals, which are gratefully acknowledged. Among Parks Canada staff Claude Mondor and Dr. David Welch provided authoritative advice on many technical aspects of the framework. In addition, vital research and extensive work needed for testing draft frameworks was undertaken by Jim Murphy of Geoheritage Planning, Kingston. Mr. Murphy is also largely responsible for the content of sub-theme 4.1 Aquatic Ecosystems.

The second edition of the framework was compiled by Nick Coomber acting as a consultant to the Canadian Heritage Rivers Board. It is based on the experience of three years of trial applications of the first edition.

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CHAPTER I

INTRODUCTION

1.1 Background

The Canadian Heritage Rivers System (CHRS) was established in 1984 and has since become one of the fastest growing heritage conservation programs in the world. As of March 2001, the System included 29 rivers, or sections of rivers, which were formally designated to the System with a number of additional rivers nominated. The total designated length of the System was 7,344 kilometres. Rivers have been designated in every province and territory, and all provincial and territorial governments participate voluntarily in the program. The System has become a truly national program and requires management with a national perspective. The present document contains a framework for natural heritage values of rivers which is intended as a tool to facilitate this.

1.1.1 Program Principles: The CHRS is founded on a number of principles that must be recognized in a national framework. The CHRS comprises rivers that are deemed to be of outstanding *Canadian* value. Rivers are nominated by provincial, territorial and federal government agencies to a nationally representative board which reviews them according to selection guidelines for natural, cultural, recreational and integrity values. A river must meet either the cultural or natural selection guidelines to be suitable for inclusion in the System.

An important principle of the CHRS that must be respected is that *all* provinces and territories are able to participate actively. This implies that all jurisdictions are allowed to have rivers included in the system, even though they may not appear to be of "national" significance, or if they contain values already represented by rivers previously included. Thus, provided that nominated rivers contain values that are of outstanding provincial or territorial significance, they are deemed to be of *Canadian*, as opposed to *national*, significance, and therefore meet the program's selection guidelines.

It is also important to recognize that the CHRS is a national, but not a federal, program. While the federal government plays a lead role in supporting the program, it does not exercise any special authority over its activities or the board's decisions. The two federal Board members may speak from a national perspective on issues, but they cannot oblige the Board to adopt policies or objectives that would support a national perspective on how the System develops or how it is managed.

1.1.2 Systematic Planning to Date: There is no national "systems plan" to guide growth and management of the System, but such plans for assessing the merits of potential Canadian Heritage Rivers are not a new concept for the CHRS. Nine provinces and territories have completed systems studies to identify rivers for future nomination within their own jurisdictions. These studies have varied in their methodology, but each has compared the relative merits of a certain

number of rivers and each has rated and ranked these rivers.

Until completion of draft natural and cultural frameworks in 1997, provincial and territorial systems studies formed the basis for setting many priorities among potential river nominations within each of the participating jurisdictions. While they are valuable tools, they provide only a provincial or territorial perspective on the significance of rivers' heritage values and they do not recognize or measure the amount of similar river values in other jurisdictions;. They do not enable consideration of entire transboundary rivers and, since they use different rating criteria, different types of nominations will be made in each jurisdiction.

It is possible that a nationally balanced and representative system of Canadian Heritage Rivers could emerge from the independent application of these systems plans. However, this is not only unlikely but, even if it occurred, there is no mechanism for knowing this.

1.2 Purpose and Objectives of the Framework

The purpose of this framework is to help foster in the CHRS a balanced representation of Canada's natural river heritage for its future management and interpretation from a national perspective.

While the framework can serve a variety of different functions, its primary objectives are:

1. To provide governments participating in the CHRS with a method of assessing, from a national perspective, how rivers in their jurisdictions can best contribute to the CHRS;
2. To encourage the adoption of a standardized approach among CHRS governments to the identification, documentation, evaluation and management of rivers' natural values;
3. To provide a tool which can be used to enable efficient use of government resources in the development and management of the CHRS.

These purposes and objectives are similar to those of the *cultural* CHRS framework completed in 2000. It is intended that the two frameworks be used in tandem and applied simultaneously.

1.3 Potential Applications of the Framework

The framework can be used by a variety of different users in different ways. In addition to providing a uniform classification of river-related heritage features and values the framework can be used for:

- a common vocabulary for CHRS documents, discussions, and interpretation of selection guidelines;
- assessment of possible nominations against existing Canadian Heritage Rivers;
- the assessment of the state of the System;
- the identification of gaps in the System;
- defining management priorities on designated rivers;
- structuring monitoring studies.

1.4 Developing the Framework

1.4.1 Parameters of the Framework

A number of basic parameters underpin the design of this framework. These requirements are similar to those which guided the design of the cultural heritage framework. It was required that the framework:

- *Reflect Canada's river-related natural heritage.* As distinct from Canada's natural heritage as a whole, which is the

concern of the national parks program;

- *Encompass the diversity of Canada's natural river values*. In order to respect the program principle that all provinces and territories must be able to nominate rivers, it was necessary for the framework to be capable of addressing river; characteristics in all parts of the country.
- *Not identify specific rivers for possible inclusion in the System.* This task is performed already in the case of provincial and territorial systems plans, and is in any case the prerogative of managing governments;
- *Be easily understood* by staff who would use the framework and by the program's public constituency;
- *Accommodate CHRS natural heritage selection guidelines*. The framework is designed to be consistent with the natural heritage selection guidelines described in the Principles, Procedures and Operational Guidelines (CHRB, 2000);
- *Harmonize with existing systems plans* of the provinces and territories.

The last two of these parameters required analysis of the natural heritage selection and integrity guidelines, and existing systems plans. This analysis, described in Chapter 3, made possible a comparison of the pros and cons of different conceptual approaches to a framework.

1.4.2 Optional Approaches to a Natural Framework: Within the above parameters, several optional approaches to a natural heritage framework were evaluated before the present one was formulated:

Option 1: Complete the provincial/territorial systems plans. This would have been equivalent to the *status quo*. By 1997, most provinces and both territories had completed systems plans to assess selected rivers within their jurisdictions. These systems plans vary in their approaches but all contain comparative assessment of the natural values of particular rivers. While these plans are useful in determining priorities from provincial or territorial standpoints, even the completion of a "network" of plans encompassing the entire country would not permit superimposition of a truly *national perspective* on river identification, assessment, nor management. Moreover, as noted in Section 1.1.2, even if a balanced system occurred by chance, provincial and territorial systems plans could not demonstrate if this were the case.

Option 2: Develop a national system of river regions. Most systems plans for natural protected areas adopt a regional approach; in other words they divide up the jurisdiction in question into relatively homogeneous regions, to be represented by sample areas. The basis for most of these regional systems are physiography and ecosystems. Regional boundaries are determined by noticeable changes in the spatial distribution of physiographic and ecological features. These are essentially terrestrial in that they extend over a land mass. Rivers on the other hand are neither terrestrial features nor do they confine themselves to physiographically or ecologically defined perimeters. Moreover, watersheds, while defining rivers hydrologically, rarely reflect other river-related values. Aquatic features associated with rivers cannot be used as a basis for regional definitions because they do not occur regionally over the land surface. In fact, as linear phenomena, many rivers extend into many different terrestrial regions. It was these factors, compounded by the absence of nationally available data for many aquatic

features, that persuaded Marsh (1994) to recommend abandonment of a regional approach to the framework.

Option 3: Extract river-related themes from the national parks systems plan. The national parks systems plan, while adopting an essentially regional approach to the identification of potential national parks, contains a comprehensive list of natural heritage themes. However, it was not possible to neatly separate from among these themes those which are *river-related*. While some of the themes in this framework bear similarity to national park themes, this is largely the result of using commonplace terrestrial classifications to describe natural features associated with rivers.

Option 4: Establish a national advisory body to CHR Board. The idea of establishing an independent non-government body to provide advice to the CHR Board on river identification, selection and management has been considered by the Board. However, this approach would be expensive and would not necessarily remove the need for frameworks. The Historic Sites and Monuments Board of Canada, which has some similarities to the CHR Board strongly advocated the preparation of national thematic studies to help in its own deliberations. A national advisory body for the CHR Board might have great value in deciding on the application of a framework, but would not necessarily remove the need to prepare one.

Option 5: Define a comprehensive set of river-related natural themes. The CHRS cultural framework that was developed in parallel to the present natural framework considered approaches similar to some of the options described above, including a possible chronological approach, which might have parallelled a spatial or regional approach. The cultural framework adopted a *thematic* approach based on human activities associated with rivers. A natural framework could also adopt a thematic approach, defining it in terms of natural processes instead of activities, and role of these processes in influencing rivers, or being influenced by rivers.

This natural framework is based on the last option, although elements of the first three were used to develop it. For example, the national parks systems plan and provincial and territorial CHRS systems studies proved useful in providing thematic concepts, and several sub-themes use regions to define elements.

1.4.3 Framework Development Process: It is Parks Canada's responsibility as the lead federal agency in the CHRS to bring a national perspective to the program. Soon after the establishment of the CHRS in 1984, Parks Canada suggested the concept of an umbrella framework that could be superimposed over provincial and territorial systems plans. This framework would not replace these plans but would complement them and at the same time provide a tool for the Board to take a national perspective on the status and development of the System. The CHR Board felt that development of the concept at that time was premature.

In 1992, with the Board's approval, Parks Canada commissioned researchers at Trent University to develop a national natural heritage framework. Taking some of the regions delineated in provincial systems studies, and some of their natural and human heritage themes, several approaches were advanced by Marsh and Kharouba (1992) and

Marsh (1994). These were based on concepts that incorporated physiographic, climatological and hydrological factors to define geographic regions that could be represented by rivers, or river sections, in the CHRS. However, Marsh concluded the work questioning whether a regional approach to the framework was in fact the most valid. At issue was the uneven availability of necessary data and, more fundamentally, the question as to whether a regional approach to classifying river-related values was theoretically sound and defensible, given the difficulties of defining terrestrial regions using aquatic and fluvial criteria. For this reason, subsequent efforts adopted a thematic approach.

The process of developing the thematic natural framework contained in this document cannot be described as linear. Its present form comprises the sum of several abortive attempts as well as considerable testing and trial applications of drafts. The development of the present framework involved the tasks described below:

1.5 Current Document

This document thus represents the culmination of nine years of work in developing a national natural heritage framework for voluntary use by the Canadian Heritage Rivers Board and each of its members. It is a companion to *A Cultural Framework for Canadian Heritage Rivers* (1997) developed for rivers nominated for their cultural values. Together these documents are unique tools for the protection and understanding of rivers not only in Canada but also in other jurisdictions. In fact, they essentially *define* river heritage. While some of the elements may be specific to Canadian values, the structure of the themes and sub-themes is universal and, with minor modifications, is intended to be adaptable for the classification of river features anywhere in the world.

Summary of the Natural Framework Development Process

1. 1992: Review provincial and territorial Heritage River system studies and literature on river classification methods;
2. 1993: Submission of a discussion document describing framework options for comment by the Canadian Heritage Rivers Board;
3. 1994-95: Development of a preliminary thematic framework by a consultant;
4. 1995: Review of preliminary framework by the CHR Board and experts;
5. 1996: Inclusion of comments and preparation of a complete draft thematic framework;
6. 1997: Testing of the draft framework on existing Canadian Heritage Rivers;
7. 1997: Review of revised framework by Parks Canada and Board staff, experts and consultants;
8. 1998: Adoption of *A Framework for the Natural Heritage Values of Canadian Heritage Rivers* by the CHR Board;
9. 1998-2000: Trial implementation of the *Framework;*
10. 2001. Trial review and preparation of 2nd Edition of the *Framework.*

CHAPTER 2

THEME DESCRIPTIONS

2.1 Framework Concept

The concept underlying the themes of this framework is the traditional hydrologic cycle. It attempts to classify abiotic and biotic features associated with rivers which result from the interaction of land and water in this cycle[1].

The hydrologic cycle comprises the evaporation of water from oceans and lakes, its condensation in clouds, deposition on land in the form of rain and snow and, key to this framework, the collection of water as runoff and its absorption into the ground, and then its subsequent discharge back into oceans and lakes. Abiotic river features are defined as those resulting directly from land-water interface in the hydrologic cycle, where rivers are formed[2]. Here, a link can be made with biotic features of rivers. Aquatic environments suitable for supporting life also develop at this interface, making use of the abiotic features created. Life forms, or biotic features, are classified as types of flora and fauna that live in association with these biotic environments.

PARADIGM FOR IDENTIFICATION OF NATURAL THEMES

Abiotic features	Hydrology	Theme 1
+	Physiography	Theme 2
=	River morphology	Theme 3
	+	
Biotic Features	Biotic environments	Theme 4
	↓	
	Vegetation	Theme 5
	Fauna	Theme 6

Similar to the cultural framework (CHRB 2000) and most of the provincial and territorial systems plans, this framework adopts a hierarchical thematic approach. The hierarchy adopted is parallel to the cultural framework in comprising themes, sub-themes and elements. The themes defined according to the paradigm described above are shown in the chart below. Sub-themes and elements, described in the next section, are classifications of features that arise from processes associated with each of the

[1] In this the framework differs from most other river classification systems which begin with air (climate) and land (physiography) (e.g. Morisawa (1985)) as the active and passive forces which combine to create streams. This framework addresses only those components of the cycle which can be represented by Canadian Heritage Rivers. Climate is not one of these.

[2] Rivers are defined here in the same way as in the *CHRS Objectives, Principles and Procedures* (1984, page 3). The term refers to the entire length or a section of a river and its immediate environment, including lakes, ponds, and estuaries.

themes. The values and features that will be represented through this framework are listed as *elements* of each sub-theme.

In the belief that a symmetrical framework is conceptually more valid and defensible than an asymmetrical one, and more likely to give rise to a balanced system, an attempt was made to ensure that each theme is of approximately equal size. Using other paradigms, a similar number of sub-themes and elements were defined for each theme. This proved possible for abiotic themes which each have four sub-themes and each sub-theme has about twelve elements. However, the three biotic themes each have only two sub-themes and there is considerable variation in the number of elements in their sub-themes.

To ensure that the definitions of sub-themes and elements would be discrete and defensible, each sub-theme was defined through a conceptual paradigm, adjusted to allow for the availability of information on a national basis and the reality of potential elements in the real world.

In defining elements in this framework, care was taken to ensure as far as possible that the theoretical existence of river features was matched by empirical knowledge of what actually exists in Canada. Some elements are definable physical forms and others are value ranges of quantifiable characteristics. Nominated rivers may potentially represent any element by *comprising* an outstanding example of an element (i.e. being a certain type of river) or by *containing* an outstanding example of an element (i.e. forming or passing near an example). In both cases a single Canadian Heritage River may represent more than one element of a sub-theme at different locations.

2.2 Theme Narratives

Users of this framework will undoubtedly refer to the following theme descriptions more than other sections of this document. In order for users to understand how to use the sub-themes and elements, the sub-theme descriptions here are accompanied by brief narratives that provide essential information about how the elements were derived, how they might be represented, and examples of existing Canadian Heritage Rivers which represent these elements[3]. The narratives also indicate where data sources might be found.

Users should be reminded that this framework addresses only river-related values. Many well-recognized terrestrial features do not appear in the theme elements. Thus, if features do not seem to be addressed in this framework, it is possible that:

- The feature is not typically associated with rivers and does therefore not represent any of the elements in this framework[4]; or
- the feature may be a sub-type or regional variant of an element, in which case this could be noted in the document being prepared; or
- the feature may be addressed in some way through a proxy, e.g. water hardness is generally reflected in the chemical properties variable of *Sub-theme 1.1: Water Content*.

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[3] In monitoring the status of representations it may be noted that most abiotic representations generally do not change, so that reporting is likely to focus on biotic representations.

[4] It may still, however, be valid evidence for including the river in the CHRS.

THEME 1: HYDROLOGY

The hydrology theme recognizes the water component of the interface between land and water. Traditional definitions of hydrology mention the relationship of water to land. The Oxford dictionary defines hydrology a *"the science of laws and properties of water and its distribution over the earth's surface"*. Haslam (1996) defines hydrology as *"the study of water and water resources in land areas".*

Subdivisions of hydrology could take many forms. In this theme, a general model based on the organizational principles of *where, when, what,* and *how much* is used. In this context:

- *where* refers to the locational attributes of rivers, in this case as expressed in terms of their location within oceanic drainage basins;
- *when* refers to changes in rivers over time, in this case seasonal flow patterns;
- *what* refers to the content of rivers, in this context the physical and chemical properties of their waters; and
- *how much* refers to the size of rivers as measured in terms of their volume and length.

In addition to fitting this paradigm, the following sub-themes were defined on the basis of their discreteness from other possible sub-themes, and the availability of information at a national level.

Sub-theme 1: Drainage Basins
Sub-theme 2: Seasonal Variation
Sub-theme 3: Water Content
Sub-theme 4: River Size

1.1 SUB-THEME: DRAINAGE BASINS

It has been mentioned how this framework is not intended to be regional in approach. Representing rivers in each of Canada's drainage basins might appear to be a form of regional classification of rivers. However, it is important that rivers in each of the major Canadian drainage basins be included in the CHRS because:

- watersheds of drainage basins are fundamental divisions between the major river systems which transcend terrestrial subdivisions such as physiographic regions;
- some significant ecological and species distinctions exist between watersheds, and representation of each is important;
- pollutants spread downstream through river systems, and the inclusion of representative unpolluted rivers from each major basin in the CHRS will contribute to the protection of each major basin.

Elements

The elements of this sub-theme are the five *oceanic drainage basins* of Canada which are subdivided according to three levels of *stream number*[5].

1. **Drainage Basins:** There is considerable variation in the sizes of the principal oceanic basins of Canada. Basins of rivers flowing into Hudson Bay comprise 38% of Canada's land surface of which the Churchill and Nelson systems are the largest. The next largest oceanic basin is that of the Arctic Ocean with 34% of Canada. Within the latter lies the single largest river basin is that of the Mackenzie River which comprises over 1.8 million square kilometres, about 20% of Canada's land surface. Atlantic Ocean basins, notably the St. Lawrence system, comprise 15% and the Pacific Ocean basins 10%.

