Canada Foundation for Innovation
Fondation canadienne pour l'innovation

Outcome Measurement Study
University of New Brunswick
Expert Panel Report
March 24-25, 2009

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Funding Synopsis

Project Leader	Number	Project Title	Program	CFI Amount
Cunjak, Richard	314	Stable isotope lab for ecological research and wildlife conservation	NOF	$105,403
Haralampides, Katy	6919	Sediment dynamics research laboratory	NOF	$99,335
Singh, Kripa	7375	Water/waste treatment and environmental research laboratory	NOF	$96,891
Peake, Stephan	7621	Canadian Rivers Institute Manitoba Field Station for Fisheries Research	Innovation	$166,661
Munkittrick, Kelly	8796	Canadian Rivers Institute Research Facilities: Ecosystem Health of Rivers and Estuaries	CRC	$1,794,202
Munkittrick, Kelly	200379	Canadian Rivers Institute	CRC	$250,000
MacQuarrie, Kerry	201668	Infrastructure to support groundwater-surface water interaction research	CRC	$67,676
Kidd, Karen	201843	Laboratory for Assessing the Chemical Contamination of Food Webs	CRC	$125,000
Munkittrick, Kelly	203660	Electrofishing Boat and Trailer	LOF with a CRC	$74,407
Cunjak, Richard	204082	Stable Isotope Laboratory for Environmental Research and Wildlife Conservation	CRC	$74,750
MacQuarrie, Kerry	207122	Infrastructure to support groundwater-surface water interaction research	NOF	$63,650
Total				$2,917,975

Summary of Theme Area

An independent Expert Panel visited the University of New Brunswick (UNB) on March 24-25, 2009, to assess the outcomes of the CFI's investment in research infrastructure for **river ecology** research. The scope of the OMS review included 11 projects for a total CFI investment of $2,917,975 million. This was further complemented by $7,026,027 from partners for a total investment of $9,944,002.

The projects included in this OMS visit involve a core group of 22 researchers from several faculties located at two campuses of the University of New Brunswick. Some of the CFI-funded facilities are located at the Fredericton campus while others are at the Saint John campus. The faculties represented include Science, Forestry and Environmental Management, and Engineering.

As of March 2009, the CFI has invested a total of $15,160,825 at UNB in 82 projects. The 11 projects included in this OMS visit represent 19% of the total CFI funding awarded to UNB. Eight of the eleven projects were considered mature enough for analysis in all impact areas (i.e., projects #200379-Munkittrick, #314-Cunjak, #7375-Singh, #6919-Haralampides, #201668-MacQuarrie, #7621-Peake, #201843-Kidd and #8796-Munkittrick) while three projects were too recently awarded for analysis of impacts (i.e., CRC renewal projects #203660-Munkittrick, #204082-Cunjak and #207122-MacQuarrie).

In Saint John, the CFI-funded infrastructure is used for the assessment of the health of river systems, the development of laboratory methods for research on environmental stressors found in Canada, such as industrial discharges and sewage, and the study of persistent organic pollutants such as pesticides in aquatic food webs and their potential to affect human health. The CFI projects at the Saint John campus are: #8796-Munkittrick, a part of #200379-Munkittrick, #203660-Munkittrick and #201843-Kidd. In Fredericton, the CFI-funded infrastructure is used to investigate the structure and function of aquatic ecosystems across scales addressing ecosystem sensitivity, resiliency, and connectivity, bio-diversity and climate change. It is also supporting research studying the links between physical and ecological components of aquatic ecosystems (e.g. processes at the surface water-groundwater interface), bioengineered structures in rivers, such as dams and fish-ways, and eco-hydraulic problems of erosion and sediment deposition; and to develop applied conservation biology. The CFI projects located at the Fredericton campus are: #314-Cunjak, #204082-Cunjak, #6919-Haralampides, #7621-Peake, #7375-Singh, #201668-MacQuarrie and #207122-MacQuarrie.

The diagram on the next page shows that the CRC-CFI project #200379-Munkittrick is the cornerstone for research in river ecology at both the Fredericton and Saint John campuses. The multidisciplinary nature of the research in this thematic area is illustrated by the four egg-shaped projects on the left, which are led by environmentally-motivated researchers from the Civil Engineering Department at UNB, while to the right the six projects (the circles) are more biology-oriented projects, which are led by researchers from the Departments of Biology in Fredericton and Saint John and the Faculty of Forestry and Environmental Management in Fredericton. As an indication of future growth planning and potential, three additional CFI proposals that were recently submitted to the CFI are presented for completeness (see dotted/dashed lines, #211803, #19421, #213342).

Figure 1: Links between CFI Projects in the River Ecosystem Theme
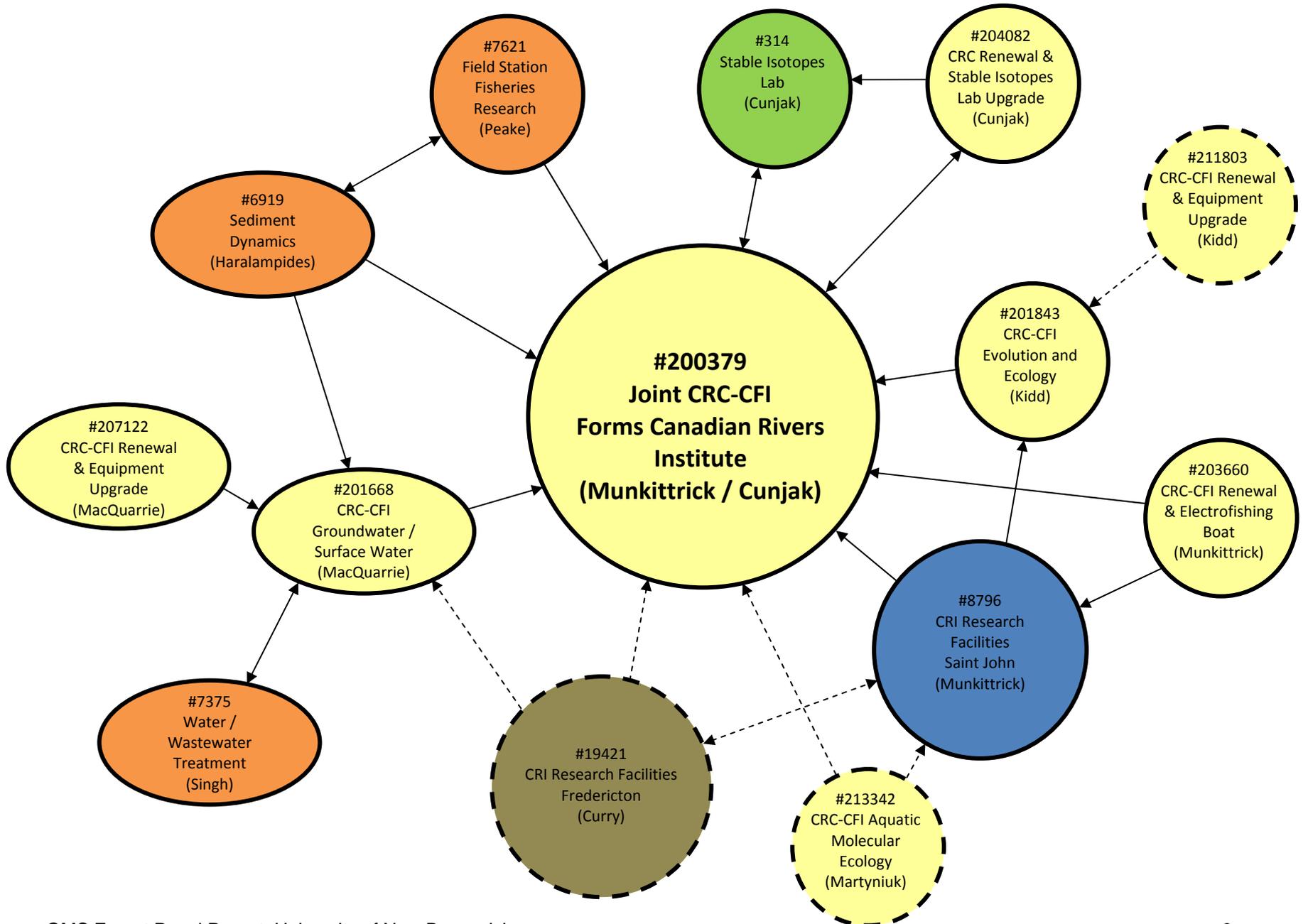
CFI's OMS Process

The Outcome Measurement Study (OMS) is a new tool in the CFI's suite of evaluation activities designed to assess the degree to which the CFI's investment in research infrastructure is a critical contributing factor in the realization of five outcomes (i.e. strategic research planning, research capacity, highly-qualified personnel, research productivity, and innovation). The OMS helps demonstrate to the CFI Board and other key internal and external stakeholders the extent to which the CFI is achieving its mandate and provides an information resource for planning purposes. The OMS is a learning exercise done in partnership with the participating institutions. It is different in objective and approach to typical merit-review processes where funding hangs in the balance, and it is not used to rank disciplines and/or institutions.