2. **Stream Number:** Some rivers flow directly into the ocean; most flow into other rivers. To recognize this, the concept of stream number is introduced into this sub-theme. This ensures that there can be representation in the System of rivers in different parts of the oceanic basins.

   Stream numbers are based on the concept of tributary trees, in which the main stem of a river flowing into the ocean would be of a number 1, a tributary of this stream would number 2, and so on upstream until no discernable permanent flow could be detected. In this way, small rivers that flow from small basins directly into the ocean can be distinguished from small upstream tributaries of rivers in large basins. Similarly, large tributary rivers that do not reach the ocean directly can be distinguished from those that do.

Considerations in Applying the Elements

In reviewing rivers included in the CHRS according to this sub-theme, it is important that representation of drainage basins should be weighted according to their area. Because Canada's drainage basins vary enormously in size it is suggested that the total length of Canadian Heritage Rivers nominated for their natural values should reflect the total area of each oceanic basin (and perhaps each basin within these

[5] Note that this differs from the well-known system of *stream order* in which numbers are assigned to tributaries from upstream to downstream.

watersheds). This would be achieved if, for example, 38% of total (natural heritage) river length in the CHRS was located in the Hudson Bay Watershed, 15% in the Atlantic Watershed, and so on.

Traditional hydrometry, which measures stream *order* (not number), can be a complicated science, and assigned stream orders can be disputed, especially in the higher numbers. In the stream number system, the main problem is to determine which is the main stem of a river since length, volume and height of source can all be considered. In many cases, the highest or most distant tributary source is not named the same as the river reaching the ocean. It is therefore important to determine where the real source of a river is. Here it is suggested that the highest point in the catch-basin where permanent flow is detectable should be regarded as the source. To simplify the application of this sub-theme, the highest stream number that need be determined is 3.

Sub-theme 1.1: Drainage Basins		
Oceanic Basin (% surface area of Canada)	**Element**	**Existing Canadian Heritage Rivers**
Hudson Bay Basin (38.6)	**1. Stream number 1**	Soper, Thelon
	2. Stream number 2	North Saskatchewan, Bloodvein, Kazan
	3. Stream number >2	Boundary Waters
Atlantic Ocean Basin (15.2)	**4. Stream number 1**	Margaree, Main, Restigouche, St. Croix, Detroit
	5. Stream number 2	Shelburne, Grand, Boundary Waters, French, St. Marys, Humber
	6. Stream number >2	Mattawa, Rideau
Arctic Ocean Basin (35.8)	**7. Stream number 1**	
	8. Stream number 2	Arctic Red, Athabasca
	9. Stream number >2	S. Nahanni, Clearwater, Bonnet Plume
Pacific Ocean Basin (10.1)	**10. Stream number 1**	Fraser, Yukon (Thirty Mile)
	11. Stream number 2	Alsek
	12. Stream number >2	Kicking Horse
Gulf of Mexico Basin (0.5)	**13. Stream number >2**	

Data Sources: Map 5.1 of the National Atlas of Canada describes Canada's major hydrographic basins.

1.2 SUB-THEME: SEASONAL VARIATION

Most activity in the creation and destruction of fluvial features occurs during seasonal floods. The commercial utility, ecology, visual appearance and recreational value of rivers change greatly in Canadian rivers over the course of a year due to the effect of melting snow, a phenomenon almost ubiquitous in Canada and highly characteristic of most of its rivers. It is important that the Canadian Heritage Rivers System reflect the variation of river flow over its seasons.

There are a number of influences on flows in Canada which could be used to help define elements of this sub-theme[6]:

- Peak flows in almost all of Canada occur as a result of the springtime melting of snow;
- Periods of low flow occur during dry summer periods or during a winter freeze-up when available water is reduced. Regions where winter freeze-up is deep and prolonged may contain rivers which completely solidify for part of the year;
- Secondary "peaks" occur as normal phenomena on some rivers usually in October and November, but sometimes in late summer;
- Rivers whose climates are influenced by the Pacific and Atlantic Oceans may not exhibit their highest flows in springtime as there is less volume resulting from snowmelt;
- North-flowing rivers such as the Arctic Red, Yukon, and Rideau rivers are subject to melting in their southern headwaters while downstream sections are sometimes still frozen. This causes earlier than normal high flows in northern reaches, downstream ice-damming, flooding, and sometimes even temporary flow reversal on these rivers;
- In the north, ground made impervious by permafrost also tends to emphasize the periodicity of runoff.

Elements

The elements of this sub-theme recognize periods of *low flows* and *high flows* of rivers.

1. **High Flows:** The month or months during which water flow of a river section reaches a measurably significant peak, measured at the outflow of the nominated section or the mouth. Elements comprise the five months between March and July (inclusive), and the entire period August to February.

2. **Low Flows:** Low flows occur normally during one of two seasons, generally summer or winter, during which water flow in a river section reaches a measurably low point. These are May to September (summer), and October to April (winter). While low flows usually occur in the season opposite to high flows, in the case of some northern rivers, the late arrival of summer implies that low flows can occur in May or June, when it is spring or summer elsewhere.

[6] Morisawa (1971) presents a method to numerically describe seasonal variations. This method has the advantage of being a precise, numerical evaluation system, and it could be applied using data available from the Canadian stream flow monitoring system. However, it does require knowledge of statistics to understand the differences among the rating categories. Furthermore, the variability index may be of limited value in distinguishing some Canadian rivers--any river that freezes solid (zero flow) or which exhibits a double peak would not easily fit into these categories.

Sub-theme 1.2: Seasonal Variation		
Period of Highest Flow	**Period of Lowest Flow**	
	May-September	**October-April**
March	**1.** Thames, Humber, Detroit	**7.**
April	**2.** Grand, St. Croix, Hillsborough, Rideau, Shelburne	**8.** Mattawa
May	**3.** Margaree, French, Restigouche	**9.** Main, Boundary Waters
June	**4.**	**10.** Bloodvein, South Nahanni, Seal, St. Mary's, Detroit, Clearwater, Arctic Red, Bonnet Plume.
July	**5.**	**11.** Alsek, N. Saskatchewan, Kicking Horse**,** Hayes, Athabasca, Kazan**,** Soper
August-February	**6.** Thelon, Fraser	**12.** Yukon

In the preceding chart, categories for low and high flows are based on those used in the *National Atlas of Canada*[7], in which river monitoring stations are depicted by symbols showing months of annual peak flows and seasonality of annual low flows. The representations of existing Canadian Heritage Rivers are shown on the chart above.

Considerations in Applying the Elements

Of interest here are not only annual peak and low flows, but also smaller peaks and, more rarely, secondary low flows. On longer rivers, high or low flows may occur in separate months due to the delay in upstream waters arriving downstream. In these ways, a river may represent more than one element of this sub-theme.

Where existing data are not available for a Canadian Heritage River, reference should be made to other regional rivers or to data available on upstream flows, rather than downstream. Similarly, where peaks or low flows occur at times that are between categories in the following chart, reference should be made to the peaks and low flows of other rivers in the same climatic region in order to understand which category is more appropriate.

It may not be possible to categorize rivers where flow is controlled by dams. While high flows are usually evident, storage of water precludes accurate measurement of low flows.

Low flows maybe accentuated or obscured in colder climates. Cold climates also affect the amount and timing of precipitation in the

[7] Canada. Department of Energy Mines and Resources. *National Atlas of Canada*, 4th Edition, 1974. Page 18. It is recognized, however, that it is unlikely that all of these 12 categories can be represented by rivers in Canada. Having peak flows in some months precludes the occurrence of low flows shortly thereafter. Alternative classifications of seasonal flows involving secondary peaks, or total runoff or precipitation, or magnitude of variation between high and low flows, were rejected as too complex.

form of rain and snow, while glaciers effectively hold water for release during summers, and the amount of water lost to evaporation, mostly from cold lakes, is less than in warm climates.

Data Sources: Data on yearly and multi-year flow patterns can be obtained from Water Survey of Canada and Quebec Department of Natural Resources monitoring networks.

Where data for individual rivers is not available, their seasonality may be imputed from neighbouring rivers. Map 23 of the *Hydrological Atlas of Canada* and pages 17-18 of the 4th edition of the *National Atlas of Canada* illustrate these patterns for a representative selection of Canadian rivers across the country. Map 5.4 of the 5th edition of the *National Atlas of Canada* also provides one example for each ecozone of Canada (see sub-theme 4.2 below).

1.3 SUB-THEME: WATER CONTENT

The most common image of a Canadian river is one of cold, clear, pristine waters. While this image is not inaccurate, there are many rivers which are neither cold nor clear, yet which are in a natural condition and hold equal significance in Canada's river heritage. The range of characteristics of water content found in Canada should be reflected in the CHRS.

Elements

There are two basic types of properties that are significant in water - chemical and physical. Chemical properties are those that are observed in such characteristics as acidity or hardness, which reflect a host of chemicals dissolved in the water. In turn, these characteristics influence nutrient values and consequently ecosystems and the presence or absence of biotic river features.

1. **Physical Properties**[8]**:** The physical contents of water contained in rivers are generally suspended solids referred to as sediment. This sediment has two profound implications for other river values: physical deposition of sediment along river banks and bottoms results in the construction of fluvial features with subsequent ecological and cultural impacts. Sediment in the form of fine mineral matter, or peat and other vegetative solids also significantly effects the suitability of rivers for fish and other aquatic life, and subsequently effects the neighbouring ecosystems.

   There are two ways of measuring the sediment content of water:
   - turbidity is measured using a Secchi disc by estimating the clarity of water to determine the amount of material that reduces the amount of light that passes through;
   - sediment load is the quantity of sediment contained in water measured according to the number of milligrams of suspended matter per litre of water or relative volume.

   While the second method is preferred, as it is more accurate, information using Secchi disc reading is an acceptable substitute.

2. **Chemical Properties:** Of equal interest in this sub-theme is the chemical composition of water in rivers. Perhaps the best known chemical feature is the acidity of water, which is primarily a reflection of the amounts of dissolved calcium and magnesium, determined by the content of underlying rocks and to some degree by climatic conditions. As a profound influence of the quantity and accessibility of nutrients, the acidity of water is an important determinant of the types and abundance of ecosystems that are found in river systems.

   However, acidity is only one measure of chemistry of water, and other dissolved solids play a major role in ecosystems and nutrient availability. In this sub-theme, total dissolved solids are used as the basis for classifying water content. Dissolved solids are primarily calcium, magnesium, bicarbonates, sodium,

[8] Temperature was considered as a possible physical property. However, data from actual measurements of the temperature of river water at different times of the year does not exist uniformly across Canada. Several proxies that might be considered, such as average summer (or other season) air temperature, time of freeze up of lakes or rivers, and time of break-up of lakes or rivers, are similar to the main component of *Sub-theme 1.2 Seasonal Variation*.

sulphates and chlorides. They are measured by their weight per unit of water.

As shown in the following chart, the matrix of these two variables produces 12 elements.

Considerations in Applying the Elements

This sub-theme is *not* concerned with water *quality*, which is considered as an integrity factor in river nominations. This sub-theme is intended to recognize different types of water categorized in terms of the content of naturally occurring materials.

It should be recognized that the physical content of river water will vary along a river's length, and will differ markedly where extensive lakes and still-waters permit deposition of loads. Similarly, velocity-induced variability also results from seasonal fluctuations in flow volume. Thus, a single river may be theoretically capable of representing a number of the elements of this sub-theme at different times of the year and in different locations along its length. Where information is available, the pervading sediment load at an average flow time should be used except where an high or low measurements of particular interest are obtained. Even so, rivers such as the Yoho section of the Kicking Horse, the Rideau, Seal and French have two distinct levels of sediment concentration and therefore each represent two elements of this sub-theme.

Sub-theme 1.3: Water Content				
Physical Properties: Sediment Content in milligrams per litre (Turbidity Level alternative measured in Jackson Units)		**Chemical Properties: Total Dissolved Solids in milligrams per litre**		
		Low 0-50mg/l	**Medium 51-100mg/l**	**High >100mg/l**
Insignificant sediment load	**0 - 50mg/l** (<5.0 JU)	**1.** French, Kazan Mattawa, Thelon, Seal (upper), Main	**5.** Bloodvein, Hillsborough	**9.** Restigouche, Margaree, Rideau (upper)
Minor sediment load	**51- 200mg/l** (5.1-10.0 JU)	**2.** Clearwater, St. Mary's, Boundary Waters, Seal (lower), French (lower), Soper	**6.** Alsek, Yukon, St. Croix, South Nahanni	**10.** Grand, Hillsborough, Detroit,
Moderate sediment load	**201 - 400mg/l** (10.1-20.0 JU)	**3.**	**7.** Fraser, Bonnet Plume, S. Nahanni, Yukon	**11.** Thames, Humber, Bonnet Plume, Fraser
Heavy sediment load	**> 400mg/l** (>20.0 JU)	**4.** Shelburne	**8.** Arctic Red, Rideau (lower), Kicking Horse (Yoho section), South Nahanni	**12.** Athabasca, North Saskatchewan

Data Sources: Primary sources of data should always take preference over secondary. In other words, where actual measurements are taken of river water content, these data should be used instead of general regional data contained in the *Hydrological Atlas of Canada*.

Information on sediment load as exhibited in turbidity is found in the *Hydrological Atlas of Canada* (*Map 28C: Turbidity of Surface Waters*), prepared by Fisheries and Environment Canada in 1978. Since turbidity varies only slightly over about 60% of the country, sediment load is the preferred measure of representations of this sub-theme. In cases where sediment load has not been measured on a consistent basis, turbidity can be used although it should be recognized that on rivers such as the Shelburne, whose waters contain dense organic components, classification may not actually reflect sediment load.

Chemical content of river water can be discerned from *Map 28B: Total Dissolved Solids of Surface Waters* of the *Hydrological Atlas of Canada* which describes the distribution in Canada of total dissolved solids in water. Any measurements taken on rivers themselves should take precedence over information obtained from this map and Map 28C. Reproductions of these maps may be consulted in the first edition of this framework.

1.4 SUB-THEME: RIVER SIZE

The inclusion of *major* rivers in the CHRS has been discussed by the Canadian Heritage Rivers Board and others as a highly desirable feature of the System. Describing a river as *major* implies that it is big in terms of the amount of water it contains. While major rivers are obviously not the only types of rivers that are needed in the System, it is important that they be recognized along with rivers representative of other sizes found in Canada. Rivers of different volume have distinct physical, ecological and cultural characteristics. Since the size of rivers is largely a function of their length, it was considered that this sub-theme should also recognize rivers according to their length.

The length of a river can be a surprisingly difficult thing to measure. Four possible measures were considered. The first, nominated length, is often arbitrary and subject to change by nominating agencies. The second, distance of the nominated section from the river source is a measure that is already closely reflected in flow volume. The third, the distance from the nominated section to the river mouth may be reflected in the Stream number included as part of *Sub-theme 1.1 River Basin*. Total length of a river from source to ocean is, however, a useful measure of importance to the CHRS, which aims to represent as many different sizes of rivers as possible.

Elements
River size is measured here according to two variables: average flow volume and total length.

1. **Average Flow Volume:** For this sub-theme, flow volumes are measured as the average annual flow at the river mouths, or in the case of river sections, at the lower end of the nominated section. This is now measured in cubic metres per second.

   Four flow volume classes are defined here. The limits for each class are established to roughly equalize the number of rivers in each. A measure of 85 cubic feet per second was chosen as the upper limit on the smallest class. This figure is derived from the data on Map 5.4 of the *National Atlas of Canada* where rivers with flows above this figure are shown.

2. **Total River Length:** River length is measured for this sub-theme as the total length of the river, from source to ocean, *of which the nominated section forms a part*. Three classifications of the total length of rivers are included here, using somewhat arbitrary measurements to ensure a roughly equal distribution of rivers among categories.

As shown in the following chart the matrix of these two variables produces 12 elements.

Considerations in Applying the Elements.
River Volume: It is not the role of this framework to establish at which point a river is too unimportant to represent Canada's natural river heritage; this is the prerogative of the Canadian Heritage Rivers Board. Moreover, to set an arbitrary lower limit could eliminate many small but nevertheless important[9] rivers in small watersheds, such

[9] *Important* should not be construed as synonymous with *large*. While the *CHRS Principles, Procedures and Operational Guidelines* (CHRB, 2000) requires that only Canada`s *important* rivers be included in the System, small rivers in PEI can be included under the Board's definition of important.

as those located in coastal drainage basins which flow directly in to the ocean.

Rivers are not defined here by the names that are assigned, often arbitrarily, to them. A small river which flows into a river which is part of a large drainage basin is measured to include the total length of that arm of the main river and all rivers downstream to the ocean. Thus, a small river in the upper part of the Mackenzie system will be classified in the highest category in terms of length. All rivers which fall into the over 1000km category will be part of the upper Mackenzie, St. Lawrence or Nelson drainage systems.

The 1000km cut-off in fact distinguishes between the Kazan (under 1000km) and Thelon (over) rivers, between the Bloodvein River (under 1000km) and the western Boundary Waters (over), and between the Grand (under 1000km) and the Thames (over) in Ontario. While this makes it feasible to represent rivers which have small average flows and long lengths, it will be difficult to find rivers which exhibit high average flows and short lengths.

Data Sources: Historical data on streamflow exist for all major rivers in Canada and many smaller ones, at many points along the course of rivers. This information can be obtained from provincial government sources and from Environment Canada. For major rivers, these data are shown on Map 5.4 of the *National Atlas of Canada* (see map folder). Flow data for other rivers can be obtained from Water Survey of Canada or Quebec Department of Natural Resources monitoring networks.

Many general atlases contain the lengths of major rivers in Canada. For other rivers, framework users are referred to a measuring wheel or other device applied to a large scale map.