The OMS methodology involves an in-depth questionnaire submitted to institutions with a follow-up validation by a visiting expert panel, whose report is the key output of the exercise. The OMS scope is unique, looking at a specific research theme area across an institution rather than examining an individual project, program or department. The theme is normally selected in discussion with institutions based on several factors including the degree of synergy between the institution's Strategic Research Plan and areas of major CFI investment. This approach lends itself to characterizing the synergies and interactions among different organizations and labs, research platforms, diverse disciplines and research methodologies, and various types of research investments. It intends to capture with numbers and narrative the outcomes of CFI and partner investment across the spectrum from basic research discovery, through to societal benefits.

The OMS explicitly recognizes the CFI as one player in a large and complex system of research support. Careful discussion of the relative contributions of funding programs, organizations, and other factors exogenous to the CFI is coupled with longitudinal analysis in order to document attribution and incrementality realistically and in context. Other stakeholder funding agencies (e.g. provincial, federal) not only contributed to the design of the OMS tool, but regularly send representatives to the visits as observers, maximizing the value of the extended effort required of institutions and the CFI on data collection.

OMS Expert Panel

The members of the Expert Panel responsible for the OMS visit at UNB on March 24-25th 2009 are identified below. The CFI worked with the institution to identify suitable expert reviewers who were independent from the institution and have recognized expertise in this theme. The panel members volunteered a considerable amount of their time to participate in the OMS process. The CFI is grateful for their support and assistance.

Dr. Alain Caillé (Chair)
Emeritus Professor
Physics Department
Université de Montréal, Canada

Dr. James H. Thorp
Senior Scientist, Kansas Biological Survey
Professor, Department of Ecology and Evolutionary Biology
University of Kansas, USA

Dr. Judson W. Harvey
Research Hydrologist
U.S. Geology Survey, USA

Dr. Paul A. Bukaveckas
Associate Professor
Department of Biology
Virginia Commonwealth University, USA

Dr. Jonathan Grey
Lecturer in Freshwater Biology,
School of Biological and Chemical Sciences
Queen Mary, University of London
London, UK.

Key Findings

- Working closely with government and industry, the University of New Brunswick conducts more than 80% of the university-based research in New Brunswick. Its annual research revenues topped $50 million in 2007 and 2008. There are some 620 full-time faculty members at UNB, which offers more than 50 degree and certificate programs to some 10,000 students. The current president of UNB presently plays a major social and political leadership role in New Brunswick both because of the importance of UNB in the province and on a personal basis. UNB is well positioned to facilitate strategic developmental projects to help the province face emerging socio-economic challenges such as important demographic outmigration and the necessity to enter even further in a knowledge based economy.

- River ecology at the University of New Brunswick has been a long standing priority, ever since the early days of the Institution. The global strategic research plan (SRP) of the University has developed very systematically since the late 1990s and now seems to be focussed on incorporating the inputs of the academic and broader communities. River ecology is related to three of the five major strategic themes of the SRP. UNB has strongly supported its strategic areas with major budgetary and financial contributions, with a high degree of correlation with its major acquisitions of new infrastructure through CFI funding and the attribution of its Canada Research Chairs. In particular, river ecology has received 30% of the total number of the Canada Research Chairs at UNB. In addition, the University has worked very hard under difficult regional economic conditions to secure the 60% matching funds for its CFI awards. In this context, the impact of the CFI investment on the strategic research planning process has been high.

- UNB's forward looking SRP has strengthened the interconnections between the different projects and fostered research collaborations, leading to a major expansion of research capacity in the thematic area. The research infrastructure devoted to river ecology went from very outdated setups before CFI funding to state-of-the-art equipment currently. However, the Expert Panel does not believe that UNB has completed its infrastructure development yet in this area. Enlargement of the expertise is necessary in order to establish a true national and international river institute. However, the challenge of securing the necessary matching funds remains an obstacle that could be overcome through collaboration with other institutions with mutual interest. That aside, the impact of the CFI investment on research capacity building at UNB has been high.

- The training of highly qualified personnel has gone through similar improvements over the years. The Expert Panel was able to observe first hand the high impact of the CFI investment on the number of trainees, their quality and on the employment perspectives after completion of the study programs. The number of PhD students has increased significantly and a very large fraction of the graduates go on to work in the private sector, which validates the relevance of the training program. UNB should consider establishing a formal graduate training program in river science in order to fulfill completely its vision to be Canada's premier river institute.

- The scientific productivity of the researchers increased significantly since the funding of infrastructure by the CFI in this thematic area. Although the Expert Panel does not believe that the Canadian River Institute has achieved international recognition yet, this status could be reached in a near future if the present progression is maintained.

- The CFI funding had a major impact on the capacity of the researchers and their research groups to contribute in a very important way to major socio-economic issues in New Brunswick (like the future of the St. John River) and to the needs of the nearby end-users of the research results, as well as to develop considerable expertise in the area of river ecology.

- In conclusion, the Expert Panel reports that in all cases, the impact of CFI on the five identified outcome areas has been at least high and very high in some cases. For example, there is a high correlation with the CRC program, a high impact on the overall recruitment, an increase in the number of their trainees finding employment in the private sector after their studies and an overall improvement in the competitiveness of the institution. An emerging challenge for UNB will be to secure additional resources to the river ecology thematic area in the future since that specific area is bound to experience increased interest in the future worldwide, reflecting the strategic importance of freshwater resources for humanity as a whole.

Overview

> **"Without CFI, the Canadian Rivers Institute (CRI) would not be what it is today. It would be a shadow of itself. CFI has been vital to the development of CRI's laboratories and to the success of the CRCs who work there."**

River ecology at the University of New Brunswick has very solid and deep roots. From the very early work of James Robb, a Scottish scientist hired in 1837 in natural history, and over the ensuing 172 years, UNB became the locus of research and instruction in New Brunswick not only in botany, cartography, geology, forestry, wildlife, ecology, but also in hydrology, watershed management, fish biology, environmental science, sustainable development, pulp and paper engineering, groundwater studies, geodesy and geomatics and finally river ecosystems.

The UNB campuses in Fredericton and Saint John are very close to the St. John River and its numerous important tributaries in New Brunswick, Maine and Quebec. Historically, the St. John River has been considered one of the more disrupted river systems in Canada and has been listed as one of the top receivers of contaminants. The proximity of this river has provided the basis and the context for the development of water-related research expertise in the faculties of Engineering, Forestry and Environmental Management, and Science and has led, ultimately, to the creation of the Canadian Rivers Institute (CRI) in 2000. The CRI focuses many of its collaborations on the St. John River, and a major initiative is the development of a framework for understanding the assimilative capacity of this river system to inform policy and provide science-based decision-making. It should be noted that, in addition to the 11 projects featured in this OMS exercise, complementary research capacity has been developed in the Groundwater Studies Group, the Jack Limerick McKenzie Pulp and Paper Research and Education Centre, the Nexfor/Bowater Watershed Management and Conservation Research Centre, the New Brunswick Cooperative Fish and Wildlife Research Unit and the Centre for Coastal Studies and Aquaculture.

In the late 1990s and early 2000, many multidisciplinary research projects were already ongoing at UNB: e.g., studies on mercury and metal contamination in fresh waters, cumulative impacts in the St. John River catchments, forestry impacts on fish and wildlife, impacts of industrial effluents on freshwater and estuarine environments and groundwater chemistry dynamics. These projects led to development of large-scale, multidisciplinary research programs to enhance aquatic science and natural resource management in the region and in Canada at large through the establishment of the Canadian Rivers Institute (CRI). Indeed, the CRI favours collaborative research, education and professional training involving biologists, hydrologists, foresters, conservationists, geochemists, water quality engineers and other researchers working collectively to solve complex environmental problems related to river ecosystems. It should be noted that in the present report, the term CRI is often used to refer to the collectivity of the projects included in the river ecology thematic area at UNB.

1. Institutional Strategic Research Planning

"UNB has recently completed a highly consultative "renewal process" aimed at establishing a shared vision and an action plan to put that shared vision into effect. The SRP was approached as an outgrowth of that dynamic process and an expression of the institution's shared vision."

1.1 Strategic Research Planning (SRP) Process

Strength of SRP process prior to the CFI	Very low
Strength of SRP process now	High
CFI impact on any changes to SRP process	Medium
CFI impact on the realization of the objectives of SRP	High

Strategic research planning at the institutional level at UNB started with the availability of CFI funding in 1998. Prior to 1998, as in most other traditional universities in Canada, the planning of the research activities was conducted largely at the individual faculty level. The evolution of the SRP documents over the years (1999, 2001, 2003, 2005 and 2008) reflects a very systematic and strategic approach, with a first reference to the Canadian Rivers Institute (CRI) appearing in 2001. UNB's strategic research planning seems to have become stronger through the years as new dimensions were brought in. For example, considerations arose over time for the involvement of new research partners, the need to create critical mass in specific areas and the strategic advantage for UNB. While there is a full recognition that the directorship of the research activities is, and will remain, a true responsibility and privilege of the individual or group of researchers (a dimension essential to maintain creativity), in parallel there is a clear direction towards strategic research planning at the institutional level.

From the beginning and over the years, UNB conducted large consultative processes involving the entire university constituency and the broader community to establish a shared vision and an action plan to put this vision in action. The current SRP is an outgrowth of this process with, for example, the allocation of the Canada Research Chairs (CRC) being one of the actions to be implemented in the SRP. UNB clearly indicates that the above consultative process and the convergence of different resources (e.g., Canada Research Chairs) were to be used strategically to support the deployment of its vision and action plan as outlined in the document called "*The Challenge and the choice – Renewal Directions: 2000 and Beyond*". As a result of its recent strategic planning session (in early 2009), UNB will be updating its SRP so that it includes specific considerations to address the challenges facing the CRI, which is central to the success of the research endeavour in this theme. It was indicated that the river ecology theme (and the CRI infrastructure) would remain a central element of the future iteration of its SRP. The latest version of the SRP (2008) indicates that the river ecology theme addresses directly three main priority areas of the five

strategic areas of UNB's SRP: Global Environment and Resources; Health; Wellness and Human Development; and Advanced Technologies and Applications.