Sub-theme 1.4: River Size			
Flow Volume at Lowest Point of Nomination	**Total Length of River**		
	<500 km	**500km - 1000 km**	**> 1000 km**
Small Rivers < 85 (m^3/sec)	1. Main, Margaree, Hillsborough,	5. Shelburne, Kicking Horse, Bonnet Plume	9. Thames, Boundary Waters, Clearwater, N. Saskatchewan
Medium Rivers 85 - 400 (m^3/sec)	2. St. Croix, Restigouche, Seal	6. Grand, Arctic Red	10. S. Nahanni, Athabasca
Large Rivers 400 - 800 (m^3/sec)	3.	7. Kazan	11. Thelon, St. Mary's
Major Rivers > 800 (m^3/sec)	4.	8. Fraser	12. Yukon, Detroit, St. Mary's

THEME 2: PHYSIOGRAPHY

As the Hydrology theme recognized the water component of the interface between land and water, the Physiography theme recognizes the land component. It must be emphasized that this theme is not a classification of all physiographic features and processes; only those that are related to rivers. The title of *geology* was considered as a title for this theme but was considered to describe a science that is essentially unrelated to rivers. As an alternative title, *hydrogeology* is normally considered to specifically refer to the study of structures holding aquifers and subterranean water. This, however, is the title of one of the sub-themes here.

Subdividing river-related physiography could take many different forms. As in the case of the Hydrology theme, a simple model based on where, when, what and how much was used. In this case, *where* refers to physiographic regions through which rivers flow, *when* refers to river-influencing geological structures produced over time, *what* refers to the water-related properties of physiographic materials, and *how much* refers to the "amount" of physiography encountered by rivers, interpreted here as topography.

Sub-theme 1: Physiographic region
Sub-theme 2: Geological events
Sub-theme 3: Hydrogeology
Sub-theme 4: Topography

Each sub-theme encompasses a discrete component of the physiographic side of the land-water interface and a subject which is readily recognizable to staff within the field of protected area planning. For each of these sub-themes it was determined that information is available on a national basis. As in the case of the hydrology theme, an effort was made to define sub-themes that could be divided into approximately ten elements.

An important distinction can be made between representations of hydrological sub-themes and physiographic sub-themes. Hydrological sub-themes are generally represented by rivers in their entirety, so that rivers are effectively classified as hydrological types. A single river can, however, represent more than one physiographic sub-theme (and those of *Theme 3: River Morphology*).

2.1 SUB-THEME: PHYSIOGRAPHIC REGIONS

While a completely thematic approach to river classification in Canada was rejected in the process leading to the development of this framework, it is recognized that the location of rivers in Canada is an inextricable characteristic of their heritage value. Marsh and Kharouba (1992) experimented with several different approaches to the delineation of river regions in Canada, including drainage basins, eco-climatic provinces, and physiographic regions. As noted, drainage basins are addressed in *Sub-theme 1.1 Drainage Basins*. Eco-climatic regions are essentially biotic phenomena and are partially dealt with under *Theme 4: Biotic Environments*.

According to Marsh and Kharouba, physiography has validity as a basis for river regionalisation because:

> *"... it is an expression of long and short-term processes, and has a major influence on hydrology and the morphology of streams, rivers, and lakes. Especially in the case of running waters, the gradient, discharge, and water velocity are largely affected by physiography. Surficial geomorphological responses to running water such as channel morphology and sediment characteristics strongly reflect the physiography of the landscape. Furthermore physiographic regions are clearly observable in the landscape; this facilitates their use in river regionalisation."*

Therefore, in parallel with *Sub-theme 1.1 Drainage Basins*, which reflect the spatial character of hydrological values, the inclusion of physiographic regions as a sub-theme enables recognition of the spatial characteristics of river-related physiographic values.

Elements

The physiographic regions used in this framework are adapted from the sixteen regions identified by Bostock (1964). These are based on the overall concept of the six major regions: Shield, Appalachian Uplands, Interior Plains, Western Cordillera, Innuitian Region, and Arctic Plains. A map showing these regions follows this section.

It should be emphasized that Bostock's original regionalization is not ideal for regional classifications of rivers since the Innuitian Region has virtually no significant rivers, while a single region, the river-rich Canadian Shield, comprises about one third of the country. On the other hand the Central Cordilleran and Appalachian Regions can be effectively subdivided. For this reason a number of modifications have been made to Bostock's regions: the Innuitian Region and the Foxe Basin are excluded and the Arctic Lowlands are combined with the interior lowlands. In this way, a roughly equal opportunity is allowed for rivers in each region.

Even with these modifications, however, there are major disparities in the number of potential Canadian Heritage Rivers in each of the regions. As in the case of drainage basins, proportional representation according to area could be considered. The proportions of Canada's land area occupied by each region are therefore shown on the following chart.

Considerations in Applying the Elements

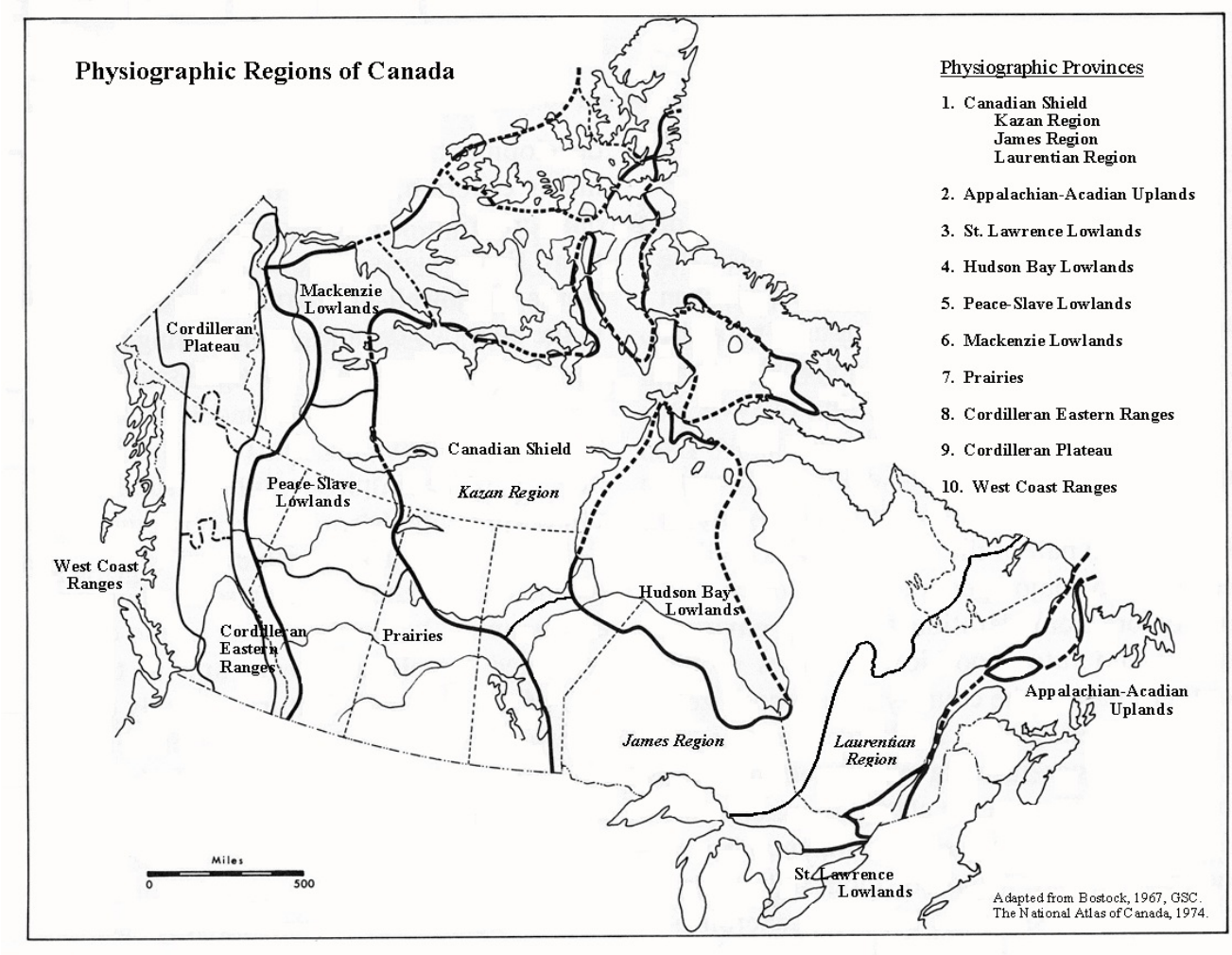
There are other regionalisations of Canada

that include physiography which might provide some guidance in deciding into which regions a river fits. Perhaps the best known among protected area planners are the 39 national park natural regions (Environment Canada 1990) which are based on physiography and ecology. However, their usefulness is compromised for this framework by their inclusion of ecology in boundary delineation, a factor considered separately in *Sub-theme 4.2 Terrestrial Ecozones.*

As in the case of *Sub-theme 1.1 Drainage Basins*, there is a need to ensure that representations of each physiographic region are proportionate to the size of the regions. The total length of Canadian Heritage Rivers nominated for their natural values which are located within a physiographic region should eventually reflect the size of the region. Thus, for example, since the Prairies Physiographic Region comprises 10% of the country, 10% of all "natural" Canadian Heritage Rivers should be located in this region.

Sub-theme 2.1: Physiographic Regions		
Element	**Area (% total)**	**Example Canadian Heritage Rivers**
1. Canadian Shield - Kazan Region	29.4	Thelon, Kazan, Seal
2. Canadian Shield - James Bay Region	19.2	
3. Canadian Shield - Laurentian Region	7.9	Mattawa, French, Bloodvein, Rideau
4. Appalachian Acadian Uplands	2.7	Main, Margaree, Shelburne, St. Croix, Restigouche
5. St. Lawrence Lowlands	1.9	Grand, Thames, Detroit, Rideau
6. Prairies	10	
7. Peace-Slave Lowlands	5.4	Clearwater
8. Mackenzie Lowlands	3.5	Arctic Red
9. Hudson Bay Lowlands	2.8	Seal
10. Cordilleran Eastern Ranges	3.6	Arctic Red, Bonnet Plume, S. Nahanni, N. Saskatchewan, Athabasca
11. Cordilleran Plateau/ Mountains	10.7	Fraser, Kicking Horse
12. West Coast Ranges	2.9	Fraser

Data Sources: Several well-known geographical texts contain physiographic regions. For details on the above regions, framework users may refer to B.J. Bird's *Natural Landscapes of Canada*, (1980) as well as to Bostock's *Physiographic Subdivisions of Canada* (1964), shown below. It should be noted that the element numbers do not correspond to the region numbers on this map.


Physiographic Regions of Canada
Physiographic Provinces
1. Canadian Shield
Kazan Region
James Region
Laurentian Region
2. Appalachian-Acadian Uplands
3. St. Lawrence Lowlands
4. Hudson Bay Lowlands
5. Peace-Slave Lowlands
6. Mackenzie Lowlands
7. Prairies
8. Cordilleran Eastern Ranges
9. Cordilleran Plateau
10. West Coast Ranges
Mackenzie Lowlands
Cordilleran Plateau
Canadian Shield
Kazan Region
Peace-Slave Lowlands
West Coast Ranges
Hudson Bay Lowlands
Cordilleran Eastern Ranges
Prairies
Appalachian-Acadian Uplands
James Region
Laurentian Region
St. Lawrence Lowlands
Miles
0
500
Adapted from Bostock, 1967, GSC.
The National Atlas of Canada, 1974.

2.2 SUB-THEME: GEOLOGICAL PROCESSES

A temporal dimension was introduced to the Hydrology Theme in the sub-theme *Seasonal Variations*. Over more extended periods of time changes occur to the land-base on which rivers flow and these have profound effects on river flow. It is important that representations of the major processes and events that typically influence rivers be included in the CHRS. This sub-theme would correspond to the *when* component of the theme model used to determine sub-themes.

Elements
The chart below lists twelve geological processes, the results of which may be found in association with rivers, either influencing them or being visible from them. They are grouped into three categories:

1. **Bedrock Formation**
2. **Surficial Material Formation**

Five of the twelve processes, including vulcanism, are generally considered as geological, since they involve processes which created the underlying bedrock over which rivers flow. Five other processes address more recent processes associated with the last ice age and modern remnant glaciers which have served to create surficial materials overlaying bedrock in almost all of Canada. Two additional processes reflect surficial features formed by the actions of wind or the temporary existence of lakes or inland seas.

Considerations in Applying the Elements
Modifications to the landscape by rivers often take the form of exposures that enable direct observation of geological processes. To constitute a valid representation of this sub-theme, the features resulting from the processes must be functionally related to rivers or visible from rivers or located immediately adjacent to them. Features which are located within drainage basins of rivers but are remote from the river itself, and which are of no influence, are not considered representations.

It should be recognized that the geological processes recognized here are common and some rivers might be associated with examples of several or even all of them. It is important that only outstanding examples located in association with rivers be recorded. In the absence of strict criteria and information for assessing *outstanding*, framework users must exercise discretion. To provide some guidance, examples of Canadian Heritage Rivers where outstanding representations of these structures are found are shown in the right hand column.

It is important to distinguish this sub-theme from *Sub-theme 2.1: Hydrogeology* which addresses the hydrological properties of underlying materials and bedrock. This sub-theme is also concerned with underlying materials and bedrock, but also addresses the processes that have created neighbouring formations and structures, regardless of their potential as aquifers.

There is also potential confusion of these elements with those of *Sub-theme 3.4 Fluvial Landforms*. Processes which are the result of, or influence by, rivers are manifested in erosional and depositional forms that are addressed in *Sub-theme 3.4* . Geological processes of concern here are those that happen to occur in relation to rivers over a time scale that is different from that contemplated in *Sub-theme 3.4.*

Data Sources: There are numerous texts describing geological processes, and most can be interpreted in terms of their relationship with rivers.

Sub-theme 2.2: Geological Processes		
Element	**Typical Features**	**Canadian Heritage Rivers containing Outstanding Examples**
Bedrock Formation		
1. Sedimentation	Laying of sedimentary rocks, sandstones, limestones, shales; incl. fossils, fossil beds and springs.	Fraser, Arctic Red, Kicking Horse
2. Faulting	Results of tectonic events, incl. plate shifts.	Alsek, S. Nahanni, Restigouche.
3. Folding	Results of orogenic events, incl. uplifting	Athabasca, S. Nahanni,
4. Vulcanism	Igneous intrusions, dykes, puys	
5. Metamorphosis	Gneisses, slates, schists, rhyolites.	French, Mattawa
Surficial Material Formation		
6. Glacial Scouring	Striations, polishing, grooves, kettles, hanging valleys (cirques), cols, aretes, kettles, chattermarks.	French, Arctic Red
7. Glacial Transport	Moraines (drift) - terminal, interlobe, radial; drumlins, erratics, crag and tail, felsenmeer; also eskers and kames,	St. Croix, Seal, Athabasca, Grand
8. Glacial Rebound	Incised channels, abandoned beaches, deltas.	Seal, Hayes, Kazan, Thelon, French, Detroit
9. Glacial Melting	Oversize channels, potholes, spillways, glacial lake deposits.	French, Mattawa, Clearwater, Detroit
10. Glacial Movement	Evidence of ice dams, stream reversal, ongoing actions, calving, neo-glacial landscapes	Alsek, Arctic Red
11. Wind Deposition	Sand dunes, volcanic dust	N. Saskatchewan
12. Inundation	Silt, clay and alluvium from former lake and sea beds	

2.3 SUB-THEME: HYDROGEOLOGY

The geological materials that make up a river bed and valley are the underpinning factor in the land-atmosphere interface that produces rivers. The properties of these materials determine the degree to which they retain, contain, or are eroded by, water. In addition to run-off, this sub-theme addresses a second major source of water that influences rivers: groundwater aquifers.

This sub-theme aims to include a comprehensive range of geological materials that underlie river systems in Canada. Analogous to the hydrology sub-theme 1.3 *Water Content*, this sub-theme addresses the physical and chemical properties of the land onto which water is deposited, within which it is held, and through which it passes. Materials include not only bedrock types but also unconsolidated materials including glacial, lacustrine and alluvial materials.

Elements

The approach to defining sub-theme elements presented here is based on their intrinsic water-retaining properties, notably their porosity, solubility, and strength. There are two major components: bedrock and unconsolidated materials.

1. **Bedrock.** Regardless of geological provenance, bedrock is generally considered to have a range of properties related to the extent to which water passes through and affects the rock.
   - Porous rocks notably sandstones, permit seepage between grains;
   - Pervious rocks, like shales and slates, permit seepage through layers and cracks.
   - Soluble rocks, notably various types of limestones and dolomites (classified generally as carbonates), are pervious but are also dissolved by water and develop underground watercourses.
   - Impervious rocks, including granites and gneisses are resistant to erosion and permit seepage only through fractures. Included in this category are other types of bedrock that are rendered impervious by permafrost.

2. **Unconsolidated Materials.** Bedrock of any type may also be overlain by any type of unconsolidated material. In Canada these are predominantly of glacial origin, and the mode of deposition - meltwater, lacustrine or glacial retreat - is a major determinant of grain size, which in turn determines the water retaining properties of the deposits. Groundwater retention and issuance is determined by the intergranular porosity of surficial materials, and course-grained materials are significantly more porous than fine-grained.

Considerations in Applying the Elements

As in other sub-themes, representation of the elements of this sub-theme should be limited to only significant sections of rivers, since a river may pass over, through, or beside many different types of hydrogeological structures. However, it is likely that many rivers will represent more than one element.

The absence, complete or virtual, of surficial materials is considered to be a valid category. Normally such ‘absence’ is not complete, and scattered pockets of weathered sandy gravels or organic soils can be found in the most harsh environments. These underlying bedrock formations may, however, be considered as “barren”.

Recently formed alluvial features are included under *Sub-theme 3.4 Fluvial Landforms.* While soil types may be considered to be forms of unconsolidated material, they do not directly influence streamflow or underlie streams, so they are not considered here.

Data Sources: *Map 30: Surficial Hydrogeology* and *Map 31: Bedrock Hydrogeology* of *The Hydrological Atlas of Canada* contain information on both surficial and bedrock hydrogeology.

However, readers are cautioned that the map of surficial hydrogeology is incomplete and does not organize information according to the elements shown here, as the primary concern is with aquifer yields.

The National Atlas of Canada (4th edition, 1974) contains a map of surficial materials on which can be identified areas which are predominantly barren, described as bedrock outcrops. *Geology and Economic Minerals of Canada* (Douglas, 1968) also contains useful information.