The SRP process at UNB integrates the priorities of the various departments/faculties and faculty members are encouraged to provide input through on-line consultation. The SRP is finally formulated by the group of the Deans working with the VP Research. Strategic research planning at UNB is a very coherent and consultative process that now permeates throughout at all levels of management. For example, the final decision for the submission of a candidate for a CRC appointment is approved by a committee composed of UNB's President, the VP Academic, VP Saint John, VP Research and the Dean of Graduate Studies, in consideration of the recommendations from the Deans councils on the two campuses. It is evident that the CFI has had a huge impact on the SRP process at UNB. From the outset, UNB had the proper attitude: UNB chose to make strategic choices, to grow a critical mass of researchers and apply its internal and external resources (CRC) to support its choices. For example, UNB decided to assign five CRCs out of a total of 18 CRCs to the Canadian Rivers Institute. The SRP process has also had a major impact on shaping university policies regarding the establishment of institutes and research centres as well as the internal approval process for these new organizations.

Securing the necessary matching funds has always been a challenge for UNB and other institutions located in the Maritimes in general. However, UNB's ultimate ability to satisfy the 60% matching of the CFI awards shows a high level of institutional commitment towards the research conducted in the river ecology theme.

1.2   External Influences on SRP

Impact of external factors and programs on SRP	High

As indicated above, the SRP was developed in broad consultation with the academic community and key external stakeholders. Such external consideration addresses directly one of the major objectives of the SRP, which is to "build and maintain research excellence, with breadth appropriate to our central role in meeting the research needs of the province and the region". The SRP also indicates that UNB favours the development of infrastructure that meets the interests of the Atlantic Innovation Fund and as such, all five priority areas of the SRP are of strategic importance for the Province of New Brunswick. In particular, the Global Environment and Resources priority, of which river ecology is a sub-theme, provides many research and networking opportunities for the academic researchers for the province and the Maritime region.

The influence of the provincial government on UNB's SRP process is not a simple affair. UNB estimates that it conducts about 50% of all research activities in New Brunswick. Consequently, the SRP developed by UNB has essentially become a key component of the research blueprint for the Province of New Brunswick. When it comes to government interactions, it is difficult to differentiate between outward influences versus inward influence in relation to the SRP process at UNB.

University administrators appear to be highly aware and cognizant of the province's needs for research and development. The synergy between UNB and the provincial government officials could not be more complete. It would seem that the access to, and the interaction with, government officials at all levels are open and frequent.

1.3   External Effects of SRP

Impact of SRP on planning and action at other institutions	High
Impact of SRP on planning and action at municipal, provincial or national levels	High

The information provided by UNB shows impacts of its SRP on other organizations. Mostly, these are strategic decisions that other organizations took as a direct or indirect consequence of the actions taken by UNB and the investments it has made to implement its SRP. Although they have a larger scope than just the river ecology theme area, here are a few examples that show a strong correlation with the SRP of UNB:

- The decision of the National Research Council (NRC) to locate in 2001 the e-business research program of its Institute for Information Technology in New Brunswick was influenced by UNB's focus in its SRP on Advanced Technologies and Applications.

- The decision of Environment Canada to establish at UNB its National Centre of Excellence for Biomonitoring Research and the similar decision of the Department of Fisheries and Oceans to relocate to UNB a regional program investigating impacts on estuarine and coastal environments (Oceans and Science Branch, Gulf Region). As a result, three federal government scientists were transferred to the Fredericton campus between 2002 and 2005.

- The decision of Statistics Canada to establish one of its secure Research Data Centres within the Canadian Research Institute for Social Policy led by a CRC holder in Human Development at UNB.

- The recent decision made by Dalhousie University, supported by the Province of New Brunswick and the Atlantic Health Sciences Corporation, to create a medical education program at UNB's Saint John campus in concordance with the Health, Wellness and Human Development priority area of the SRP.

- The decision of the University of Prince Edward Island to allocate one of its CRC appointments to research related to aquatic health sciences. The CRC holder has been a fellow of the Canadian Rivers Institute since October 2006.

The impact of the SRP at UNB on the government departments and agencies is even clearer. Amongst the demonstrated cases are:

- The New Brunswick Innovation Foundation (NBIF) was created in 2003 by the New Brunswick government as an independent corporation to enable the province's universities and other research organizations to leverage support for innovative projects in strategic industries in areas related to the SRP at UNB.

- The planning by the provincial government for a "recreation corridor" in Fredericton is directly related to the research priority of Health, Wellness and Human Development at UNB.

The well-targeted SRP on the future needs of New Brunswick had a major external effect on a project entitled *"Next New Brunswick"* that is led by present UNB President John McLaughlin. This far-reaching public exercise and conversation with New Brunswick citizens, which is aimed at determining the province's future directions, directly addresses the SRP priority of Socio-Cultural Research Environment. It has resulted in several important outcomes, including the creation of the New Brunswick Business Council and the creation of 21inc, an organization for young professionals committed to improving life in the province.

1.4 Complementary Investments by Institution

CRCs in theme vs. institution wide	Very high
New faculty member hires vs. institution wide	Very high
Other institutional research funding	High
Operations and maintenance resources	Don't know
Infrastructure Operating Fund allocated	High
Other investments	High

In human resources

Out of a total of 18 CRCs available at UNB, five have been allocated to the river ecology theme area. This shows a strong institutional commitment towards this theme. Two of the CRC holders were awarded in 2001, the joint cluster project that is the core infrastructure obtained from the CFI in this thematic area. One of the five CRC appointments made in 2007 was eventually declined. A new nomination has been put forth and a decision is expected in May 2009. As mentioned earlier, UPEI has also allocated a CRC position to a collaborator of the UNB's research group at the Canadian Rivers Institute.

The following table illustrates the priority given by UNB to new Faculty hires in the theme area.

Table 1 – Faculty Hiring			
Human Resources	**# in the Theme**	**# at Institution**	**% #Theme / #Institution**
CRCs	5	18	28%
New Faculty Hires	9 1 left 8 (net)	327 181 left 146 (net)	2.8% 0.55% 5.5%
Total Faculty	14	635	2%
CFI Investment **(as a comparator)**	$3.6 Million (includes IOF) for 11 projects	$20.3 Million (includes IOF) for 83 projects	18% of CFI funding 13% of CFI projects

Although it accounts for only 2% of the total Faculty contingent, the river ecology theme obtains 5.5% of the net new Faculty hires, 18% of the CFI funding and 13% of the CFI projects. This is a clear expression of the institutional priorities as well as evidence of the value of UNB's strategic plan when it comes to university decisions for the allocation of its resources. In comparison with the new Faculty hires in the rest of the university, the retention in the theme area is excellent. It was made clear during the OMS visit that access to highly competitive infrastructure in the river ecology area explains this performance.

In financial investments

UNB contributed more than $1.5 million in matching funds to six of the 11 CFI projects included in this OMS exercise. In addition to these investments, donors have contributed some $600,000 towards the support of two research professorships in the river ecology theme. The Expert Panel considers that $2.1 million is a very high contribution level for an institution of the size of UNB.

In operation and maintenance of the infrastructures funded by CFI

Only six of the projects of the theme area were eligible for IOF support. The other projects include four CRCs and the first CFI project (Stable Isotopes in Nature Lab), which pre-dated the availability of IOF. UNB allocated the full $670,000 IOF amount generated by the six projects to cover the operations and maintenance costs of these same projects.

Other operation and maintenance resources in the theme area

UNB's financial monitoring system does not track separately the annual operating and maintenance expenditures associated with the CFI infrastructure. These are embedded in departmental expenses as part of regular O&M expenses. The data reported in the Institutional Data Document and in this present report are only estimates. These estimates were derived from the projected expenditures for each of the 11 projects over a five year period, from which UNB then netted out the received IOF funding and divided by five to arrive at an annual total O&M expenditure of $328,960. If we add the average IOF allocated by CFI on an annual basis ($135,000), we obtain a total of roughly $460,000 for the annual O&M costs. If we exclude the $5.3 million in major construction and laboratory renovations, the total capital investment in the CFI infrastructure projects is $4 million. The O&M reported by UNB is of the order of 11% of the initial capital

investment on a yearly basis. Taken globally, the O&M resources reported by UNB seem appropriate for running, maintaining and operating the CFI-funded infrastructure since the normal rule-of-thumb is that the annual O&M support should be of the order of 10% of the initial instrumentation costs. Although UNB's support for the O&M expenditures seems appropriate, the rating retained by the Expert Panel for this OMS indicator was "Don't' know", not being able to conclude one way or the other. Nevertheless, the tour of some of the laboratories that the members of the Expert Panel were able to do has shown them that the infrastructure was properly maintained and operated.

It was noted that most of the technical and professional staff running the large infrastructure that compose the Canadian Rivers Institute are paid from soft revenues – that is, user fees and IOF allocations which have a limited period of existence. One would expect the Institution to increase its support in the near future so as to compensate for the ending of the IOF and to ensure that service activities do not displace (or take precedence over) the research activities taking place on the CFI-funded infrastructure.

Other investments in the theme area

UNB made $6 million in other investments in the period 1999-2008 in relation to the theme area of river ecology. This includes library acquisitions ($990k), renovations and alterations ($350k), equipment purchases and rental ($1.5 million), various expenditures covered by donor contributions ($614k) and research assistantships ($2.7 million). In addition, UPEI made a contribution of $581,000 for the infrastructure of a CRC holder collaborating with the UNB researchers. Globally, the $6 million in other investments is an important contribution especially for a university of the size of UNB. It is a clear sign of the high priority given to the thematic area under consideration.

2. Research Capacity

> **"Without question, the CFI granting programs—the support they have provided, the investors and partners they have helped to attract, and the capacity they have engendered—have been fundamentally important to the growth, productivity and synergy of the CRI, its Fellows, Associates, staff and graduate students."**

2.1 Infrastructure Investment Value

|	
Total Infrastructure Investment	Very high
Change in infrastructure investment	Very high

The total infrastructure investment including the IOF funding in the selected theme area (river ecology) at UNB has been $9,944,002 over the past decade. As indicated earlier, this is about 18% of all the CFI funding awarded to UNB to date. This high percentage shows that the theme area is a very high priority and a strength area that UNB wants to develop.

The diagram below shows the evolution over time of the funding in infrastructure in this theme. The period from 1999 to 2003 is characterized by a fast growth. In 2004, a major infusion of $6,527,027 occurred with $5.3 million going to a major building addition and laboratory renovations for the Canadian Rivers Institute (CRI) at the Saint John campus. The CFI's share was in this case a little less than 28%. If we only take into account the matching funds, the net increase would be in the order of $4.5 million. Nevertheless, this remains a substantial increase in funding. Since 2005, only a modest increase is observed in infrastructure investment and the fast growth pace prior to 2004 is not sustained. It was indicated during the OMS visit that UNB purposely refrained from seeking additional infrastructure funding for the river ecology theme to give time to both the institution and the provincial partners to absorb the major cost overruns encountered during the building of the CRI in 2004/05.

Prior to the CFI, the funding of infrastructure and consequently its acquisition was almost absent in the river ecology theme. It has now reached a level of $300,000 per year if we exclude the construction of the CFI-funded building and major renovation of laboratory spaces. This is a huge change over time; even more so for an institution of UNB's size. It is clear that the CRI and the current level of research activities in river ecology would not exist without the CFI investment. The CFI awards were vital and played a major role in establishing research capacity in river ecology at UNB. It has also been instrumental in the success of the CRC program in this theme at UNB. The researchers demonstrate clearly the positive impacts of the CFI infrastructure on their research activities, training of HQP and the development of productive partnerships and collaborations. Prior to the CFI, the UNB researchers had to send their laboratory analysis to the Environment Canada facilities in Burlington or in Saskatoon. According to the UNB researchers, prior to the CFI "the facilities and equipment were very limited and there was no dedicated research space and the research was largely field-based. In addition to this the recruitment of graduate students and the hiring of postdoctoral fellows and technicians were either very limited or almost impossible."

The river ecology infrastructure at UNB consists of the SINLAB, in Fredericton, which is equipped with an IRMS system, an elemental analyser and other analytical instruments that are used to study contaminants in the aquatic food web. It also includes eco-hydraulics infrastructure used to study sediments (including several flumes) and groundwater/surface water interaction. And the third major component is the new CRI building in Saint John that houses sophisticated laboratories and fish holding tanks to assess the health of river systems, to study environmental stressors and identify pollutants in aquatic food webs and their potential to affect human health (ecotoxicology).

Figure 2
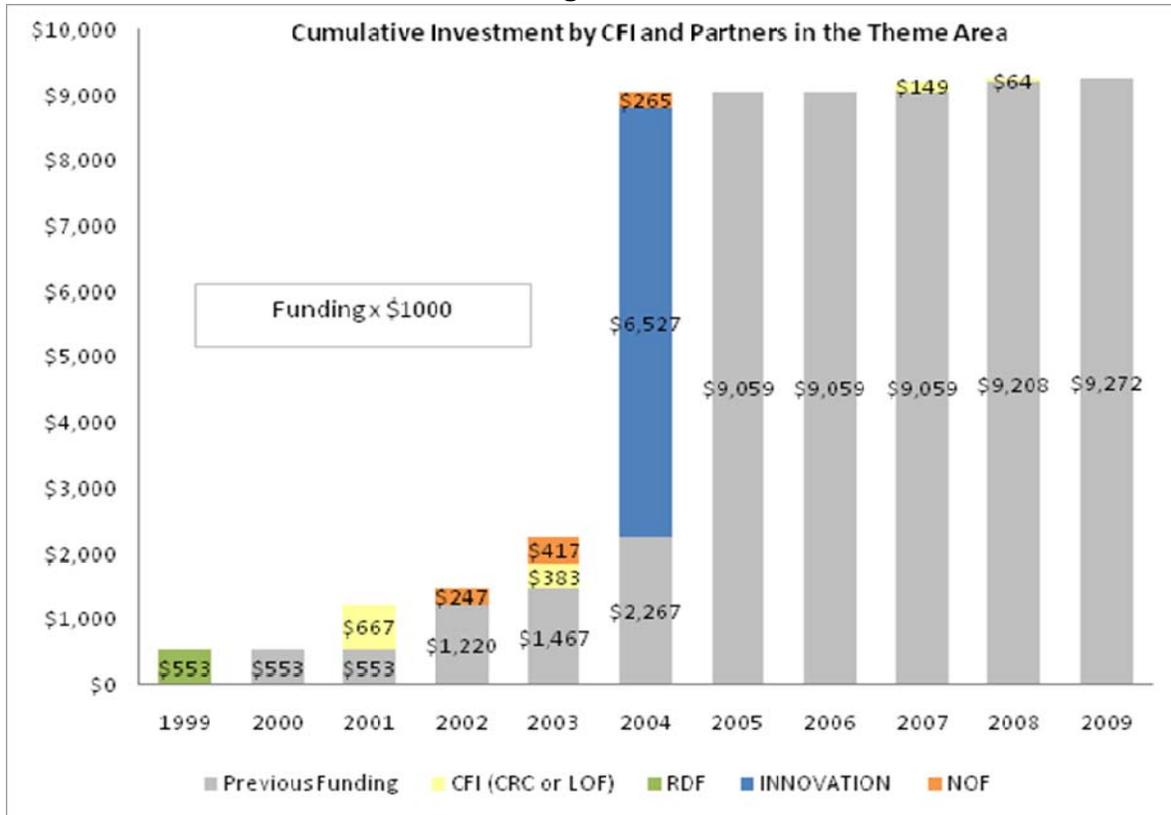
2.2   Capabilities

Pre-CFI technical capability	Useful for supporting research and training
Technical capability now	State-of-the-art
Pre-CFI operational capability	Obsolete and no longer useful
Operational capability now	State-of-the-art

The table below provides information on the technical and operational capabilities in the thematic area. It shows that 96% of the CFI-funded infrastructure is either state-of-the-art or still highly useful for research.

The Expert Panel suspects however that the 88% figure for state-of-the-art could be overestimated. Nonetheless, this is a major improvement in technical capability compared to the state of infrastructure prior to the CFI where none of the infrastructure was considered to be state-of-the-art and only 30% was considered useful for research. UNB estimates that the pre-CFI infrastructure in river ecology infrastructure available on the two campuses was valued at $750,000 as compared to an estimated value of $9.3 million now. This figure could be more reasonably estimated at $4 million if we subtract $5 million for the new CRI building, which is the large CFI project #8796-Munkittrick that was completed in 2007.

The operational capability of the majority of the infrastructure funded by the CFI at UNB in river ecology remains "State of the Art," which is as expected given the recent completion of the CRI building and the presence of three other projects still in their infancy. However, UNB indicated during the OMS visit that, although still fully operational, computers and software are starting to require more support.

Table 2: Technical and Operational Capabilities	Technical Capabilities		Operational Capabilities	
	Pre-CFI	Now	Pre-CFI	Now
State-of-the-art	0%	88%	0%	80%
Still highly useful for research, but no longer state-of-the-art	30%	8%	25%	12%
Useful for supporting research and teaching	40%	4%	35%	8%
Obsolete and no longer useful	30%	0%	40%	0%
Total Value of Infrastructure	$750,000	$9,300,000	$750,000	$9,300,000

Technical capability includes accuracy, resolution and throughput while operational capability considers facility space, user capacity, computing, technical and professional support.

2.3   Sponsored Research Funding and Number of PLs and PUs

CFI impact on sponsored research funding	High
CFI impact on sponsored research funding per PL/PU	High

The table below shows that from 1999 to 2005 the total sponsored research funding in river ecology grew from $724,000 from all sources to $6,217,664. In 2005, the average funding per researcher reached a high of $444,000. Over the same period, the number of project leaders (PLs) and principal users (PUs) went from 5 to 14. The increase in the amount of funding of the research per researcher is high and steady over the years (the year 2005 seems particularly high and should not be considered in the analysis). The recent small decrease in 2007 is too early to justify further analysis. UNB completed a strategic planning retreat in early 2009 to plan the future development and priorities of the Canadian Rivers Institute. An action plan is being drafted to ensure the sustainability of the CRI through stable sponsored research funding levels.