Sub-theme 2.3: Hydrogeology			
	Surficial Unconsolidated Materials		
Bedrock Type	**High Porosity: Thin Soils and Barrens**	**Low Porosity: Fine-grained Clay and Silt**	**Medium Porosity: Loams, Sand and Gravels**
Porous (Sandstones)	1.	5. Margaree, Athabasca, Thelon	9. Hillsborough
Soluble (Carbonates)	2. S. Nahanni, N. Saskatchewan, Bonnet Plume, Kicking Horse,	6. Rideau, Humber	10. Humber, Clearwater, St. Mary's
Pervious (Shales)	3. Athabasca, N. Saskatchewan, Fraser, Kicking Horse	7. Arctic Red, Detroit, Thames, Fraser, Grand (lower), Yukon, Alsek, Restigouche	11. Restigouche, Bonnet Plume, Soper, S. Nahanni
Impervious (Igneous and metamorphic)	4. Bloodvein, French, Shelburne, Kazan, Boundary Waters	8. Rideau, Boundary Waters, Seal, Thelon, Mattawa, Main, St. Mary's, Clearwater (lower), Bloodvein (upper), Fraser	12. St. Croix, Mattawa, Margaree

2.4 SUB-THEME: TOPOGRAPHY

Topography is defined as the general configuration of a land surface (Bates and Jackson, 1980). It is basically about relief and slopes. Relief implies the extent of the slopes above sea level, while the slopes themselves determine much of a river's personality, manifested in the velocity of its waters. A river's velocity is a function of the gradient it follows. Steps in gradients are waterfalls and rapids (see Sub-theme 3.3) and lakes and ponds (see Sub-theme 3.2). Through its influence on velocity, the gradient of a river reflects its aesthetic qualities and recreational uses, particularly where its steps produce whitewater.

Canada's enormous size means that there are many potential representations of rivers at various heights above sea level. Rivers' size, water content, and seasonal variation are affected by the climatic implications of relief.

Elements
The two variables which create the elements of this sub-theme are gradient and height.

1. **Gradient:** As indicated on the chart below, gradient is measured as the overall difference in height over the length of the nominated section, in metres per kilometre.
2. **Relief:** Relief is measured as the height of the river's immediate environment above sea level. While this may be significantly lower than much of the surrounding topography, it is nonetheless a measure of the vertical distance that the river's waters must travel to reach the sea. Longer rivers which pass through significantly different heights may represent more than one element.

Considerations in Applying the Elements
Since river gradient varies greatly over its course, a single river might potentially represent all gradients. To keep representations simple, it is suggested that rivers may represent only one of the gradient categories shown on the following chart for each category of relief. The gradient should be measured along the whole length of the river section within a relief category.

Over short sections, rivers may fall into any of the gradient categories almost anywhere in Canada, since even in the flattest parts of Canada, there are occasional sharp changes in height. However, relief over 1000 metres is not so universal and is mostly confined to Alberta, British Columbia and the Yukon.

A potential complication in applying the gradient classifications is the artificial regulation of flow by dams and other structures. While rivers with impoundments are no longer included in the System on the basis of their natural values three are "grandfathered": the St. Croix, Mattawa, and French rivers. In these cases, since dams generally replace rapids and falls of similar height, the height of the dams could be included in the calculation of an overall gradient.

A more complex situation arises in the case of estuarine rivers, where the height of water at the river mouth depends on the height of the tide. High tides might be analogous to the rise in water levels at river mouths during flood peaks, except that the higher base levels caused by tides result in a lower velocity. Nevertheless, in applying this sub-theme, the tidal range should be added to the river gradient so as to be analogous to a step.

Rivers which extend into more than one relief category can represent more than one element. Nominated sections which are much shorter than the river's entire length, such as the North Saskatchewan and Yukon rivers, will be recognized within a single element of the sub-theme. Recognition that they are part of a much larger river is enabled through *Sub-theme 1.4: River Size.*

Sub-theme 2.4: Topography			
Gradient (Metres per Kilometre)	**Height Above Sea Level**		
	0 - 400 metres	**400 - 1,000 metres**	**> 1,000 metres**
Shallow <1m/km	1. Grand, St. Croix, Mattawa, Thames, Fraser	5. Clearwater, Yukon, Boundary Waters	9. Yukon
Moderate 1-2m/km	2. Seal, Kazan, Thelon, Bloodvein, Shelburne	6.	10. S. Nahanni, Fraser
Significant 2-5m/km	3. Margaree	7. Soper	11. Arctic Red, Bonnet Plume
Steep >5m/km	4. French, Restigouche, Humber	8. Main	12. Alsek, Kicking Horse, Athabasca, N. Saskatchewan, Fraser

THEME 3: RIVER MORPHOLOGY

This theme, river morphology, recognizes the features that are the result of the first two themes. The combined effects of hydrology and physiography on rivers are observable in their morphology. River morphology is defined here as river-influenced features in the landscape.

The classification of river morphology in this theme is not based on the same model as the previous themes *(where, when, what,* and *how much*), since it was considered that all features in this theme were functions of the *what* part of the model, being *what* is created by the interaction of water and land. The four sub-themes of this theme are instead based on four dimensions, the three spatial dimensions and time. The first three sub-themes reflect the profiles of rivers from each of three perspectives: cross-section, horizontal and vertical.

The fourth sub-theme reflects the time dimension in the form of ongoing processes. These processes, distinct from long-term past events (*Sub-theme 2.2 Geological Events*), are a direct response to the second CHRS selection guideline, as discussed in Chapter 3, which requires rivers to display ongoing processes.

Unlike elements of many of the first two sets of sub-themes, where rivers were "classified" within certain value ranges, all elements of these sub-themes are discreetly described features. Each sub-theme lists elements which are unique and result from the interaction of hydrological forces on the physiographic character of the land base.

The four sub-themes are:

Sub-theme 3.1: Valley types
Sub-theme 3.2: Channel Patterns
Sub-theme 3.3: Channel Profile
Sub-theme 3.4: Fluvial Landforms

Data Sources: Most information sources are common to each of these sub-themes and need not be listed separately for each one. Listed in the *Selected Bibliography* are several easily found examples of traditional geological and geomorphological texts that address river features including two classics: Schumm (1977), Morisawa (1985). Users may also find helpful articles in the two compendiums edited by Calow and Petts (1994). A more modern and less conventional approach can also be found in Knighton (1998).

3.1 SUB-THEME: VALLEY TYPES

Valleys not only reflect the geological history of river systems but are also the most dominant component of the river user's experience. They are the context in which a river's "immediate environment" exists and is shaped. This sub-theme attempts to classify rivers according to the various typical shapes of their cross-sections.

Elements
Key components of the valley are the valley floor, walls, and interfluves. Each of these three components, occurring in combination with another comprise different valley types.

1. **Valley Walls:** these may have a concave profile, or convex form, or may be straight-sloped;
2. **Valley Floors:** these may have non-existent or wide flood plains;
3. **Interfluves:** these may be peaked, rounded or flat.

To limit the number of possible combinations of these components, the four most common combinations which are believed to be found in Canada are listed in the chart below for each of the three types of valley wall.

Considerations in Applying the Elements
As in other sub-themes, representations must be of elements found within nominated river sections. Of concern here are the larger physiographic structures that contain the main stem of designated river sections. Not of concern here, but relevant to *Sub-theme 3.2: Channel Patterns*, are the immediate sides of rivers, which at flood times are inundated, which may be defined as the "bankfull" stage.

It is important that representations recorded using this framework be limited to river sections that are significant parts of the whole river. *Significant* in this context might be judged according to the general CHRS integrity guidelines, in particular the second guideline which refers to size of the nominated section. For example, the existence of a sort gorge on a river does not signal that the whole river can be considered a representation of a vertical walled valley.

To aid in determining valley types, the following descriptions of valley walls are offered.

- **Concave Walls:** U-shaped glaciated valleys are perhaps the best known of valleys in Canada. They are found in the northern and mountainous regions of Canada, and prime examples are found in the western cordillera and northern Canada, where in many cases, glacial action still occurs. Interfluves are usually peaked, although on the west coast of Newfoundland fiords are topped by flat tablelands.

  U-shaped valleys are generally not well-represented in eastern Canada, where the low peaks were overridden by glaciers and deep scouring of the original valleys was inhibited by hard bedrock and the non-alignment of the valleys to the direction of glacial movement.

- **Straight Walls:** The most common form of straight-walled valleys are V-shaped valleys associated with upper reaches of streams in the western cordillera and certain parts of the Appalachian Mountains of the Atlantic Provinces. Here, rapid downward erosion may have obscured glacial actions and created winding and rapid streams with narrow

floodplains.

Straight-walled valleys include steep, and sometimes literally vertical, walls extending to the valley floor. They are of two basic origins:

- those that simply *contain* rivers, termed here rift valleys, and
- those that are *created* by rivers, termed here incised valleys.

Rift valleys are a specialized type of vertical-walled valley that *contains* a river. One or both walls may be vertical, created by tectonic forces, as in the Annapolis Valley in Nova Scotia. Rift valleys are also distinct from faults recognized in *Sub-theme 2.3: Geological Processes*, which may traverse a water course or may be visible from it, but do not necessarily create its valley.

Incised valleys are typically associated with relatively soft underlying geology where the lateral erosion of bluffs has altered valley profiles to become more rectangular in shape. In some cases broad flood plains have been allowed to build up, but sometimes rivers flow through spectacular deep, narrow canyons or ravines. These are distinct from gorges and are dealt with under *Sub-theme 3.4 Fluvial Landforms*.

- **Convex Walls:** Convex walls are seen in areas where downward erosion has proceeded faster than lateral and where interfluves of straight-walled valleys have been overridden by glaciers. These are sometimes distinguished in the narrow, rounded convex-walled valleys of the northern tundra, where erosion into permafrost and a complex geological history has dictated stream flow. Usually there is only a narrow floodplain and the lower part of the valley may be V-shaped.

In northern tundra and Shield areas, because of hard underlying bedrock or permafrost, complex drainage patterns emerge. These often do not exhibit a specific valley type and are not addressed here or elsewhere in the framework.

Sub-theme 3.1 Valley Types		
Walls and Interfluves	**Narrow floodplain**	**Significant floodplain**
Concave-walled Valleys		
Peaked interfluves	1. N. Saskatchewan, Bonnet Plume	7. Kicking Horse, Athabasca, Arctic Red, Fraser
Rounded interfluves	2. Soper	8. Margaree
Straight-walled Valleys		
Peaked interfluves	3. S. Nahanni	9. Bonnet Plume, Fraser
Flat/rounded interfluves	4. Main, Clearwater, Thelon, Yukon	10. Margaree
Convex-walled Valleys		
Rounded interfluves	5. Kazan	11. Thelon
Flat interfluves	6.	12

3.2 SUB-THEME: CHANNEL PATTERNS

Juurand et al. (1972) noted a "lake and stream" pattern as a common feature of rivers he observed in the Canadian Shield and the northern tundra. The pattern of river channels viewed from above can be characterized not only by the various types of courses followed by the river itself, but also by the frequency of natural impoundments, notably lakes and ponds. These discontinuities in the flow of a river are primarily a reflection of the underlying geology, and specifically the perviousness of underlying materials. They also reflect climatic conditions, particularly in areas of permafrost, and topographic variations.

Elements

The elements of this sub-theme are partly derived from Morisawa (1971) who developed a rating system for channel patterns that reflects the importance of lakes and ponds in regulating a river's flow. This classification has been expanded to include types of channel patterns that would be observable looking down from above a river system. Two types of elements are included:

1. **Stream Configurations**
2. **Lake Systems**

The elements in the following chart attempt to define channel patterns in terms of their visual appearance from above. Brief definitions of each element are included in the chart.

Considerations in Applying the Elements

The channel patterns of interest here are those of the nominated section of river, not those of the entire river. Of interest are significant parts of the main channel of the nominated river, and distinct patterns of lake and stream combinations that display the character described in the chart.

Ponds are sometimes referred to locally as stillwaters, steadies, or other descriptors. Since they may vary greatly in size, they should be judged according to what is characteristic of the prevailing region and what might be judged a lake or pond relative to the normal width of the stream at "bankfull" stage[10].

It should be recognized that some parts of Canada, most notably the Prairies, have very few lakes, so any small lake may have a significant role on the flow of a river. Similarly, the difference between a lake and a pond may be one of interpretation of regional circumstances.

[10] Defining the ratio of surface area or volume of lakes to the length and/or discharge of the river was considered. This, however, requires calculations that are not normally part of river nominations.

Sub-theme 3.2: Channel Patterns		
Element	**Typical Characteristics**	**Canadian Heritage Rivers with Outstanding Representations**
Stream Configuration		
1. Straight	Almost straight channels, often with angular bends and bedrock or steep unconsolidated banks.	Main "gorge", The Thirty Mile (Yukon), French
2. Sinuous	Floodplain channel, shallow bends, flowing continually in one general direction	Grand, S. Nahanni
3. Meandering	Floodplain or incised channel, flowing in wide loops; floodplain may have oxbows and other features.	Margaree, Arctic Red, Lower Fraser
4. Tortuous	Extreme meandering, anastomosing channel, cutoffs and blind channels.	Kicking Horse, Athabasca, Mattawa
5. Branching	Channels separated by significant land masses, including vegetated bars. Includes river distributaries, including those in deltas.	French, Arctic Red, S. Nahanni
6. Estuarine	Widening river mouth area where salt water mixes, includes sub-tidal and tidal zones.	Hillsborough, St. Croix, Seal
Lake Systems		
7. Ponds	Permanent or temporary small in-stream water bodies, steadies, wider than flood channel.	Margaree, Grand, Restigouche
8. Floodplain Lakes	Permanent water bodies in-stream or closely linked beside main course	Arctic Red
9. Feeder Lakes	Permanent water bodies at or near source, or on tributaries feeding the main stream.	Arctic Red, St. Croix, Clearwater, Rideau
10. Lake Chain	Series of separate lakes linked by the main river stem.	Bloodvein (upper), Shelburne Mattawa, Kazan, Boundary Waters
11. Elongated Lakes	River section is essentially an elongated lake, possibly a drowned channel, flowing only at outlets.	French
12. Lake-contained Channel	River channel is part of a large lake, or its level is dependant on a large lake.	St. Marys, Detroit

3.3 SUB-THEME: CHANNEL PROFILE

The third dimension in viewing river channels is the horizontal profile, which describes the descent of the river over its course through the nominated section. The overall gradient of a river (see *Sub-theme 2.4: Topography*) partially explains its velocity and its personality. A river's flow is a reflection of its overall profile, which can be regular or stepped, or various combinations of these. Steps in the profile are waterfalls and rapids, which are perhaps the best-known features of a river. They are certainly the main feature of interest to canoeists and photographers. However, in this sub-theme it is important to classify the various forms of whitewater from a perspective other than recreation.

Elements
The elements of this sub-theme are descriptors of various types of steps, or the absence thereof, in a river profile. They are sequenced in order of the amount of vertical drop normally associated with the feature. This gradation passes from flat water to major waterfalls. To assist in distinguishing between elements they are divided into three self-explanatory categories:

1. **Level Water**
2. **White Water**
3. **Waterfalls**

Brief definitions of each element are included on the following chart.

Considerations in Applying the Elements.
Some elements may appear in a nominated river section only at certain times of the year, depending on flow levels. While representations may vary in quality according to the length of time they are present in a river section each year, occurrences which are distinctly ephemeral should not be included.

A rough guide to the classification of steps in a river profile might be obtained by observing the various recreational classes of rapids found along a river. These classes, assessed on the basis of recreational boating difficulty, are often equivalent to the size of the vertical drop of each set of rapids. However, it should be recognized that this is not always the case, especially in the case of the many gentle class 1 rapids that signify a lengthy, yet sizeable, drop and class 5 or 6 (impassible) drop which vary from a few metres to a major waterfall.

As not all gradients can be found in all parts of Canada, a significant regional bias could be introduced into elements defined according to height of rapids and falls. The types of profiles defined here are thus generic types that have fewer regional affiliations and most may be found anywhere in Canada[11].

[11] Some consideration was given to classifying waterfalls according to provenance. Such a method is described in the report *Waterfalls of Canada* (Reilly and Beardmore, 1980). Each set of waterfalls is classified according to a system of eight major categories based on their origins e.g. stream erosion, lowering of outlet, blocking of course. However, this information is sometimes not easily obtained, and conflicting opinions of waterfall origin occur. However, the study identifies 84 waterfalls located in each of Parks Canada's terrestrial natural regions that contain significant falls. Any of these identified waterfalls would be a significant feature to include in the System, and some, such as Wapta Falls on the Kicking Horse River, are already part of the CHRS.

Sub-theme 3.3: Channel Profile		
Element	**Typical Features**	**Canadian Heritage Rivers with Outstanding Representations**
Level Water		
1. Flatwater	Insignificant gradient, can include in-stream lakes	Detroit, St. Mary's, Thelon, Arctic Red, Alsek, Fraser
2. Swift Water	Regular shallow gradient with notable surges.	Yukon (30-Mile), Fraser
3. Pool and Riffle	Brief episodes of shallow white water separated by steadies and pools. Includes reversing rapids.	Margaree, Grand, Shelburne, St. Croix, Soper Lake reversing rapids, Restigouche
White Water		
4. Riffle	Shallow, sustained ripples over cobbles, often with shallow pools, islands and bars.	Glacier Rapids (N. Sask), Lafferty's Riffle (S. Nahanni)
5. Cataract	Abundant whitewater, rapids, significant gradient, with large boulder obstacles and eddies.	Des Roches (Mattawa), Aleksektok (Thelon), Deaf (Seal)
6. Prolonged Rapids	A single long cataract or several sets of rapids spaced at semi-regular intervals.	Turnback Canyon (Alsek), de la Cave to Paresseux (Mattawa), Great Island (N. Channel of Seal), Elora Gorge (Grand), St. Mary's, Rapid River Unit (Main)
7. Whirlpool	Major eddy or vortex with backflow, often associated with deeps and channel bends.	French, Yukon, South Nahanni
8. Chute	Narrow, usually short channel, steep flume; little whitewater.	Dalles (French), Skull Canyon (Clearwater), Talon (Mattawa)
Waterfalls		
9. Ledge	Abrupt, level drop extending across river channel.	Mud Lake Falls (St. Croix), Recollet Falls (French), Hardisty Ledges (Athabasca)
10. Cascade	Water falls vertically over rocky channel; free-fall of some of water.	Chap Falls (Bloodvein), Three Cascades (Kazan), Canyon Falls (Soper), Hogs Back (Rideau)
11. Waterfall	Water falls freely; some spray but no mist created; with plunge pool at base.	Smoothrock Falls (Clearwater), Paresseux Falls (Mattawa), Laughing (Kicking Horse), Rideau
12. Large Waterfall	All water falls freely for significant height; abundant mist and spray; deep plunge pool.	Virginia Falls (S. Nahanni), Sunwapta, Athabasca (Athabasca), Weeping Wall (N. Saskatchewan), Wapta (Kicking Horse), Twin, Takkakaw (Kicking Horse)

3.4 SUB-THEME: FLUVIAL LANDFORMS

The second CHRS natural heritage selection guideline identifies manifestations of ongoing processes as important components of rivers considered for inclusion in the System.