Table 3 – Sponsored Research in River Ecology										
Year	1st major CFI award	1999	2000	2001	2002	2003	2004	2005	2006	2007
Research Funding in thousand (k$)	$724	$570	$583	$1,270	$1,640	$2,590	$3,330	$6,220	$4,000	$3,380
Total number of PLs & PUs	5	6	7	9	10	12	13	14	14	14
Average funding per researcher, k$	$145	$95	$83	$141	$164	$215	$256	$444	$286	$241

2.4   Critical Mass

CFI impact on number of Project Leaders (PLs) and Principal Users (PUs)	High
Critical mass	High

The CFI funding had a high impact on the number of PLs and PUs in the river ecology theme, which increased from 5 to 14 over the last decade. Because of the strong correlation with the Canada Research Chairs (CRC) program, part of this significant increase of researchers has to be attributed to the CRC program.

The CFI funding also had a high impact on the establishment of a critical mass in the thematic area. Although, the CRI does not yet have the full range of disciplines and expertise needed to be Canada's premier rivers research institute, UNB has indeed gathered a sufficient number of researchers that would be needed to make significant progress in the river ecology research. The establishment of the CRI building in Saint John has been and will continue to be a vector of integration among the researchers with multidisciplinary backgrounds in biology, chemistry, forestry and environmental management as well as engineering.

The size of the research team at UNB is in a league with institutions that are internationally known for river research (e.g., the Hudson River group at the Institute of Ecosystem Studies and the upper Mississippi group at the University of Illinois). The UNB researchers are particularly strong in the areas of contaminants and food-webs. The addition of three federal scientists to the CRI is a strong asset for supporting applied research and providing internship opportunities to graduate students. However, the Expert Panel believes that UNB should try to complement its expertise in unrepresented areas in river geomorphology and in nutrient biogeochemistry through partnerships with other research groups both in Canada and abroad (see the Challenge section at the end of this report).

2.5   Recruitment and Retention

CFI impact on number of faculty members attracted from abroad	Low
CFI Impact on overall recruitment and retention	Very high

Since 1998, nine new researchers have been recruited in this thematic area. Most of them were recruited from elsewhere in Canada (7) but a few came from abroad -- one from the US and one from Scotland. In addition, Dr. Michael van den Heuvel, who graduated from the University of Waterloo, was repatriated from New Zealand by a partner institution (UPEI). Overall, the impact of the CFI investment on repatriation of Canadians has been low in the river ecology thematic area.

At the time of the first CFI award in 1998, the core group of researchers in river ecology at UNB included only five faculty members. The impact of the CFI investment on retention has been very high since only one faculty member left in 2008 to become Dean and eventually Vice-President Academic and Provost at Wilfred Laurier University in Ontario. The Expert Panel noted the high level of enthusiasm among senior faculty and recent hires during the OMS visit. The quality of the research facilities attained through CFI funding will be an attractive feature for recruiting future faculty and trainees.

2.6   Visiting Researchers

CFI impact number of visiting researchers	Very high

CFI funding had a very large impact on the number of the visiting researchers both within and outside Canada -- going from four visitors prior to CFI funding to 21 now on a yearly basis. Both the university and the visitors have benefited greatly as this helped to establish new research collaborations while providing visiting researchers with access to state-of-the-art facilities. UNB reports the interesting case of a visitor from the University of Havana in Cuba who was appointed by UNB as a Harrison McCain Visiting Research Professor. He made extensive use of the SINLAB and histology facilities at UNB. Now back in Cuba, he continues to be an Associate of the CRI and that association has resulted in a number of new graduate students from Cuba enrolling at UNB.

Students already at UNB have also largely benefited from the exposure to visiting scientists who help broaden their expertise and teach them new approaches in river research and aquatic ecology. It also has created employment opportunities for some Canadian students. For example, a doctoral graduate from UNB is now working at the Australian Rivers Institute, setting the stage for future international collaborations.

2.7   Multidisciplinarity

Number of disciplines involved	High
Degree institution fostered multidisciplinarity	Don't know
Value-added by multidisciplinarity	Medium

The specific disciplines of the Project Leaders (PLs) and Principal Users (PUs) are biology, chemistry, environmental management and civil engineering. The specialties of these PLs and PUs include analytical modeling, biochemistry, bio-geology, conservation, eco-hydrology, eco-toxicology, estuarine ecology, eutrophication, fish physiology, fish behaviour, fluid dynamics, forestry, geophysics, hydraulics, and microbiology. It is clear that the CFI funding has helped develop a wide spectrum of expertise in river ecology at UNB.

The CFI-funded infrastructure has also been used by numerous other researchers at UNB who are involved in solid waste and aquaculture waste management, storm water runoff, in life-cycle analysis of concrete structures, in evolutionary ecology of birds, in impact of climate change, in fluidization and re-circulating aquaculture systems, in eco-physiology and biochemistry of seaweeds, and larval fish ecology. This broad diversity shows that the science and technology benefits go far beyond the positive impact of the CFI investment in the river ecology thematic area.

Even if UNB indicated that it has been specifically appointing CRC holders with diverse but complementary expertise so as to foster a multidisciplinary approach, the Expert Panel noted that with respect to the training of highly qualified personnel, the traditional university structure does not support this goal by partitioning students into separate programs (e.g., environmental engineering versus ecology versus environmental science and policy). The Expert Panel therefore encourages UNB to develop a River Science curriculum that would provide students with the multidisciplinary knowledge needed to address modern problems of resource management. Such a program would also have the benefit of enabling UNB to compete nationally for students interested in river science. Also, the Expert Panel is concerned over the researchers not always working together since the infrastructure is located at two campuses, which are separated by a 1.5 hour driving distance. This concern is partly addressed by the scientific retreats that are held twice a year and the shared research projects focusing on the St. John River. Although this is viewed as a positive step, a formal multidisciplinary training program in River Science would foster much closer ties among faculty working in river ecology.

3.   Highly-Qualified Personnel (HQP)

The CFI infrastructure for water and river ecosystem research has had a significant impact on the quality of the training provided to HQP by the Canadian Rivers Institute. Indeed, "the CFI infrastructure has made training possible that would otherwise not be offered."

3.1   Number of Research Trainees

CFI impact on number of master's students	High
CFI impact on number of Ph.D. students	Very high
CFI impact on number of Post Doctoral Fellows (PDFs)	High

Taken from the Institutional Data Document, the table below shows a clear increase in the number of graduate students and postdoctoral fellows enrolled annually from the pre-CFI year to year 2008. Overall, it amounts to an increase of almost 3-fold at the Master's level, 5-fold at the Ph.D. level and 4-fold at the post doctoral level. In contrast, during that same period there was less than a 2-fold increase in the number of researchers and professors in this theme. The number of trainees has increased more than twice as fast as the number of potential thesis directors. This faster rate of increase can be correlated to the availability of state-of-the-art research equipment and spaces, which in turn indicates a high degree of impact of the CFI investment.

Table 4 – Graduates and Trainees in River Ecology				
Trainees	**Annually Pre-CFI**		**Annually Now**	
	Number of students	**Number of PLs & PUs**	**Number of students**	**Number of PLs & PUs**
Master's students	13		49	
PhD students	3		17	
PDFs	1		5	
Total	**17**	**5**	**71**	**14**
Trainees/PL+PU		**3.4**		**5.07**

3.2   Quality of Training and Trainees

CFI impact on quality of trainees	High
CFI impact on quality of training	Medium
CFI impact on the training program's reputation or competitiveness	High

One way to evaluate the increase in the quality of trainees at the Canadian Rivers Institute (CRI) is to look at the evolution in the number of trainees holding a scholarship who pursue graduate studies. Between 2001 and 2008, the number of trainees that were holding a major scholarship (including an NSERC scholarship) went from 8 to 35, which is a 4-fold increase. The total number of graduate students went through an equivalent 4-fold increase. This is a good indicator for the capacity of the theme area to attract high quality trainees since the proportion of scholarships was maintained even with the large increase in the total number of students.

Another indicator of the quality of the trainees is the evolution of individuals winning awards. Indeed, graduate students affiliated with CRI have consistently won awards over the past few years. For example, a UNB student received a grant for research in botany, mycology and zoology from the NB Museum. Another one received the Clemens-Rigler Travel Award from the Canadian Congress for Fisheries Research. There are many other awards including: the Dr. John S. Little International Study Fellowship offered by UNB; the President's Award for international travel from the North American Benthological Society; the Garfield Weston Doctoral Award for Northern Research from the Association of Canadian Universities for Northern Studies; the Lorraine Allison Scholarship from the Arctic Institute of North America; and the Best Oral Presentation and Best Poster from the International Congress on the Biology of Fish.

There are also other indicators that demonstrate the quality of the training environment at UNB in this theme, including the following:

- The CRI was selected 2005 to offer the Integrated Water Resources Management Diploma sponsored by the United Nations University;

- The CRI has recently submitted an application to the NSERC Collaborative Research and Training Experience (CREATE) program for a certificate and a diploma in Applied Aquatic Science and a Master's of Environmental Consulting;

- In June 2007, one of the research facilities established with CFI funding, the SINLAB, hosted the 13th International Continuous Flow Isotopic Ratio Mass Spectrometry Workshop for operators of isotope labs.