Fluvial landforms are the quintessential result of ongoing development and evolution of rivers. They are a direct reflection of the dynamic created by hydraulic and other forces acting on the physiography of an area. The results of these processes are an array of evolving morphological features, many of which are common to rivers throughout the world.

Processes that influence rivers are addressed here without regard to their origin. Thus, for example, gorges created as a result of uplift from glacial rebound are considered equivalent to gorges caused by a lowered base level - the results are the same and so there is no distinction here.

Elements

The fluvial landforms of this sub-theme are classified as either:

- **depositional, or**
- **erosional**

It may be possible to find parallels between features created by erosion and deposition, such that each erosional feature is mirrored elsewhere in a drainage basin by a parallel depositional feature. Six major types of erosional and depositional features are paired in the above chart. This bestows a form of symmetry to the list of elements shown on the following table. For brevity, the above table of parallels uses short-form names to describe an array of related features; in the following chart a more complete description of the features is included.

Parallels Between Erosional and Depositional Features

Erosional	Depositional	Parallel
Deeps	Fans	Localized hydraulic action
Gullies	Deltas	Source vs. mouth
Undercuts	Braiding	Lateral cut and fill
Ravines	Levees	Longitudinal features
Terraces	Oxbows	Abandoned streambed and stream
Sinkholes	Tufa	Solution vs. precipitation

Considerations in Applying the Elements

A river may contain numerous examples of these elements. Virtually all rivers will contain some good examples of fluvial landforms. It is important that only outstanding examples, judged according to size, condition and form, be included as representations and used as the bases for river nominations.

There is considerable potential for confusing the elements of this sub-theme with those of other sub-themes, particularly those included under *Sub-theme 3.2: Channel Patterns* and *Sub-theme 3.3: Channel Profile*. For example, meanders and anastomosed channels are not included here as they describe a channel type, rather than a specific feature like an oxbow lake. Features such as braiding and deltas, while contributing to divided or branching channels (*Element 3.2.5*), are also part of this sub-theme.

Ravines and gorges, often the spectacular results of erosion, are included here as they are considered to be short versions of longer valley types, referred to in this framework as *canyons*. Gorges formed by faulting, however, are not

considered gorges by this definition and are recognized under *Sub-theme 2.2: Geological Processes*. Wetlands, including marshes, bogs and fens are generally depositional features but since they are biotic features they are dealt with below under *Sub-theme 4.1 Aquatic Ecosystems.*

Sub-theme 3.4: Fluvial Landforms		
Element	**Characteristics**	**Canadian Heritage Rivers containing Outstanding Examples**
Depositional Landforms		
1. Fans	Cone-shaped, sloped washouts on valley sides composed of debris from mountain tributaries.	Fraser
2. Deltas	Large flat deposits of fine materials at river mouths on water bodies. Includes distributaries.	Main, Fraser, Seal
3. Braiding	Temporary islands, shoals, and point or longitudinal bars caused by accretion of sands, gravels and cobble in channel.	North Saskatchewan, Arctic Red, Fraser, Yukon
4. Levees	Raised banks enclosing channels within floodplain. Includes splays at breaches.	Thames, Detroit
5. Oxbows	Crescent-shaped lakes in anastomosed channels. Includes blind channels, abandoned courses and "scrolls".	Margaree
6. Tufa mounds	Dissolved minerals precipitated around hotsprings.	South Nahanni
Erosional Landforms		
7. Deeps	Small streambed potholes or large plunge pools formed below past waterfalls.	Grand, S. Nahanni
8. Gullies	Small upstream tributary cuts made by temporary or permanent streams in soft material. Includes rills and hoodoos.	Detroit, Thames, Grand
9. Undercuts	Lateral erosion on outside of bends. Includes knickpoints, slumping, and landslides prompted by undercutting	Arctic Red, Grand, Margaree
10. Gorges	Deep channels created by rapid downward erosion. Includes ravines and natural bridges.	Seal, Margaree, (Grand), Main
11. Terraces	Abandoned floodplains and beaches atop scarps facing river, created by episodal wave erosion.	Rideau
12. Caves	Sinkholes, caves and potholes in limestone areas. Includes limestone pavement features, dry valleys and river beds.	South Nahanni

It should also be noted that landforms that are not functionally connected with rivers are not recognized here. Landslides, scree slopes, and permafrost features such as polygons and pingos are not created as a result of fluvial processes, nor are they affected by them.

THEME 4: BIOTIC ENVIRONMENTS

The first three themes of this framework attempt to classify the abiotic characteristics of rivers. The combined effect of hydrological and physiographic processes not only produces the third theme, river morphology, but also lays the foundation for biotic environments in which exist a variety of river-related ecosystems. These ecosystems can also be considered as habitats in which species of river-related flora and fauna exist. Thus, the first three themes of this framework are the physical foundation for the second three themes: biotic environments, vegetation and fauna.

In keeping with the land-water paradigm used to develop the first three themes of the framework, this theme attempts to address biotic environments which are water-based and those which are land-based. The theme thus comprises two sub-themes:

Sub-theme 4.1: Aquatic Ecosystems
Sub-theme 4.2: Terrestrial Ecoregions

The first sub-theme classifies the generic types of environments that are found on all river systems and which support biota. The second sub-theme is a regionalisation of biotic systems, based on the occurrences of definable ecosystems in Canada.

4.1 SUB-THEME: AQUATIC ECOSYSTEMS

Aquatic ecosystems may be divided into four basic groups that have physical and functional association with rivers and which reflect the potential of a river to support plant and animal species: river channels, lakes, estuaries and wetlands. These are the bases for the four components of this sub-theme:

1. Riverine Systems
2. Lake Systems
3. Estuarine Systems
4. Wetland Systems

Elements

1. **Riverine Systems:** Three riverine ecosystem elements described here are based on the river continuum concept (Vannote, *et al.* (1980), namely: the headwater zone, middle zone, and lowland-tidal zone.

   The elements are based on a contemporary approach to river classification, namely, the *river continuum* concept (Vannote, *et al*., 1980). This classification system is based on the premise that river ecosystems evolve in harmony and are 'based on geomorphic principles, particularly those expressed in hydraulic geometry and dynamic equilibrium relationships'. This is consistent with the longitudinal distribution of fish and invertebrates and in the classification of river zones which have unique communities (Vannote *et al*., 1980:303). A river may represent any one or all of the three elements described above.

   - The general characteristics of the headwater stream zone include the area of sediment production; coarse channel substrate; low seasonal water temperature; low species diversity; and primary invertebrates include shredders and collectors.
   - The middle-order zone is the area of sediment transport; broad seasonal water temperature regime; variable discharge; and common invertebrates comprise of collectors and grazers.
   - The lowland zone is the region of sediment deposition; fine sediment substrate; stable discharges; and high species diversity.

2. **Lake Systems:** There are a number of ways in which lakes can be classified. Some of these classification systems are based on water chemistry, physical form, size, depth, phytoplankton, zooplankton, microphytes, invertebrates nekton, and anthropologic use (Gaffers and Mills, 1990). The most common means of classification is based on "trophic status" (used here) and thermal stratification (Gaffers and Mills, 1990).

   The elements in this component of the sub-theme are based on lake trophic status including oligotrophic lakes, mesotrophic lakes and eutrophic lakes. The trophic status reflects the productivity, age and catchment character of a lake.
   - *Oligotrophic* lakes are those of low primary productivity and in which the lowest level (hypolimnion) does not become depleted of oxygen during the summer months.
   - *Mesotrophic* lakes are those having intermediate levels of primary productivity and minerals required

by green plants. Lakes that have high primary productivity are rich in mineral nutrients required by green plants.

- Europhic lakes are those where the lowest layer of water (the hypolimnion) becomes depleted of oxygen during the summer through the decay of organic matter sinking from the highest level (epilimnion).

3. **Estuarine Systems:** Estuaries are the interface or transition zone between the freshwater of the inland river and the saline water of the ocean. While some might argue that estuaries are not strictly a part of a river system, they are recognized in the *CHRS Objectives, Principles and Procedures* (1984 Section 1.1) as a legitimate component of Canadian Heritage Rivers.

   Estuarine ecosystems are quite dynamic in nature and are areas of high biological productivity. There are a number of ways in which estuaries can be classified, they include: geomorphic character; distribution of salinity and density (chemical composition); type of tidal activity; type of circulation (tidal currents); and biological character (Ketchum, 1983; Wilson, 1988).

   The elements proposed for estuarine systems are those defining subtidal and intertidal zones.

   - *Subtidal* zones in estuaries are those in which the substrate is continually submerged, while *intertidal* zones are those in which the substrate is exposed and flooded by tidal action.
   - Intertidal zones are represented by the evidence of *offshore bars (bar-built)* formed in the ocean across the mouth of a river and lying parallel to the coastline.

4. **Wetland Systems:** Wetland or "palustral" ecosystems are commonly situated along older abandoned parts of the river course which are often connected through flooding. A common water table connects wetlands and riverine ecosystems.

   Classification of wetlands are typically based on vegetation, nutrient regime, hydrology, soil materials and development trends, and are commonly associated to the hydro-topographic features of rivers and lakes (Zoltai, 1983; Glooschenko *et al*., 1993; Stanek, 1977).

   The standard hierarchical classification of Canadian wetlands has been developed by the National Wetland Working Group of the Canada Committee on Ecological Land Classification. Based upon the Committee's wetland classification system the following elements are suggested: bogs, fens, marshes, and swamps.

   - Bogs are peatlands, typically with the water table at or near the ground surface. River-related bogs can be further divided into *floating* and *shore* bogs (Glooschenko, et al., 1993).
   - Fens are peatlands with the water table normally at or above the ground surface and can be further divided into *floating* and *stream* fens (Glooschenko, et al., 1993).
   - Marshes are mineral wetlands or peatlands that are periodically flooded or inundated by standing or

moving waters and can be further defined as *freshwater* and *saltwater* marshes.

- Swamps are peatlands or mineral wetlands with standing or slow moving water occurring in pools or channels.

Sub-the me 4.1: Aquatic Ecosystems	
Elements	**Canadian Heritage Rivers With Outstanding Examples**
Riverine Systems	
1. Headwater zone	Kicking Horse, Athabasca, Soper, Alsek
2. Middle zone	Clearwater, Yukon, Bonnet Plume, Arctic Red, Restigouche
3. Lowland zone	Hillsborough, Margaree, Fraser, Seal, Kazan, Thelon, Grand
Lake Systems	
4. Oligotrophic lakes	Kazan, Thelon, Alsek
5. Mesotrophic lakes	Soper, Clearwater, Hayes,
6. Eutrophic lakes	Grand, St. Croix, Shelburne, Boundary Waters
Estuarine Systems	
7. Subtidal zone	St. Croix, Fraser, Restigouche
8. Intertidal zone	St. Croix, Hillsborough
9. Saltwater marshes	Fraser, Hillsborough
Wetland Systems	
10. Bogs and fens	French, Shelburne, St. Croix, , Main
11. Marshes	Bloodvein (Ma.), Athabasca, Kicking Horse, Bonnet Plume, Fraser, St. Marys
12. Swamps	Mattawa, (Grand), ,

Considerations in Applying the Elements

All rivers possess aquatic ecosystems of some type. It is important that the ecosystems recorded through this framework are significant parts of the river concerned. They should be relatively large not only to meet integrity guidelines, but to ensure that there is not excessive duplication within the System.

Because of climatic variations across the country, there will be numerous regional variants of these ecosystems. It is important that the character of these variants, including dominant and rare species lists, be recorded. Lakes are commonly the source of a river and are often situated along their course.

To avoid overlap with other sub-themes the distinction should be emphasized between abiotic and biotic characteristics of rivers and lakes. The morphological character of rivers and lakes is addressed within *Theme 3: River Morphology*. Similarly, although

individual plant species may be important features of some ecosystems, their rarity or other outstanding characteristics are recorded in *Theme 5: Vegetation*.

Data Sources: *Wetlands of Canada* (National Wetlands Working Group, 1988) can be consulted to identify the types of riparian communities typical of the different regions of the country. In the *National Atlas of Canada* Map 9.1 Distribution of Wetlands and Map 9.2 Wetland Regions are useful references for aquatic species.

4.2 SUB-THEME: TERRESTRIAL ECOSYSTEMS

It is important that this framework recognize the land-based ecosystems that encompass Canadian Heritage Rivers which, although they are terrestrial and this is a water-based framework, have a profound impact on the biotic environments of rivers. While *Sub-theme 4.1 Aquatic Ecosystems* recognizes the generic types of ecosystems associated with rivers, this sub-theme recognizes the various types of land-based ecosystems that rivers flow through in Canada.

Rivers do not create their own ecosystems in isolation from those which comprise its immediate environment. In passing through different ecosystems, rivers modify them, for example, by providing additional accessible water or micro-climatic variations. Although species may prosper in the immediate environment of a river more than on dry interfluves, the general character of each ecosystem usually remains intact. It is therefore not necessary to attempt to devise a new regional system of river-based ecosystems.

There are a number of published definitions of ecoregions in Canada. The National Atlas of Canada publishes several that might be usable for this sub-theme, including one showing Wetland Regions. This map classifies forty wetland regions with similar ecological characteristics. However, it was felt that use of this system, and others which are water-based, would duplicate aquatic ecosystems described in *Sub-theme 4.1 Aquatic Ecosystems*.

Because of the significance of climate in determining species' ranges, some classifications have adapted climatic zonations to reflect plant communities. An example of this is the map of ecoclimatic provinces prepared in 1986 by the Ecoregions Working Group of the Canada Committee on Ecological Land Classification. Other eco-regionalisations, such as that of Crowley (1967), recognize the total landscape, including physiography.

Vegetation mapping systems have been applied to identify the types of plant communities typical of the different regions of the country. For example, the document *Heritage Rivers of the Northwest Territories* (Baker, 1984) uses Rowe's forest regions, combined with the vegetation regions presented in the *National Atlas of Canada*, to define "vegetative/forest regions" to represent in Heritage Rivers.

In all of these systems, there is some similarity with physiographic regions, in particular where climate is influenced by elevation. However, a river in such a situation could thus represent several different sub-theme elements in this framework simply through its location.

Elements

The "ecoregions" used in this framework are the 15 terrestrial ecozones developed by Environment Canada in 1986 (Wiken,1986). This selection is based in large part on the adoption of this system by most provincial parks agencies in Canada as the basis for defining provincial ecozones and regions. This facilitates harmonisation of the framework with provincial and territorial systems plans.

The 15 ecozones are shown on the chart below and a copy of the map is reproduced on the next page. Each ecozone comprises an element of this framework. Canadian

Heritage Rivers, and significant sections thereof, which flow through each ecozone are shown below.

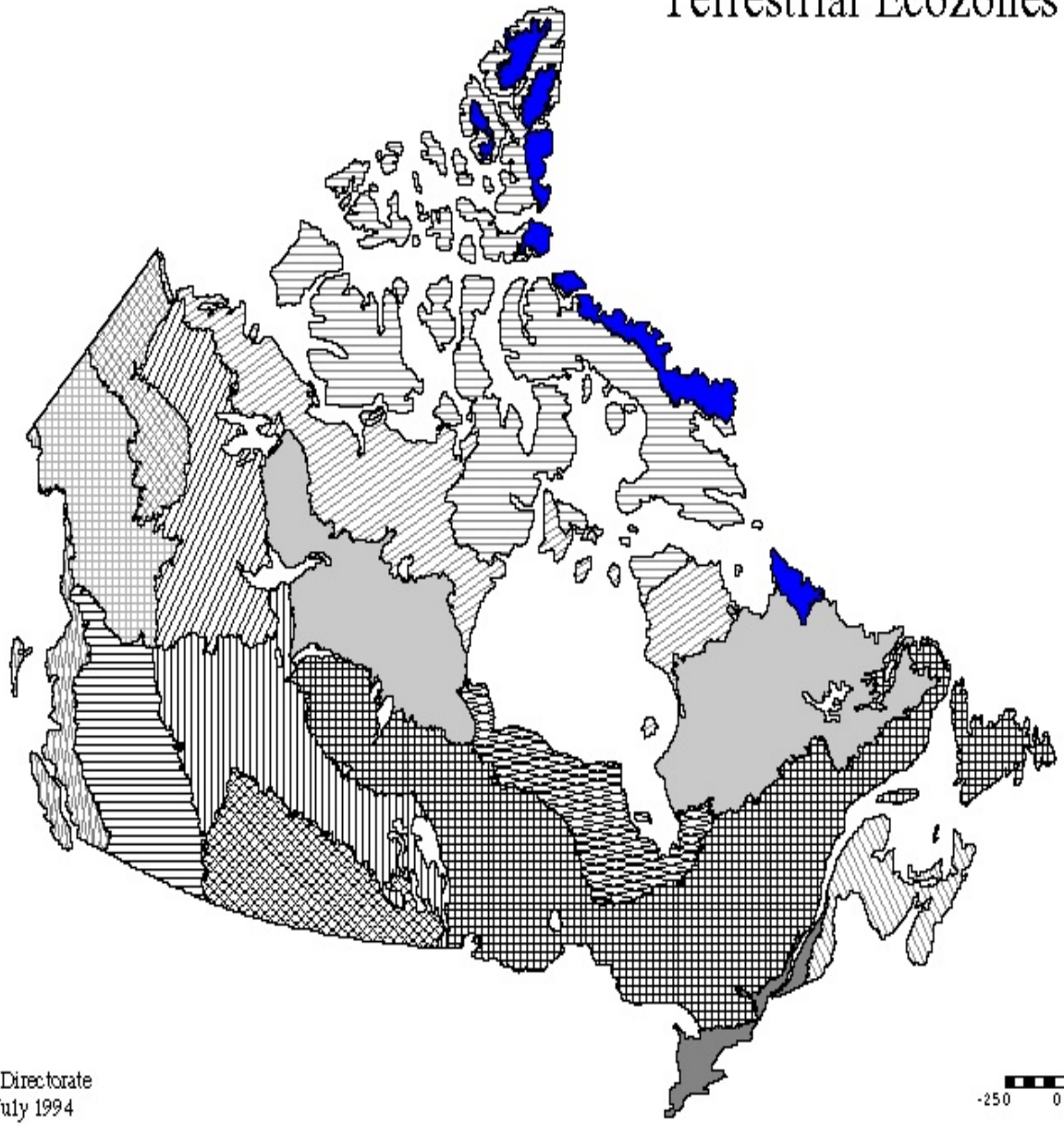
Sub-theme 4.2: Terrestrial Ecosystems		
Ecozone	**Approximate Area (% of total)**	**Canadian Heritage Rivers with Outstanding Representations**
1. Arctic Cordillera	2.5	
2. Northern Arctic	15.2	Soper
3. Southern Arctic	8.3	Thelon, Kazan, Seal
4. Taiga Plains	6.5	Arctic Red
5. Taiga Shield	13.7	Seal, Thelon, Kazan
6. Taiga Cordillera	2.7	Bonnet Plume, Arctic Red
7. Hudson Plains	3.6	Seal
8. Boreal Plains		Peace, Clearwater,
9. Boreal Shield	19.5	Bloodvein, French, Mattawa, Clearwater
10. Boreal Cordillera	4.7	Yukon, Alsek
11. Pacific Maritime	2.2	Fraser
12. Montane Cordillera	4.9	Fraser, Kicking Horse, Athabasca, North Saskatchewan
13. Prairies	4.8	
14. Atlantic Maritime	2.0	Main, Margaree, St. Croix, Shelburne, Restigouche
15. Mixedwood Plans	2.0	Grand, Thames, Detroit, Humber

Considerations in Applying the Elements

Representation of all ecozones may not be feasible, particularly the two most northern zones where there are very few if any significant rivers. On the other hand, for ecozones that contain several Canadian heritage rives it is notable that the 15 zones are divided into 217 ecoregions, which may be used for detailed descriptions of individual rivers. It is suggested, however, that any assessment of the representation of this terrestrial ecosystems sub-theme be based on the length of rivers in each ecozone.