Although the Expert Panel recognizes the quality of the skills and knowledge currently imparted through the CFI-funded infrastructure, the following concerns are expressed:

- The emphasis of the current training seems too highly focused on the research activities of specific projects/equipment. There is a need to enlarge the scope of the studies, to give students a wider spectrum of academic training activities in order to prepare them to face the challenges of their professional activities either in the academic or the private sector.

- Attracting students/graduates seems to be done too informally. UNB would benefit from offering a graduate program (e.g., River Science) because it could attract more high quality trainees from elsewhere in Canada and internationally. UNB could possibility partner with other institutions offering complementary expertise to offer such a graduate program in River Science.

For these reasons, the training program offered at the CRI is at best qualified as "average" in terms of training environment. In addition, there were many unanswered questions regarding the breadth of the training offered in this theme. Consequently, the Expert Panel gave a medium rating for the impact of the CFI investment on the quality of the training in river ecology at UNB.

3.3   Knowledge Transfer through HQP

Jobs in Canadian academia or research hospitals	Low
Jobs in Canadian private sector	Very high
Jobs in Canadian public sector	High
Jobs in Canadian not-for-profit sector	High
Jobs abroad	High
Further academic training in Canada	High
Further academic training abroad	High
Overall number of graduates	High

The pie chart shown here illustrates well the high impact of the CFI investment on knowledge transfer through Highly Qualified Personnel. It shows that 41% of the UNB graduates in this Theme are now active in Canada; in the private sector (23%), the public sector (15%) and in the not-for-profit sector (3%). The 8% holding jobs abroad is largely the result of foreign students being trained at UNB in the first place. This is an excellent performance. Another 37% is pursuing study and research training at Canadian universities (29%) and abroad (8%). The small 8% of the graduates going into academia can be explained by the fact that it is too early yet to observe this type of impact.
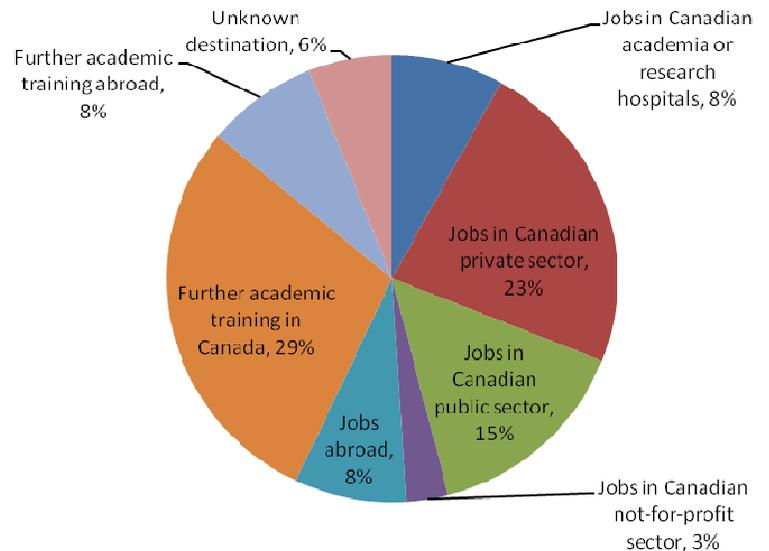
The Expert Panel found that UNB rated high or very high for all indicators regarding the knowledge transfer through HQP. It is also important to notice the great diversity of the sectors as reported in figure 3. Consequently, directly or indirectly, the infrastructure funded by the CFI had a major impact on knowledge transfer since the training of the HQP would not have been possible without the presence/use of the CFI-funded infrastructure.

Figure 3 – After Graduation

4. Research Productivity

> **"The CFI infrastructure has been the primary factor in the CRI's capacity to pursue its research mission."**

4.1 Competitiveness

Overall competitiveness	National level
CFI Impact on institution's overall competitiveness	Very high

Overall competitiveness

The table below was extracted from the Institutional Data Document. It identifies UNB's main competitors and main collaborators in the River Ecology theme area at the provincial, national and international level.

Table 5 – Competitors and Collaborators		
Provincial	**National**	**International**
Main Competitors		
-none	-University of Waterloo -University of Guelph	-Centre for Water Resources, UC Davis -Water Institute, University of Florida -River Basin Centre, University of Georgia -River Systems Institute, Texas State University -University of Colorado -University of Washington. -University of Helsinki -University of Utrecht -University of Queensland -Australian Rivers Institute, Griffiths University
Main Collaborators		
-NB Dept. of Natural Resources -NB Dept. of the Environment -ADI Systems, New Brunswick	-Fisheries and Oceans Canada -Environment Canada National Water Research Institute -Agriculture Canada -Parks Canada -University of Prince Edward Island -Memorial University of Newfoundland -University of Calgary - Coop Freshwater Ecology Unit, Laurentian University -Institute for Watershed Science, Trent U. -Canadian Water Network -Alberta Water Research Centre, U. of Lethbridge -Toxicology Research Centre, University of Saskatchewan -Manitoba Hydro -Manitoba Water Stewardship	-Australian Rivers Institute, Griffiths U. -Laboratoire d'écologie, INRA, France -Conte Anadromous Fish Research Centre, U. of Massachusetts -Department of Environmental Protection, Maine (USA) -EULA Research Centre, Chile -Centro de Investigaciones Marinas, Cuba

The Expert Panel was surprised to see only two Canadian universities listed as competitors. This list seems very short and certainly leaves out a number of other organizations involved in similar research in the rest of Canada. The Expert Panel suspects that UNB used for comparison a very limited definition of the theme area (river ecology). The number of competitors conducting aquatic ecology research at the national level is much greater. The CRI has developed an important network of collaborators.

To assess competitiveness, the Expert Panel considered the following factors:

- The bar is very high in this field to be competitive at the highest levels internationally;

- Although the Canadian Rivers Institute (CRI) has productive collaborations, sponsors meetings, and hosts visiting researchers, it must also aspire to producing more ground-breaking research results to be truly recognized internationally;

- The international collaborations at this point in time have largely been initiated by a limited number of senior researchers at the CRI;

- The ten most recent significant publications identified in the Institutional Data Document are not explicit demonstrations of ongoing international linkages and partnerships;

- Six of the top 8 publications (in scientific periodicals) appeared in journals with an average impact factor of just below 2. Although judging the quality of journal articles from the impact factor is admittedly imperfect, this is one of the few metrics available to assess the quality of recently published papers by the UNB researchers. That said, two of the top ten papers were published in *Environmental Science and Technology*, which has a relatively high impact factor of over 4 and it is an excellent, internationally recognized journal. Nonetheless, the large proportion of papers published in journals with an impact factor below 2 would seem to indicate that CRI is not highly competitive internationally at this stage.

The Expert Panel concludes that the CRI as a whole is currently recognized as competitive at the national level and making good progress toward international competitiveness. Several individuals at the CRI currently have strong international recognition. The CRI is on the right track to reach a highly competitive status internationally within a decade, particularly if UNB establishes a formal graduate training program in this thematic area.

The impact of the CFI investment on competitiveness

UNB provided a number of examples that clearly show the importance of the CFI funding in helping the CRI increase its competitiveness. The Expert Panel highlights below the most convincing examples:

- The new laboratories at the Saint John campus have provided the CRI researchers with the state-of-the-art infrastructure needed for world-class research in eco-toxicology;

- The stable isotopes laboratory (SINLAB) at the Fredericton campus is central to leading studies of fish movement patterns and riverine food webs. UNB is known internationally for demonstrating the power and limitations of stable isotopes analysis in aquatic ecology;

- The laboratory for assessing the chemical contamination of food webs is now used to study aquatic systems in the Arctic as well as in temperate and tropical lakes and streams – a worldwide impact will soon result from CRI's research and findings;

- The infrastructure used to support groundwater-surface water interactions has boosted research in the theme area. UNB's expertise is increasingly being sought by other Canadian jurisdictions and international agencies dealing with hydrological matters;

- The new laboratory for water/wastewater treatment and environmental research has been forging strong university-industry research collaborations;

- The Manitoba field station for fisheries research has given the CRI a national reach by installing facilities halfway across the country on the Winnipeg River. The fish studies conducted there are highly innovative and already starting to impact regulation on fish passage in rivers used for hydro-electricity.

It is clear that the CFI investment has played a critical role in promoting the CRI to its present level of competitiveness. Without this funding, UNB would never have achieved the exceptional accomplishments of the last decade.

4.2   Research Productivity

CFI impact on quantity of research	High
CFI Impact on quality of research	High

Key research, scientific and technological issues

The CFI-funded infrastructure was a determinant in addressing the following key research problems and scientific/technological issues that are being investigated by UNB researchers:

- The leading study on arctic char, a species of great importance to the northern aboriginal community, is revealing the presence of contaminants in freshwater lakes in the Arctic;

- The use of stable isotopes in food webs studies is advancing our understanding of the long-term impact of aquaculture;

- The evaluation of the link between aquifers and the St. John River is assisting the City of Fredericton in appropriately and safely managing its drinking water resources;

- The analysis of the impact of fertilizer application on ground and surface water in Prince Edward Island is showing the serious consequences of monoculture on ecosystems;

- Breakthrough studies have made a connection between fish physiology and behaviour, which has led to a whole new understanding of fish passage through hydroelectric dams.