As in the case of other regional approaches to the definition of sub-theme elements in this framework, it is desirable and feasible to aim at a balanced representation of the elements in the System. This can be achieved by the inclusion of total lengths of river sections in each ecozone in proportion to the area of the ecozone. Thus, for example, the total length of Canadian Heritage Rivers (nominated for their natural values) in the Boreal Shield should be about 19.5% of the total length of all Canadian Heritage Rivers (nominated for their natural values)

Terrestrial Ecozones of Canada



State of the Environment Directorate
Environment Canada, July 1994

THEME 5: VEGETATION

The first three themes of this framework attempt to classify the abiotic characteristics of rivers. The combined effect of hydrological and physiographic processes not only produces the third theme, river morphology, but also lays the foundation for biotic environments, the fourth theme. The biotic environments of this theme enable the recognition of plant species that are typical of river environments. Theme 4 does not, however, provide a means of recognizing plants that are of special interest. Theme 5 therefore focuses on exceptionality among plant species.

Since all plant species depend on water and most can be found in association with rivers, this theme could potentially address a vast number of plant species in Canada. This number might be pared to include only those species which are directly associated with rivers, but such a list does not exist and this would in any case exclude significant non-river-dependent species which happen to live near rivers.

There are several possible approaches to the definition of sub-themes for this theme.

- Rarity: COSEWIC[12] classifies plant species at risk according to the categories of endangered, threatened and of special interest;
- Phylogeny: Traditional floral classifications: trees, shrubs, herbaceous plants, and lichens and mosses;
- River Association: Classification according to the location of species relative to the river course, such as in-stream, riparian, and valley;
- Exceptionality: The reasons for species to be of interest such as rarity, location, dynamics, size, extent etc.

These four approaches each have certain drawbacks as the basis for sub-themes: unevenness of sub-theme size, variable relevance to rivers, and variable levels of significance.

To provide uniformity in the framework it was also judged desirable that the classification adopted here should be adaptable for use in *Theme 6: Fauna*. CHRS selection guidelines, which address both flora and fauna, provided some guidance:

- The third natural selection guideline requires that rivers contain *unique, rare or outstanding examples of natural phenomena*[13].
- the fourth selection guideline indicates that *rare and endangered species of plants and animals*, and *outstanding concentrations of plants and animals* should be represented in the System.

The CHRS selection guidelines were used as the basis for the primary division of this theme into sub-themes. The other possible approaches, based on rarity, phylogeny and river-relatedness, are used to define elements for each sub-theme. The two sub-themes are designed to distinguish between significant communities of plants and significant individual plant occurrences.

Sub-theme 1: Significant Plant Communities
Sub-theme 2: Rare Plants Species

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[12] Committee on the Status of Endangered Wildlife in Canada.

[13] The CHR Board has defined *phenomena* as including biotic as well as abiotic features.

5.1 SUB-THEME: SIGNIFICANT PLANT COMMUNITIES

The fourth CHRS natural heritage selection guideline makes reference to *"areas where outstanding concentrations of plants and animals of Canadian interest and significance are found"*. It is important for the CHRS to contain representations of vegetation species which although not rare in themselves are of Canadian significance because of their association with other species, their size, or other qualities.

The second natural heritage selection guideline addresses a river environment which *"Is an outstanding representation of significant ongoing ... biological processes."*. Thus, evolutionary dynamics that effect plants species, such as re-vegetation, succession and fire, are relevant to this theme.

Four alternative approaches to the categorization of plant communities, and thus the definition of sub-theme elements, were noted above:

- Rarity
- Taxonomy
- River association
- Exceptionality

It is possible to eliminate two of these approaches:

- Rarity, while an important form of exceptionality, is the concern of *Sub-theme 5.2 Rare Plant Species* and need not be duplicated here.
- River association is an inherently distorted criterion, since it also measures significance from a river standpoint; species which are more closely associated with a river are inherently more significant elements of river heritage.

It is also important that this sub-theme help define what constitutes a *significant* plant community The fourth CHRS selection guideline requires that communities that would represent this sub-theme would be found in "outstanding concentrations" and be of "Canadian interest". While concentrations can be defined numerically, by estimating population sizes, Canadian interest is open to interpretation.

Elements

The elements of this sub-theme are defined according to two variables: species type and exceptionality.

1. Species Type

Plant communities are divided among four species types, defined partly according to their habitat and partly taxonomically:

- **Aquatic/Riparian:** plants growing in-stream, along margins or in associated wetlands;
- **Vascular Plants:** herbaceous plants not growing in or beside the river, but within the river environment, including its valley;
- **Trees and Shrubs:** woody species growing within the immediate river environment, on the river banks, or valley slopes.

2. Exceptionality

Exceptionality is defined here as any of the following four qualities:

- **Extent:** the abundance of a plant community, as demonstrated in the number of plants, the areal extent of the community or its purity;
- **Location:** the unusual location of the plants relative to the normal distribution of the species in the ecozone in which

Sub-theme 5.1: Significant Plant Communities		
Element	**Example Communities or Species**	**Canadian Heritage Rivers where found**
Aquatic/Riparian Plants		
1. Extent	Lake cress Black River IBP site species Coniferous swamp Floating fens and bogs	Mattawa Margaree Humber Shelburne
2. Location	Prairie rush, marsh marigold	Bloodvein
3. Dynamic		
4. Diversity	Fluvial scrub and meadow Carex and salix species at Black River Marshland ANSIs	Kicking Horse Margaree Rideau
Vascular Plants		
5. Extent	Virginia chain fern Churn Creek grasslands Orchids at Virginia Falls	French, Mattawa Fraser South Nahanni
6. Location	Virginia chain fern Grasslands on valley sides Prairie, arctic, southeastern taxa Tall-grass prairie	French, Mattawa Clearwater Bloodvein Grand
7. Dynamic	Oak savannah Neoglacial colonisation Post glacial migration corridor Relict species, no glaciation Colonisation of sand bars	Humber, Detroit, Thames North Saskatchewan French South Nahanni Athabasca
8. Diversity	646 vascular species Mosses, lichens, vascular plants 2200 plant species	Kicking Horse Restigouche Detroit
Trees		
9. Extent	Jackpine stands in lea of eskers Red oak stands Garry Oak/Big-Leaf Maple-Wild Cherry Old growth black spruce	Seal Hillsborough Fraser Arctic Red
10. Location	Easternmost occurrences of red cedar White spruce krummholz White spruce, balsam at northern limit Large willows in valley bottoms Maple-beech, oak-hickory stands Tamarack stand at Slats Creek	Kicking Horse Alsek Clearwater Soper Grand Bonnet Plume
11. Dynamic	Old black spruce Old growth hemlock Lodgepole pine fire succession Over-mature Montane forest Old growth sugar maples Mature cedar and black ash stands	Arctic Red Mattawa, Shelburne North Saskatchewan Athabasca, Kicking Horse Margaree Rideau

Sub-theme 5.1: Significant Plant Communities (continued)		
Element	**Example Communities or Species**	**Canadian Heritage Rivers where found**
12. Diversity	Silver birch complex Carolinian Canada species Oasis complex Boreal-mixed forest transition	Mattawa Grand, Thames, Detroit Thelon Boundary Waters
Shrubs		
13. Extent	Dwarf shrub barrens	Main
14. Location	Willow shrub complex Shrub birch	Soper Alsek
15. Dynamic	Oak savannah Colonisation of shifting bars Re-vegetation of avalanche paths	Detroit, Thames North Saskatchewan Kicking HOrse
16. Diversity	Four relief dependent communities	Soper

the river is located, due to localized soil or climatic conditions or climate change, including relict species;

- **Dynamic:** community dynamics such as rapidity of its change or slowness, or in the age of the plant specimens, measured in absolute terms or relative to those typical of the ecozone; or
- **Diversity:** the diversity of a plant community, reflected in the number of different species present or in the unusual association of particular species.

As shown in the preceding chart, the matrix of these variables creates 16 possible elements.

Considerations in Applying the Elements

Of first importance in applying this sub-theme is the need to recognize that *rarity* in plant communities is part of the following *Sub-theme 5.2: Rare Plant Species*. Plants or communities which are not only exceptional in terms of the four element types of this sub-theme but are also *rare* should be noted here, even if they are potential representations of the next *Sub-theme: Rare Plants*.

Also important is the possibility of including groups of plants, growing together as a community, as potential element representations. These will, for the most part, represent at least the exceptionality *diversity*.

The size of plant specimens may be of significance in certain cases. This may reflect age or other local factors such as water availability, nutrients or microclimate. Where the main cause can be determined simply as age, the species or community should be included under the *dynamic* element. Thus, old growth forest stands should be recognized under the appropriate *dynamic* element. The size of the area covered by a community is recognized under the element *extent*.

The apparent absence of change in an isolated occurrence of a species or community, such as in the continued

presence of relict species, should be recognized under the *location* element.

Plant communities which serve simply as habitat for a significant species of animal are not recognized here. The animal population may, however, be recognized in *Sub-theme 6.1 Significant Animal Populations*.

5.2 SUB-THEME: RARE PLANT SPECIES

Rivers and riverbanks are often the site of plants that grow nowhere else in Canada. In some cases, rivers offer a unique environment on which plants depend, and in other cases, previously widespread plants find refuge in river valleys. In some cases river valleys provide a migration corridor for plants with affinity for a different climate and whose distribution is still adjusting from the last ice age. One of the most valuable roles that the CHRS can play is to enable recognition and protection of these species.

As noted in the introduction to this theme, the third CHRS natural heritage selection guideline refers to rivers that contain *"unique, rare or outstanding examples of natural phenomena"*. In 1992, the Canadian Heritage Rivers Board ruled that *phenomena* included biotic features, as well as abiotic. The fourth selection guideline also refers to *"rare and endangered plants and animals*". It is therefore necessary that the framework should address rare plant species[14].

As distinct from significant plant *communities* that are addressed in *Sub-theme 5.1* above, this sub-theme is concerned with plant specimens that are uncommon either because of natural causes or because of ecosystem destruction by humans. Each species represents a possible element in this sub-theme. However, the list of rare plant species in Canada is long. In addition to the numerous plants listed by provincial and territorial governments, in November 2000 the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed 123 plant species that were considered "at risk" in Canada.

It is therefore necessary to organize these species. This can be achieved in several different ways:

- in the same way as plant communities, according to their taxonomic or other general type;
- according to their association with rivers, aquatic, riparian or valley;
- according to degree of rarity.

River association suffers from the same problem outlined in the case of Sub-theme 5.1, in that there is an inherent rating of degree of significance. Also, since only one tenth of the COSEWIC listed species are trees or shrubs, and only one is a moss, taxonomic classification alone would not produce balanced elements.

Elements

Each species listed as at risk, potentially at risk, or rare by COSEWIC and other agencies comprises a potential element of this sub-theme[15]. Ideally, this framework should serve as a tool to permit recognition of how many of these species are represented on Canadian Heritage Rivers. To simplify the list of elements, however, some form of grouping is needed.

Categorization of rare species in this sub-theme uses one of the two variables used to define elements of the previous *Sub-theme 5.1 Significant Plant Communities*, and a

[14] A more complete discussion of the implications for this theme of the guidelines is contained in Chapter 3, sections 3.1.3 and 3.1.4.

[15] It is recognized that it is unlikely that all of these elements will ever be represented in the CHRS. Caution should be used in attempting to describe representation rates of this theme compared with other themes in the framework; the rate is likely to be incomparably low for this sub-theme.

variable directly related to the rarity of plants.

1. Species Type: the taxonomic distinction is made between two species types (vascular[16] or woody) with an additional sub-category of plants to identify those which are directly associated with rivers either as aquatic, riparian or wetland species.

2. Degree of rarity: Species are divided into four groups, the first three of which are levels of designation established by COSEWIC:

- endangered;
- threatened;
- of special concern;
- otherwise listed by recognized provincial or other agencies, termed here *Regionally Rare*.

As shown in the following chart, the combination of these variables creates 12 possible elements[17].

Considerations in Applying the Elements
It is essential that users of this framework consult the most up to date lists of species at risk, using both COSEWIC and other listings. Although some of these plants are not normally found in association with rivers, because they can occur within the immediate environment of rivers as defined in the CHRS (i.e. within the river valley), virtually all listed species potentially comprise an element in this sub-theme.

Unlike the possible representations of the previous sub-theme, which included groups of species within recognizable communities, elements of this sub-theme must comprise specific species.

Data Sources. Detailed evaluation of rivers under this sub-theme may require some expertise in aquatic ecology and botanical inventory data. The most recent list of plants at risk is published on the World Wide Web by the Committee on the Status of Endangered Wildlife in Canada at (http://www.cosewic.gc.ca).

[16] As in Sub-theme 5.1, vascular plants include mosses and lichens.

[17] It is recognized that these elements do not reflect aspects of river heritage that need to be represented in the same way as elements of Themes 1-4. They are merely a convenient way of grouping rare plants to permit a snapshot of which Canadian Heritage River environments contain representations.

Sub-theme 5.2: Rare Plant Species		
Element	**Example Species**	**Canadian Heritage Rivers where found**
Aquatic/Riparian Plants		
1. Designated *endangered*		
2. Designated *threatened*	*Papaver walpolei*	Bonnet Plume
3. Designated *of special concern*		
4. Regionally rare species	One-sided sedge, water millfoil, clustered sedge Siberian sedge Prairie rush	French Alsek Bloodvein
Other Vascular Plants		
5. Designated *endangered*	Prickly pear, white wood aster, broad beech fern Wood poppy	Rideau Thames
6. Designated *threatened*		
7. Designated of *special concern*		
8. Regionally rare species	Virginia chain fern Southern panic grass, pinedrops Prairie golden bean	Mattawa, French French Kicking horse
Other Woody Plants		
9. Designated endangered	Cucumber tree Blue ash	Grand Thames
10. Designated threatened		
11. Designated of special concern	Green dragon tree	Grand
12. Regionally rare species	Northern pin oak Pawpaw tree, burning bush	Boundary Waters Thames, Grand, Detroit

THEME 6: FAUNA

It would be natural to assume that there are many parallels between this theme, *Fauna*, and the foregoing *Vegetation Theme*. These parallels could have implications for the organisation of this theme into sub-themes and elements. There are indeed some similarities:

- There is a vast number of species in Canada that could be present on Canadian Heritage Rivers;
- Like all plant species, animals depend on water and many can be found in association with rivers;
- Like plants, some animals are intimately associated with rivers, while others have less dependent relationships;
- There is a traditional taxonomic classification of animal species, in this case fish, mammals, birds, reptiles, invertebrates, molluscs and so on;
- The same CHRS natural heritage selection guidelines (2nd and 3rd) apply equally to animal species and have the same implications for recognizing groups of animals and individual species.

A major difference, however, is in the ability of animal populations to move around and to perform various activities that are in no way analogous to vegetative processes. Activities such as nesting, feeding, migrating and rearing young also do not have any equivalence in the vegetative world. Three types of animals are implied:

- Indigenous species: live their entire lives in association with rivers and perform all of these activities;
- Migratory species: visit river environments seasonally in order to feed moult, calve or breed;
- Transient species: may pass through a river environment on their way elsewhere and stop briefly to feed and rest. This form of activity has the least connection with rivers.

Populations of different animal species, while interacting and in some cases being symbiotic, are dynamic and overlap in their ranges, which in most cases are neither well-understood nor mapped. Thus, one cannot describe groups of animals in the same way as plant communities. Here they are referred to as "populations".

With this terminological exception, the sub-themes of this theme are defined in parallel to *Theme 5: Vegetation*: one addressing groups of animals, and one addressing rare species:

Sub-theme 6.1: Significant Animal Populations
Sub-theme 6.2: Rare Animal Species

6.1 SUB-THEME: SIGNIFICANT ANIMAL POPULATIONS

The fourth CHRS natural heritage selection guideline makes reference to *"areas where outstanding concentrations of plants and animals of Canadian interest and significance are found"*. As in the case of *Sub-theme 5.1: Significant Plant Communities,* this implies that the framework should recognize animal species which are not rare in themselves but, together with other species, are of Canadian significance for other reasons.

The most direct way of recognizing river-associated animals would be to draw up a list based on empirical information about such species in Canada. There is, however, no list of Canadian fauna, rare or otherwise, that are associated with aquatic habitats. This is probably because all animal species depend on water and most can be found in association with rivers.

Thus, as in classifying plants, there is a similar number of ways of classifying animal species:

- Rarity
- Taxonomy
- River association
- Exceptionality

As in the case of plant communities, it is possible to eliminate rarity which is the concern of *Sub-theme 6.2: Rare Animal Species* and therefore need not be duplicated here.

Similarly, river association, which might categorize animal species as aquatic, riparian or land-based, suffers from the same problem, the inherent measurement of significance, as in its possible application to plant species.

The fourth guideline also requires that animal populations that would represent this sub-theme would be found in "outstanding concentrations" and be of "Canadian interest". While concentrations can be defined numerically, by estimating population sizes, *Canadian interest* is open to broad interpretation, it is not possible to draw up a list of qualifying species.

There are some parallels in describing the exceptionality of animal populations to that of plant communities. However, while plant communities may be significant because of their age or specimen size, these are not relevant characteristics in classifying animal species.

Elements

This sub-theme uses two variables to classify significant animal populations:

1. **Taxonomy:** The taxonomy for animals: fish, mammals, birds, and reptiles and amphibians, and invertebrates.
2. **Exceptionality:** The same four exceptionalities used for plant communities may be applied here: size, location, dynamic and diversity. Communities that may be judged to be *outstanding* are defined here as those that exhibit one of these exceptionalities.

As shown in the following chart, the matrix of these variables creates 16 possible elements.

Considerations in Applying the Elements

In this sub-theme, animals that may be judged to belong to *significant communities* are those which:

- are indigenous to the river environment and valley, passing their entire lives

Sub-theme 6.1: Significant Animal Populations		
Element	**Example Population or Species**	**Canadian Heritage Rivers where found**
Fish		
1. Population size	Yellow pickerel Smallmouth bass Lake trout Arctic char Whitefish Atlantic salmon Pacific salmon (6 species)	French St. Croix Mattawa Kazan, Thelon Arctic Red, St. Mary's Margaree, Main, Restigouche Fraser
2. Location		
3. Dynamic	Smallmouth bass, Atlantic salmon Lake whitefish	St. Croix St. Croix, Main Bonnet Plume
4. Diversity	Various species at warm tributaries 88 species incl. 10 hybrids	Mattawa Thames
Mammals		
5. Population size	Dall's sheep, grizzly bear Musk oxen Barren ground caribou Lemming Dall's sheep	Alsek Thelon, Kazan Kazan, Thelon, Seal, Arctic Red, Bonnet Plume Soper Bonnet Plume
6. Location	Elk (wapiti) Southern flying squirrel	French Thames
7. Dynamic		
8. Diversity	Large mammals incl wolf, cougar Conc. large mammals	N Saskatchewan Kicking Horse
Birds		
9. Population size	Double-crested cormorant White pelican Bald eagle, ospreys Black swift Loons, cranes, ducks	French Clearwater S. Nahanni, Bloodvein Athabasca Thelon
10. Location	Cliff swallows	Seal
11. Dynamic	Bald eagles, osprey Canvasback ducks	St. Croix Detroit
12. Diversity	Ducks, cranes, geese, swan species Graveyard Flats species 200 species 300 species in lower basin 70% of Ontario's species	Alsek, Arctic Red N. Saskatchewan Kicking Horse Fraser Thames

Sub-theme 6.1: Significant Animal Populations

Element	Example Population or Species	Canadian Heritage Rivers where found
14. Location	Blandings Turtle Wood frog Jefjerson salamander	Mattawa, Shelburne Seal Humber
15. Dynamic		
16. Diversity	Dragonflies	St. Croix

within it. Hibernating animals are considered to be indigenous.

- stay temporarily in the river environment to perform a significant part of their life cycle such as resting, breeding, nesting, birthing, rearing, feeding, wintering, fattening, or dying.

Species which are not only exceptional in terms of the four element types of this sub-theme but are also *rare* should also be noted here, even if they are potential representations of the next *Sub-theme: Rare Animals*.

6.2 SUB-THEME: RARE ANIMAL SPECIES

Rivers and riverbanks are sometimes the site of animals that exist nowhere else in Canada. Rivers may offer a suitable habitat on which indigenous animals depend or a refuge for previously widespread animal species. One of the most valuable roles that the CHRS can play is to enable recognition and protection of these animal species.

As noted under *Sub-theme 5.2: Rare Plant Species*, the third CHRS natural heritage selection guideline refers to rivers that contain *"unique, rare or outstanding examples of natural phenomena"*, and the fourth guideline refers to *"rare and endangered plants and animals*". It is therefore necessary that the framework address unique and rare animal species[18].

The list of animal species at risk in Canada is long. The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) identified 214 animal species in November 2000 as either endangered, threatened or of special concern[19].

Elements
The elements of this sub-theme are structured in a similar way to rare plant species. Each species listed by COSEWIC comprises a potential element of this sub-theme. Species that are officially listed by provincially or territorial agencies or through formal designation by these governments, are an additional type of element.

Elements are defined as categories of species using the same two variables as for rare plants:

1. Taxonomy: Conventional classifications of species type: fish, mammals, birds and other types (reptiles, amphibians, and invertebrates)
2. Degree of rarity: endangered, threatened, of special concern, or otherwise listed by a recognized agency.

As shown in the following chart, the matrix of these variables creates 16 possible elements[20].

Considerations in Applying the Elements
It is essential that users of this framework consult the most up to date lists of species at risk, using both COSEWIC and other recognized listings.

In the context of this sub-theme, *rarity* is both an absolute and a relative term. As an absolute term it refers to animal species that are scarce throughout Canada, and as a relative term it refers to animal species that are scarce in various jurisdictions in Canada. In either case, the rarity of representatives of the species is the reason for their recognition.

In this sub-theme, no distinction is made between species that are rare because of natural causes, and those that are rare because of species destruction by humans.

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[18] A more complete discussion of the implications for this theme of the guidelines is contained in Chapter 3, sections 3.1.3 and 3.1.4.

[19] COSEWIC classifications also include extinct and extirpated animals, which are not included here.

[20] It is recognized that these elements do not reflect aspects of river heritage that need to be represented in the same way as elements of Themes 1-4. They are, however, a convenient way of grouping rare animal species to permit a snapshot of which Canadian Heritage River environments contain representations.

Sub-theme 6.2: Rare Animal Species		
Element	**Example Species**	**Canadian Heritage Rivers where found**
Fish		
1. Desingated *endangered*		
2. Designated *threatened*		
3. Designated of *special concern*	White sturgeon Redside dace	Fraser Humber
4. Regionally rare species	Lake sturgeon	Mattawa, Bloodvein
Mammals		
5. Designated *endangered*	Pine marten (Nfld. pop.)	Main
6. Designated *threatened*		
7. Designated of *special concern*	Grizzly bear Wolverine Polar bear Gaspe shrew Southern flying squirrel	Alsek, Athabasca, Kicking Horse Thelon, Yukon, Seal, Alsek Kicking Horse Seal Margaree Rideau
8. Regionally rare species	Long-tailed weasel Pine marten Lynx	Kicking Horse Margaree Restigouche, Margaree
Birds		
9. Designated *endangered*	Henslow's sparrow Loggerhead shrike	Humber Rideau, Thames
10. Designated *threatened*	Peregrine falcon *anatum*	S. Nahanni
11. Designated of *special concern*	Tundra peregrine falcon Short-eared owl Red-shouldered hawk Least bittern	Soper, Arctic Red, Bonnet Plume S. Nahanni, Mattawa, Kicking Horse Humber Rideau, Detroit
12. Regionally rare species	Golden eagle Bald eagle Trumpeter swan White pelicans Great blue heron Osprey Gyrfalcon Peregrine falcon Tundra swan	S. Nahanni, Alsek, Seal St. Croix, Seal, Margaree S. Nahanni, Alsek, Kicking Horse Clearwater Bloodvein, Hillsborough Mattawa, St. Croix, Restigouche Arctic Red, Soper, Bonnet Plume N. Saskatchewan, Kicking Horse Kazan, Thelon, Bonnet Plume

Sub-theme 6.2: Rare Animal Species		
Element	**Example Species**	**Canadian Heritage Rivers where found**
Herptiles, Invertebrates		
13. Designated *endangered*		
14. Designated *threatened*	E. Massassauga rattler Blandings turtle E. Spiny softshell turtle Queen snake	French, Detroit Shelburne Thames, Detroit Detroit
15. Designated of *special concern*		
16. Regionally rare species	Isopod, amphipod species Pickerel frog Stinkpot turtle	N. Saskatchewan Rideau Rideau

Data Sources. Detailed evaluation of rivers under this sub-theme may require some expertise in aquatic ecology. Up to date information on rare and endangered species can be found on the Website of the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (http://www.cosewic.gc.ca).

CHAPTER 3

CONSIDERATIONS IN THE DEVELOPMENT AND IMPLEMENTATION OF THE FRAMEWORK

The themes described in Chapter 2 are the result of extensive research, discussion, consultation, trial and test within the parameters imposed on the framework by user needs and conceptual limitations. In developing and assessing alternative approaches, it was necessary to analyse in some detail two of the basic considerations of the framework:

- to link the framework with the CHRS selection guidelines, and
- to harmonize with existing provincial and territorial systems studies and plans for Canadian Heritage Rivers.

3.1 Linkage with CHRS Natural Heritage Selection Guidelines

The natural heritage selection guidelines did not provide specific direction on the structure and content of a framework. While they refer to traditional classifications of natural features, such as geology, geomorphology, flora and fauna, they do not detail the types of these features that should be represented in the System.

The architects of the CHRS and its selection guidelines made no pretence that the guidelines would provide for a balanced or comprehensive approach to river selection, nor that they would need no further elaboration. As expected, application of the CHRS selection guidelines has proven to require some significant semantic interpretations by nominating governments and, on occasion, by the CHR Board. It was therefore judged useful in developing the framework to identify key terms in the selection guidelines, including those which have been analysed in the past, those which could provide some technical guidance, and those which required some clarification

There was no presumption that the selection guidelines should be used as determining factors in developing the framework structure or content, merely that they should not conflict with its structure or content. Thus, the mention of a type of feature in the guidelines implied that it *should be considered* for inclusion in the framework. But there was no need to slavishly include features that might be conceptually in conflict with the framework simply because they are mentioned in the selection guidelines.

The four guidelines adhere to the following common preamble: *Outstanding Canadian natural heritage value will be recognized when a river environment meets one or more of the following guidelines:*

3.1.1 Guideline 1. *Is an outstanding example of river environments as they are affected by the major stages and processes in the earth's evolutionary history which are represented in Canada.*

This guideline introduces the potential terrestrial themes of geology and, by implication, physiography. By defining its scope as *Canada*, the guideline

implies that the framework may be empirical and location-specific in approach, identifying any number of major classifications of geological features provided that they actually occur somewhere in Canada. This in turn might imply that a framework should take a regional approach to representation of earth's evolutionary history where unique spatial divisions of physiography are delineated. The guideline also clearly implies that a temporal dimension should be considered. In fact, the framework attempts to incorporate both spatial and temporal dimensions.

For this framework and in previous consideration of nominations, however, two difficulties in interpreting this guideline have occurred:

- It applies solely to the land part of the land-water interface, not directly to rivers; and
- taken literally, the guideline limits suitable rivers to only those whose courses have been altered during a *major* era of orogeny or glaciation. Information simply does not exist on whether or not the modifications to rivers in Canada occurred during a *major* period of earth change.

As a result, interpretation of this guideline by the Board has been flexible, and almost all river nominations to date have been judged to meet this guideline. Provided that major geological or glacial structures occur in the immediate vicinity of a river, it has been accepted that they are associated with it in some way.

Implications for the Framework:
Using this interpretation, the framework could:

- be regional and/or thematic;
- address the results of processes and events such as orogenies and glaciation, but without the necessity of ensuring that they occurred during a *major* geological era; and
- could allow for recognition of significant geological features found in a river's immediate environment without regard to how they are associated with the river.

3.1.2 Guideline 2. *Is an outstanding representation of significant ongoing fluvial, geomorphological and biological processes.*

This guideline also addresses natural processes and change, in not only fluvial features, but also terrestrial. This guideline would be very similar to the first, except that this guideline refers to plants and animals, and uses the key word *ongoing*. This word implies for a river to meet this guideline its processes should be observable, relatively rapid, and likely to continue. Unfortunately, this type of change in river features, particularly biological, is often man-induced. This would be in conflict with natural integrity guidelines (CHRB Board, 2000, page 29) that states that natural values should not be primarily the result of human activities.

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In nominations to date, it has been necessary to interpret this guideline with flexibility, in part because of the difficulty of identifying natural processes, and in part because of the inability of available data to demonstrate that a river's ongoing processes are *outstanding* compared with others across Canada.

Implications for the Framework: The implications of this guideline for the framework are therefore to address processes and features that demonstrate recent change and to define theme elements that reflect river morphology and plants and animals.

3.1.3 Guideline 3. *Contains along its course unique, rare or outstanding examples of natural phenomena, formations or features.*

This guideline seems intended to address only abiotic features although the Board has conceded that the word *phenomena* can include biotic as well as abiotic features. In this it could be very similar to the fourth guideline, discussed below, but for this framework it was interpreted to apply only to abiotic features

Implications for the Framework: The main implications of this guideline are:

- *examples* of features and processes are acceptable bases for nomination provided that they are outstanding. Given the almost universal absence of evidence comparing alternative examples, this might be equated to *good representations*.
- the words *unique* and *rare* imply that the framework should address not only the typical but also the atypical. While exceptionality is also implied in the term *outstanding*, rarity is a more simple numerical concept. Rarity, of which uniqueness is the extreme form, can be applied to abiotic river features through measures of relative number, size or areal extent.

3.1.4 Guideline 4. *Contains along its course habitats of rare or endangered species of plants and animals including outstanding concentrations of plants and animals of Canadian interest and significance.*

The focus of this guideline, in both the first statement and the more flexible second statement, is *plants* and *animals*. Key words in this guideline are concerned with rating the significance of features, rather than defining their taxonomy: *rare, endangered, outstanding, of Canadian interest and significance.* Like the third guideline, these terms imply that the framework should contain mechanisms that recognize rarity of plants and animals, and allow for assessing numbers relative to total Canadian populations.

It is also notable that the term *Canadian* rather than *national* significance is used. This nuance enables rivers in all jurisdictions, some of which may not contain *nationally* significant concentrations plants or animals, to potentially meet the guideline, since a feature which is of outstanding significance within a province or territory is generally held to equate with *Canadian* significance. As in the case of the first guideline, this implies that the framework can be regional in approach.

Implications for the Framework: There are two important implications of this guideline for the framework:

- plants and animals are of interest to the CHRS not only if they are individually rare, but also if they are numerous and exceptional in some way;
- these plant or animal communities (*concentrations* in the guideline)

need not be compared nationally, need not be rare nationally, and may represent theme elements even if significant in a provincial or territorial context.

3.1.5 Summary

The natural heritage selection guidelines had some significant implications for the structure and content of framework themes and sub-themes. There is in fact a close relationship between the six themes of the framework and the natural heritage selection guidelines as show below.

RELATIONSHIP OF FRAMEWORK THEMES TO CHRS NATURAL HERITAGE GUIDELINES

Theme	Associated Guideline(s)
Hydrology	2 & 3
Physiography	1 & 3
River morphology	1 & 3
Biotic environments	2 & 4
Vegetation	2, 3, & 4

3.2 Harmonisation of the National Framework with Provincial and Territorial Systems Plans

In order to be acceptable to, and usable by, participating provincial and territorial governments, this framework needed to be compatible with the structure and content of the existing provincial and territorial systems plans, mentioned in Chapter 1. A comparison of the approaches used in these systems plans, and their similarities to the present framework, is shown in the chart below.

3.2.1 Approaches.

In the following chart, the basic approaches of the plans are described as thematic, regional or "other". Only two plans, for the Northwest Territories (Baker 1994) and the Yukon (Juurand (1986), can be described as regional in approach, and these also included themes. The plans attempted to identify rivers within each natural region which represented some of the river-related natural features of those regions. These two plans were the first to be completed, and subsequent plans have not attempted to develop regions.

All plans identified actual rivers and attempted to rate them according to sets of criteria. An attempt was made in all cases to ensure that rivers in all parts of the province were included in the plan. This resulted in a larger number of rivers being studied than might otherwise be the case. The initial selection of rivers for inclusion in the plans, while influenced by their location within the jurisdiction, was not driven by their potential to represent a region's fluvial character.

Perhaps because of its size, only the plan for rivers of the Northwest Territories[21] used natural regions in deciding which rivers to study, and a roughly even number of rivers in each region were included. The plan of Yukon rivers, which was the next undertaken, superimposed a regional approach after a thematic analysis was completed. This ensured that relatively high priority

[21] Prepared when the NWT included Nunavut.

rivers were identified in all natural regions. However, this approach was not copied in subsequent plans, and references to regions in Manitoba, Nova Scotia and Saskatchewan studies are descriptions, not determinants, of where high priority rivers are located.