The 10 most significant scientific publications directly related to the infrastructure

As mentioned earlier, the Institutional Data Document presents a list of ten publications as the most significant scientific publications directly related to the CFI-funded infrastructure. Most publications involve multiple authors and they are representative of the multidisciplinary nature of the research activities conducted at UNB. The publications are not all of equivalent importance; one of them, for example, is a book chapter yet to be released (The United Nation University on the state of the St. John River, 2010). Nevertheless, several publications have already received recognition by the scientific community. One paper was rated as the top Canadian science story and is in the top 100 science stories in the world in 2007 (Kidd/Jardine). Another paper has ranked 8th in terms of top cited papers in the Journal of Fish Biology, which is an international journal (Peake/Farrell). Although no data were provided to help judge the comparative impact of these significant papers (i.e. citation numbers or impact factors of the journals), the top ten papers as a whole are considered to be good but not outstanding. The majority of the publications demonstrate progress toward greater international recognition of the Canadian Rivers Institute.

The important national and international research programs

The CRI researchers exercise leadership roles in several programs as either project leader or co-leader, examples of which are listed below. The CFI-funded infrastructure played a major role in enabling the CRI researchers to lead these important research programs, which yields a high impact rating on the research productivity in river ecology at UNB.

National

- Canadian Water Network NCE Theme Leader in Watersheds and Ecosystems (Munkittrick)
- Coordinate the United Nations University North American Virtual Learning Centre on Integrated Water Resources Management (Munkittrick, Gray)
- Co-leader Fish Health and Ecosystem Dysfunction theme, Great Lakes Fisheries Commission Board of technical Experts (Munkittrick)
- Environment Canada National Lead for study of Cumulative Effects on Aquatic Biodiversity (Culp)
- Co-lead National Agri-Environmental Standards Initiative (NAESI) for the development of new national standards for suspended and bedded sediment, in-stream flow, and nutrients for agricultural watersheds (Culp)
- Co-lead for the Arctic Freshwater Biodiversity Research and Monitoring Network (Baird, Curry, Culp)
- Co-lead on Environmental Effects monitoring Fish Expert Working Group, which is part of the national Science Committee (Munkittrick)
- Lead for the Expert Water Steering Group for the Circumpolar Biodiversity Monitoring Program of the Arctic Council's Conservation of Arctic Flora and Fauna working group (Culp)
- Run the national CABIN training program for Environment Canada (Gray, Curry)
- Spearhead the Development of Experimental Wetlands Centre at Gagetown Armed Forces Training Centre (Kidd, Houlahan)
- Theme leaders at the New Hydronet research network (Cunjak, Peake)
- Canadian representative on CUASHI-Consortium of Universities for the Advancement of Hydrologic Science Inc. (Culp)

Provincial

• Responsible for NB Aquatic Data Warehouse, which is a database service for NB water resources; the only public online database of its kind in the country (Curry)

• Member of a Regional Technical Advisory Group (RTAG) that has been formed by the Prince Edward Island Department of Environment, Energy and Forestry (MacQuarrie).

• Involved in the development of a new international network looking at the integration of hydraulics and fish behaviour, which was inspired by the ecology and habitat use by lake sturgeon in Manitoba (Peake).

• Host for the NB Cooperative Fish and Wildlife Research Unit for the NB Department of Natural Resources (Curry)

Regional

• Leads for the State of the St. John River Watershed Synthesis (Munkittrick/Curry)

• Involved in the St. John River Online Atlas (Curry)

• Lead of a network of researchers studying on endocrine impacts in experimental lakes (Kidd)

The impact of CFI funding on the <u>quantity</u> of research of publications

The figure below shows the number of papers per year for each of the seven Project Leaders. In this analysis, only published papers in ISI-ranked journals were counted (excluding conference proceedings) and the compilations started after the researcher's arrival at UNB. Given the short time span represented, it is difficult to identify significant trends. Nevertheless, the Expert Panel made the following observations. Since 2001, only four individuals have had a substantial upward change in their number of papers per year. In the other cases, there is either no readily apparent change or only an initial burst that may largely represent research that was ongoing prior to the CFI awards. In several cases, there is evidence of a slow down after an individual's recruitment. This is perfectly understandable because junior faculty need to spend considerable time getting established at their new institute while senior faculty must invest considerable time adjusting to a new leadership role. Overall, the Expert Panel rated both the research productivity and the related impact of the CFI investment in this indicator as high.

Figure 4: Papers Per CFI PI
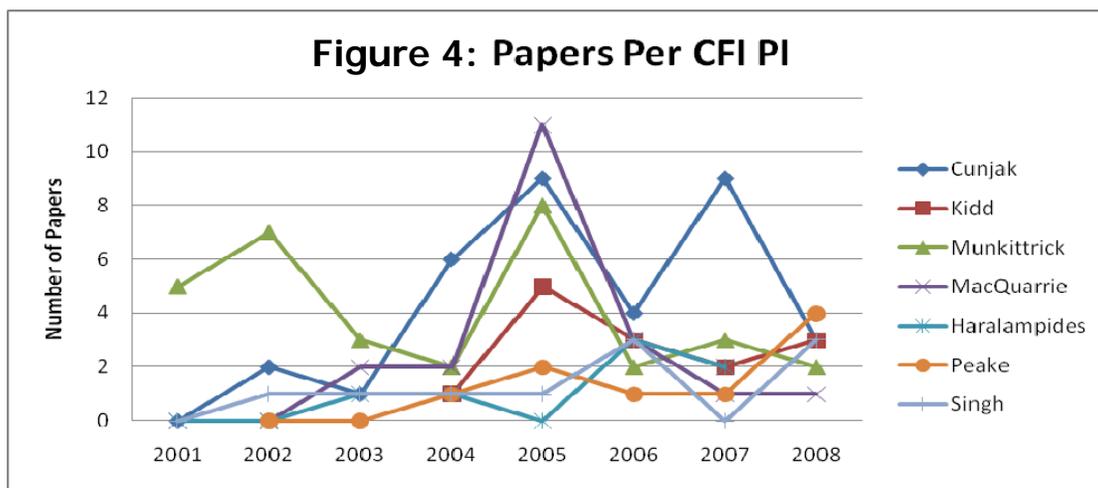
The impact of CFI funding on the <u>quality</u> of research of publications

The figure below shows the citations of the publications of the Project Leaders of the CFI-funded infrastructure in the river ecology theme. In all cases except one, an increase over time is observed. It is always very difficult if not impossible to trace back the changes in citations to a specific event such as CFI funding. Nevertheless, the Expert Panel considers this positive trend to be representative of the increasing stature of researchers at the Canadian Rivers Institute.

Figure 5: Citations Per CFI PI
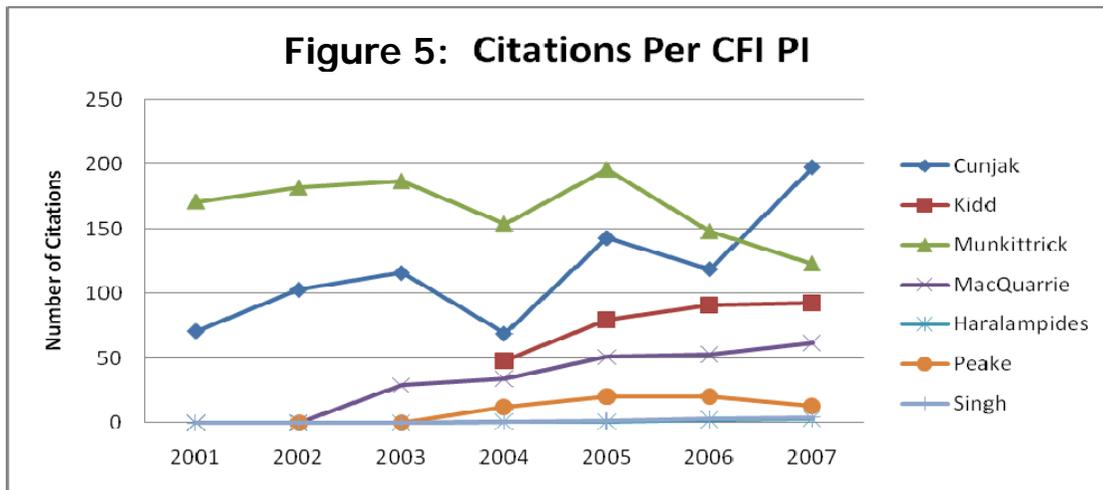
Furthermore, the two figures below were extracted from the bibliometric analysis conducted by UNB in preparation for the OMS visit. The data represent the count of published articles in the following categories (using keywords): stream, river, lakes, aquatic and monitoring; and selecting subcategories for water resources, freshwater, ecology, environmental science, toxicology and fisheries. The analysis compares the number of hits for the CRI researchers and other Canadian institutions. Although the robustness of this type of analysis should be verified, the Expert Panel found these results rather interesting.