CHRS Natural Heritage Themes used by the Provinces and Territories (continued)

Jurisdiction	Approach			Themes(sub-themes)[1]	Similarities to National Framework
	Thematic	Regional	Other		
Northwest Territories (1984)	✓	✓		- Hydrology (flow pattern, flooding, lake balance, water quality) - Morphology (permafrost relationships, channel morphology, valley morphology) - Botanical (vegetation/forest regions, rare plant communities) - Zoological (fish, mammals, birds)	Plan is very similar to the framework, except in its evaluation of rivers within each of 5 physiographic regions. Theme structure and sub-themes are similar, especially in the hydrology and river morphology themes. Biotic environments not included in the plan.
Yukon (1986)	✓	✓		The Northwest Territories approach was used as a model. - Physiographic region representation - Hydrology - Morphology - Vegetation - Wildlife	Similarities in this plan are very close to those of the NWT plan.
Ontario (1987)			✓	No themes. The revised Ontario systems study reviewed various studies to rank rivers based on diversity of bedrock geology and "life sciences".	No similarity except for division of earth and life sciences (abiotic and biotic).
Nova Scotia (1988)	✓			- Geology/paleontology - Landscape development/river morphology - Hydrology/water quality - Vegetation - Wildlife	The national framework contains almost exact replicas of these five themes, as well as a sixth that is not present in the Nova Scotia plan - biotic environments.
Newfound-land (1990)		✓		Five themes were used: physiography, geological processes, vegetation, wildlife and aquatic habitats, and natural and scenic phenomena.	Hydrology not addressed, and scenery not included in final framework. However, aquatic habitats is similar to biotic environments.
New Brunswick (1992)	✓			Themes were derived directly from the CHRS selection guidelines: - Geological development (physiography, geology) - Ongoing processes (physical processes, biological processes) - Natural phenomena/natural beauty - Biota (rare/endangered species, species concentrations)	The framework contains a similar treatment of physiography and biota, but not ongoing processes, and excludes natural beauty. Approach to biota is almost identical to national framework.

CHRS Natural Heritage Themes used by the Provinces and Territories (continued)					
Jurisdiction	Approach			Themes(sub-themes)[1]	Similarities to National Framework
	Thematic	Regional	Other		
Prince Edward Island (1994)	✓			Used the New Brunswick as a model: - Geological processes (physiography, bedrock geology, palaeontology, surficial geology) - On-going processes (hydrology, water quality, morphology, vegetation, wildlife) - Natural beauty - Biota (rare/endangered species, species concentrations)	There are more similarities than in the case of the New Brunswick plan. Hydrology and morphology, both contained in the national framework, are addressed. Approach to biota almost identical to national framework. Natural beauty not part of national framework.
Saskatch-ewan (1996)	✓			- Physiography (geologic periods, fossils, physiographic regions, structures, landforms) - River hydrology (water properties, flow and special characteristics) - River morphology (diversity of features, outstanding/unique features) - Flora (natural regions, species/community diversity, concentrations, vulnerable species) - Fauna (diversity, critical habitat, concentrations, vulnerable species)	Plan is very similar to the national framework, although "scenic appeal" is an additional sub-theme under each theme. Almost all of the plans sub-themes have close counterparts in the framework. Contains sub-theme similar to biotic communities (flora sub-theme - natural regions)
Manitoba (1993, 1997)	✓			The first stage of the plan (1995) used the four CHRS natural heritage value guidelines. The 1997 plan made use of the February 1997 draft natural heritage framework.	Framework also used most but not all parts of guidelines. All themes are essentially similar to the national framework, except for the absence of biotic environments. A few sub-themes were added and deleted.

While a regional approach was not discredited in these plans, it was clearly not the approach of choice. An important flaw in the a regional approach is demonstrated by provincial and territorial boundaries which frequently slice through watersheds and boundaries of physiographic or other types of natural regions. It is thus quite possible that neighbouring jurisdictions might have rivers, or sections of rivers, that would be better representations of such trans-boundary regions. None of the studies attempted to ascertain whether this might be the case.

3.2.2 Themes and Sub-themes.

All except one plan defined themes and sub-themes for use in the classification of features associated with their rivers. As can be observed in the chart, there is considerable similarity between the themes and sub-themes of most of the plans and those of the final framework. Common similarities included:

- inclusion of a physiography theme;
- inclusion of a river morphology theme
- inclusion of themes to classify biotic phenomena

Common dissimilarities include:

- hydrology was not addressed in most plans;
- natural scenery was addressed in all plans;[22] and
- biotic environments were rarely addressed in plans.

3.3 Weighing Optional Bases for the Framework

From the above analysis, three optional approaches were considered in developing the framework: a regional approach, using the selection guidelines, and defining new themes. These options and some of their advantages and disadvantages are summarized here:

3.3.1 "River Regions" of Canada

As mentioned in Chapter 1, much earlier work was undertaken prior to the development of the present framework centred on the possibility of dividing Canada into river regions. While this approach seemed initially promising, its actualization appeared to be not as feasible, or even as theoretically sound, as first thought. Marsh (1994) and Marsh and Kharouba (1992) explored this concept in detail. Their approach was to identify and map a system of geographic "river regions" across Canada. Candidate Heritage Rivers would be identified to represent these regions. While this approach followed traditional protected area systems planning, it suffered from some serious constraints:

- Rivers are intrinsically not regional. Notwithstanding the fact that all land surfaces are comprised of water-sheds, and rivers are best managed on a watershed basis, rivers themselves are linear, not areal. The CHRS is firstly a *river* conservation program, not a watershed or area conservation program.
- Rivers are a function of the land-atmosphere interface, and any regionalisation of Canada would necessarily be primarily land-based.
- Rivers, particularly in Canada, often flow long distances through vastly different ecosystems, landscapes and geological regions, as well as through many different jurisdictions. A long river cannot exist within, nor represent, a single "river region".
- At a practical level, much of the source material available for the mapping of regional boundaries consists of physiographic, vegetation and biophysical inventories, and thus has a terrestrial rather than aquatic focus.
- The unevenness of data availability

[22] This is the result of an earlier phrasing of the third natural selection guideline. Prior to the revision of the 1984 *CHRS Objectives, Principles and Procedures* in 2000, this guidelines included the opportunity for rivers to possess "areas of exceptional natural beauty".

across the country meant that it was not possible to define water-based parameters with which to delineate regional boundaries without resulting in either an excessive number of regions in the Arctic Islands, where there are virtually no significant rivers, and a single region encompassing all of the Maritime provinces.

In spite of these difficulties, which led to the abandonment of a strictly regional approach to this framework, the spatial distribution of river features and values is a part of this framework. Three sub-themes address regional classifications of natural features: drainage basins (Sub-theme 1.1), physiographic regions (Sub-theme 2.1), and terrestrial ecozones. (Sub-theme 4.2).

3.3.2 CHRS Natural Heritage Selection Guidelines.

The direct application of CHRS selection guidelines to a river systems plan is best exemplified by the preliminary systems study of rivers in Manitoba (Brunton, 1993)[23]. While all provincial and territorial systems studies to some extent reflect CHRS selection guidelines, the Manitoba study uses the natural heritage selection guidelines themselves as themes for the classification of heritage values, both natural and cultural. Thus, the evaluation of each of Manitoba's candidate rivers involves a description and a high-medium-low rating under each of the subject areas covered by the guidelines: geological processes, ongoing fluvial activity, natural landscape character, and rare flora and fauna.

This approach is conceptually the simplest to develop and might have been fairly easily applied, as it could draw on the experiences of many previous river nominations. However, as implied from the discussion of the guidelines above (section 3.1) there are several drawbacks to its use for the national framework:

- The wording of the guidelines does not provide the basis for a *comprehensive* breakdown of river characteristics from which could be derived classifications of all major river values in Canada. Simply because the guidelines permit certain values to be the basis for including a river in the CHRS does not necessarily mean that the sum total of those values constitutes Canada's river heritage.
- There is considerable ambiguity in the wording of some guidelines and they have on several occasions required detailed interpretation by the CHR Board when their meaning in regard to types of river values was unclear, for example the meaning of *phenomena,* which is now interpreted to mean both biotic and abiotic features.
- The guidelines are derived from the World Heritage Convention Guidelines for natural areas. They therefore have a land-based provenance that does not focus on important water-based characteristics. According to the first guideline, for example, a river could

[23] The completed study of Manitoba rivers (Hilderman Thomas Frank Cram, 1997) is the first systems study to make use of the national frameworks, using the final cultural heritage framework and an earlier draft of this natural heritage framework.

in fact be included simply because it passes near a major geological fault.

- The guidelines are not *determinants* of what may be commonly accepted as "Canada's river heritage". While they serve as the criteria adopted by the CHRS for deciding whether or not to accept a river, this does not mean that they must be totally adhered to in a national framework.

3.3.3 Hierarchical Themes.

Following the analysis of past approaches, CHRS selection guidelines, and provincial and territorial systems studies and plans, it was proposed that a hierarchical thematic approach could be designed which could comprehensively address river heritage in Canada. In this approach, themes would be defined starting with a conceptual classification of components of the river environment. For each theme there would be a set of sub-themes, and for each sub-theme a range of possible features and values, termed *elements*.

By encompassing and adjusting to the implications of themes, sub-themes and elements derived from the selection guidelines and systems plans, the national framework would be compatible with existing and future systems plans and could be applied in conjunction with them in nominations, research documents and management plans. The framework would also allow for recognition of additional natural values that are not mentioned in the guidelines or plans, while omitting those features that, while perhaps contributing to meeting a selection guideline, would not comprise an element of Canada's river heritage.

There are a number of other advantages to this approach:

- While the selection guidelines are constrained by their terrestrial origins, a hierarchical framework could be tailored to water-based features;
- Being theoretically based, a hierarchical framework could be more comprehensive than the "selection guideline" approach, thus avoiding the disadvantages cited above in Section 3.3.2.
- Most jurisdictions that have already adopted systematic approaches use some variation on a thematic approach (see Summary Table above).
- As the *cultural* framework is also thematic, the two frameworks would be essentially similar in approach and application.

Thus, while a thematic approach cannot be graphically portrayed as simply as could a regional approach, and may not be as familiar to most people as regionally-based natural heritage conservation plans and frameworks, it was considered to be more sound in principle, more comprehensive in scope, and therefore more defensible.

3.4 Framework Structure

3.4.1 Framework Themes.

The paradigm used for the national framework consists of a refined interpretation of the hydrological cycle: interaction of water and land, hydrology and hydrogeology, which create rivers and river-related features, which in turn support biotic environments, and the diversity of animal and plant species.

This structure allows the framework to make the link between animals and plants and river morphology through the creation of *Theme 4: Biotic Environments*. Essentially, these are ecosystems, complex symbiotic collections of plants and animals that make use of the products of the interface of land and water.

The framework themes use traditional taxonomic systems which describe the natural world, in particular the aquatic world: hydrology, hydrogeology, river morphology ecosystems, and river associated vegetation and wildlife. This terminology may be interpreted differently by users of the framework. It is hoped that the theoretical soundness of the paradigm used will enable users to accurately assign river features by following the logic of theme and sub-theme development.

3.4.2 Framework Sub-themes.

The sub-themes for the framework are based on the classification of natural processes *and* features associated with rivers in Canada. It was possible to construct simple paradigms that described river-related processes and features while accommodating both the selection guidelines, sub-themes and elements of provincial systems plans, and the biotic/abiotic dichotomy.

The rationale for defining the framework's sub-themes was to provide an understandable, yet scientifically defensible, breakdown of the six themes. It was seen as necessary for the sub-themes to represent major generic classifications of processes and features commonly accepted in scientific literature.

- **Hydrology and Physiography Themes:** To be comprehensive, to derive sub-themes for both of these themes the paradigm used a *Where, When, What and How Much* approach.
- **River Morphology Theme:** The model adopted a four dimensional approach, viewing channels from above, in profile and in cross-section, and ultimately used temporal classification of typical channel landforms.
- **Biotic Environments Theme:** These environments were simply divided into aquatic and terrestrial ecosystems.
- **Vegetation and Fauna Themes:** Both of these themes were organized into sub-themes to distinguish between individual species and groups of species.

As far as possible, the sub-themes were defined so as to be discrete, although there are some inevitable overlaps within and between themes. An effort was made to ensure a roughly equal number of sub-themes for each theme in order to ensure that any numerical rating system subsequently applied would not automatically favour themes containing the most sub-themes. However, while there are four sub-themes for the first three themes, there are only two sub-themes for each of the other three themes.

Availability of data was also a consideration. For example, sub-themes under the hydrology theme are simple not only to understand, but also to divide

into elements on which data are available nationally. Theme narratives contain sections on data sources for all sub-themes.

Apart from the three sub-themes that are regionally based (drainage basins, physiographic regions, and ecoregions), the sub-themes were defined so as to have no regional affiliation. In other words, a river in any part of the country could theoretically contain features associated with any of the sub-themes. There are some necessary exceptions to this due to the great extremes of climate and distance within Canada. For example, fluvial aspects of glaciers are not found in Atlantic Canada.

3.4.3 Sub-theme Elements.

The definition of the term *element* used in the framework is found in the *CHRS Objectives, Principles and Procedures* (Parks Canada, 1984, page 16), which states that *"elements are defined as resources or groupings of resources identified as having values essential to the nomination of a river"*. Elements may be values that are characteristic of the entire river or river section nominated, or they may be associated features located somewhere in the river's immediate environment. Features that are associated with a river, but which are not in the immediate environment, such as migrating animals, can also be addressed.

One modification of the above definition of an element is the use of the concept of *association* instead of being *essential*. All elements in this framework are, by definition, *associated* or functionally related to rivers. In other words, features and processes that are not river-associated cannot represent elements of this framework. This is not to say that any located within the immediate environment of a river, but which are not functionally related to it, cannot be part of a river *nomination* or addressed in a Canadian Heritage River management plan. These serendipic values may be a part of what the river brings to the System, regardless of the type of natural value they may be provided that such values contribute to meeting a selection guideline. However, they do not become a component of Canada's natural *river* heritage, which is the essence of this framework.

For most sub-themes, elements have been defined which represent distinct types and sub-classes of features or processes. The definition of elements according to value ranges are often the most practical means of defining elements. However, element definitions based on subjective criteria (e.g. water quality variables) have been avoided, and quantitative (e.g. size classes and value ranges) criteria have been determined to roughly equalize the numbers of potential representations of each category.

Potential vegetation and fauna elements are not comprehensively listed in this framework. While a list is provided for other themes, to do the same for the these two would entail a massive inventory of fauna and flora species in Canada. However, for *rare* species of plants, there are some clear guidelines on which species can be considered element

representations. For both flora and fauna, the user is referred to the latest lists of "species at risk", according to the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), which are posted on the Committee's Website: (http://www.cosewic.gc.ca).

3.5 Representing Framework Elements

This framework is intended as a tool that can be applied to the assessment of rivers' potential for inclusion in the Canadian Heritage Rivers System. Representations of its elements are to be identified in nomination documents and ultimately judged by the Canadian Heritage Rivers Board, nominating Ministers and the Minister responsible for Parks Canada. It is also not intended that this framework describe how assessments of individual representations of sub-theme elements, or entire rivers, be undertaken. However, *national studies* of selected elements would serve to provide a national perspective on potential representations of selected elements. Such research studies might also serve to identify regionally identifiable sub-elements.

3.5.1 Types of Possible Representations.

How rivers represent framework elements will differ from theme to theme. In deciding upon what constitutes a representation of an element it is important that framework users apply a common definition to certain key terms:

- *Value ranges* may be defined as characteristics of rivers that pertain to the entire river environment, or a large part of it, such as seasonal variations or chemical content of the water. In the natural heritage context these are mostly hydrological characteristics.
- *Features* are characteristics and forms that a river contains or passes within its immediate environment. A river might "contain" one or many features representing a sub-theme element.
- *Rivers* in this document could be the length of a river form source to mouth, or any section in between, depending what has been onminated to the CHRS. Assessments of rivers are made using the sum total of the assessments of values and features to determine suitability for their inclusion in the CHRS
- *Entire rivers* refers specifically to the total river, from source to ocean, as required in for example the representation of *Sub-theme 1.4: River Size.*

3.5.2 Potential Representation of Vegetation and Fauna Themes.

Representation of the *significant* vegetation and fauna sub-themes (Sub-themes 5.1 and 6.1) by elements found on Canadian Heritage Rivers differs from representation of other themes. The list of possible elements is virtually unlimited. Any plant species growing, or any animal found, in a significant community could comprise an element. The absence of any particular species from representations of either sub-theme should not be interpreted by framework users as an indication of a gap that should be filled. While additional representations would be desirable, the goal CHRS is not to protect all

significant species or significant plants communities; other conservation programs are intended to achieve this. The CHRS can contribute in this regard, particularly in regard to aquatic species, and can play a useful role in maintaining a record of significant species within the immediate environment of rivers

3.5.3 Quality of Representations.

At some future point it will be desirable to assess the quality of representations. This was attempted by Murphy[24] in applying an early version of the framework and used two criteria.

- *Functional association* between a process or feature and a river refers to a relationship between a natural feature or process and a river. Either the river has in some way been influenced by a process, e.g. geological faulting, or the river has created or modified the feature, e.g. an aquatic ecosystem. Alternatively, the feature may pertain directly to the character of the river itself, as in the case of hydrological features such as velocity or periodicity of discharge.

- *Physical proximity* of features is normal in a functional relationship. However, in some cases, features or species not traditionally considered to be associated with rivers may be found in proximity to rivers. These are valid representations of framework elements. Association of a feature with a river solely through its *physical proximity* is to some extent defined by the selection guidelines which state criteria are met by features located in the *immediate environment* of rivers. Thus, a feature which lies within a river's immediate environment, however this is defined, and regardless of whether it is functionally related to the river, is legitimately representations of framework elements.

  Similarly, some features remote from rivers are actually river-associated. The great caribou herds of the barrens have little physical association with the Kazan River, but they cross it in several places and there they are hunted by Inuit, thus establishing a functional relationship with the river. Similarly, some rivers serve as resting places or nesting grounds for migrant birds, travelling many thousands of kilometres, often outside Canada.

  The phrase *immediate environment* seems to exclude features located some distance from a river but within its watershed. For distant features to be recognized, they would normally require some kind of functional relationship e.g. spawning beds on tributaries or hanging valleys. However, it might also be argued that anything that is visible from a river is "immediate".[25]

It must be emphasized that, while

[24] Murphy, J. Geoheritage Planning. Unpublished draft prepared for Parks Canada. 1997.

[25] A more complete discussion of river-relatedness in the context of cultural features is found in Goldring (1996, Chapter 4), and Murphy (1996, Chapter 2).

nominating governments may claim that selection guidelines are met and rivers may be assessed as being of outstanding Canadian heritage value, this can only be affirmed by the Board, the nominating minister(s), and the Minister responsible for Parks Canada

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