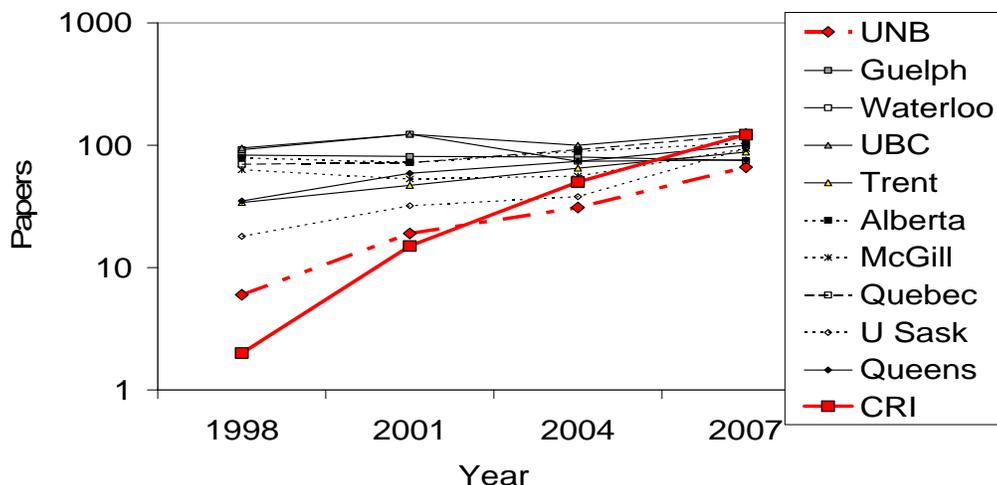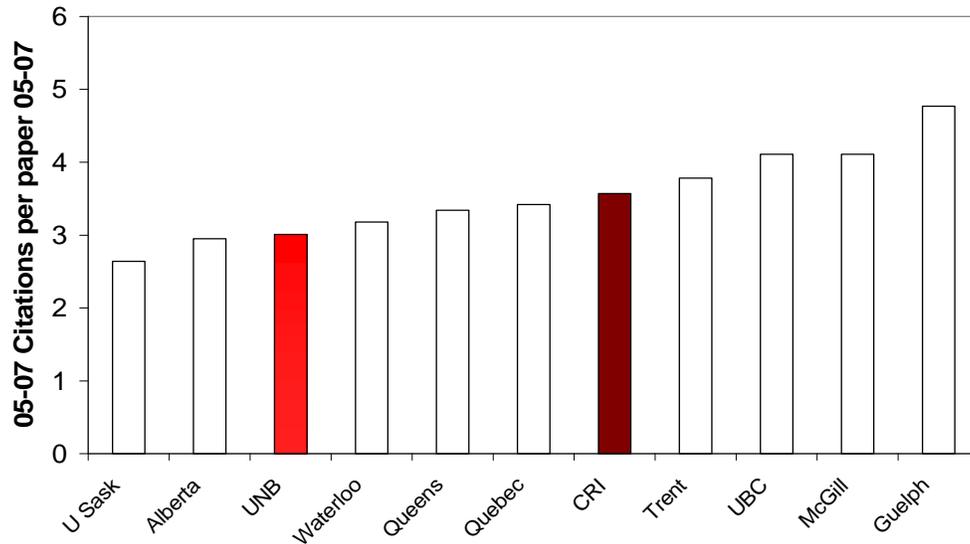**Figure 6 – Published Papers in River Ecology and Related Areas**

Figure 7 – Citations in River Ecology and Related Areas

The two figures above show consistent trends:

- The number of papers by the UNB researchers in this theme area has quickly risen and has now reached the productivity level of competing institutions in Canada and that over only the period of a decade.

- As illustrated by the increase in citations in the period 2005-2007, the quality of the research at the CRI has progressed significantly; ranked 24th in 1998, it is now in 11th position in 2007.

In conclusion, with respect to the progress in the quantity and quality of the research in river ecology at UNB, the Expert Panel considers the impact of the CFI funding to have been high.

4.3   External Research Linkages

Degree of external networking and collaboration	High
Number of formal research networks	High
Value added by external networking and collaborations	High

External network and collaborations

There has been a major increase in the networking and collaboration since the creation of the Canadian Rivers Institute at UNB and the funding of the infrastructure by the CFI in this thematic area. Highlighted below are a few examples that illustrate well the type, scope and significance of the partnerships, including both formal and informal collaborations:

- CRI is a major partner in several collaborative river studies across Canada: nutrient inputs as part of the Lake Winnipeg Basin initiative in Manitoba; design of a cumulative effects monitoring plan for the lower Columbia River system in British Columbia; the international Polar Year assessment of Eastern Arctic food webs in Quebec, Nunavut, and Newfoundland.

- CRI is the national lead for Environment Canada's program on Cumulative Effects on Biodiversity.

- CRI is the leading centre for the Expert Water Steering Group for the Circumpolar Biodiversity Monitoring Program of the Arctic Council's Conservation of Arctic Flora and Fauna Working Group.

- CRI is an important contributor to the Canadian Barcode of Life Network from Genome Canada and it runs the national CABIN training program for Environment Canada. CRI is also working with federal partners and industry to develop fish bioassays to meet international criteria for screening and testing endocrine disruptors.

- CRI is host to the NB Cooperative Fish and Wildlife Research Unit for the Department of Natural Resources. It also has significant partnership agreements with Environment Canada's National Water Research Institute, DFO's Gulf Fisheries Centre and Parks Canada's monitoring programs.

- CRI has collaborators and associates across Canada. CRI Fellows have co-authored papers with 22 Canadian universities, including the Coop Freshwater Ecology Unit at Laurentian University, the Institute for Watershed Science at Trent University, the Alberta Water Research Centre at the University of Lethbridge and the Toxicology Research Centre at the University of Saskatchewan.

- CRI has forged partnerships with the pulp mill and forest industries and hydroelectric companies (Alliant Energy in Wisconsin, BC Hydro, Manitoba Hydro, Hydro Quebec). CRI researchers also work with engineering and environmental consulting firms like ADI that advise mining and petroleum companies (Irving Oil, Diavik Diamond Mines), with municipalities (Saint John, Fredericton, Battleford, Saskatoon), and other agencies such as the Saint John Port Authority and the Maritime Road Development Corporation.

- CRI has active partnership agreements with five federal agencies in the US.

Formal research network

UNB has established some fifteen formal research networks in this thematic area with six of them outside Canada. All but one of the partnership agreements were set up after the CFI funding, pointing to a high impact for the CFI funding in river ecology at UNB.

4.4   Sharing of Infrastructure

Sharing of infrastructure by researchers within the institution	Very high
Sharing of infrastructure with researchers from outside the institution	High

The majority of the CFI projects in the theme area of river ecology are considered small in terms of infrastructure costs. Six of the 11 projects received less than $100,000 from the CFI while another three projects are between $100,000 and $200,000. Within the core group of researchers at the Canadian Rivers Institute, the sharing of infrastructure is done on an informal basis whereby the PLs, PUs and their students share space and equipment as needed, which is perfectly suited for this organization. The OMS visit revealed that the sharing of infrastructure is strongly encouraged and it seems frequent and efficient. Furthermore, the figures shown in the table below clearly indicate that there is also a high level of infrastructure sharing with other researchers at UNB and visiting researchers that mostly come from outside of New Brunswick. The category "other" includes users outside Canada (e.g., US, France, Bahamas, Bhutan, Argentina, Chile and Cuba) and the high figure indicates that the UNB facilities are garnering international attention.

Table 6 – Infrastructure Sharing							
Project number	# of other UNB Researchers (than the PL)	% Use by Other UNB Researchers	# Visiting Researchers (Outside)	% Use by Visiting Researchers (Outside)	Origin of visiting researchers		
					NB	Can	Other
314	7	40%	3	40%	0	1	2
6919	5	10%	0	0%			
201843	5	10%	4	20%	0	2	2
201668	3	0%	2	0%	1	1	
200379	10	25%	7	30%	0	3	4
8796	4	70%	3	10%	1	1	1
7375	14	40%	1	20%	1		
7621	1	0%	1	10%	0	1	0
Totals	**49**		**21**		**3**	**9**	**9**

5.   Extrinsic Benefits

"CFI support has provided a "seal of approval" that has helped to build the credibility of the CRI and fostered partnerships with other organizations."

5.1   Partnerships

Number of partnerships with end user organizations	High
Importance of these partnerships	High
Amount of financial contribution made by end user organizations	High
CFI impact on these partnerships and contributions	Very high
Signs of an evolving industrial cluster	NO

Formal partnerships with end users

In compiling its partnerships with end users, UNB took a very liberal definition and reported some 217 joint research projects and collaborations in this thematic area for a total of $15,238,632 from partners. While it made for an impressive listing, the lack of differentiation between major strategic partnerships and more modest contractual activities complicated the assessment of the significance of the value-added of the CFI investment in terms of end-users benefits. Nonetheless, the CFI-funded infrastructure was deemed to have been essential in enabling the various partnerships. Highlighted below are the key observations made by the Expert Panel:

- Most of the CRI projects and partnerships are conducted with different government departments or not-for-profit organizations (more than 95%);

- In a large number of these partnerships, the partner is directly involved in the research activities per se – i.e., not just providing funds but also participating in the research;

- Most of the time, the involvement of the private sector is for very specific studies aimed at collecting data or addressing immediate problems (applied research);

- As shown in the table below, 18 of the 217 projects (9%) involve very large collaborations and they account for 44% of the total partner contributions ($6,789,017);

- The vast majority of the collaborative activities conducted at the Canadian Rivers Institute (CRI) are largely targeted, and rightly so, to addressing specific needs expressed by the partners. There is a high level of synergy with the various partners;

- In addition, the amount of revenues generated by training and fee-for-revenues activities is impressive (see table below).

Table 7- Major Partnership with End-Users		
Partnership Description	**Importance**	**Financial Contributions**
Manitoba Hydro	Strategies to protect and mitigate the effects of hydro power on lake sturgeon & their habitat & spawning requirements	$2,573,700
Environment Canada (1)	Cumulative Effects on Aquatic Biodiversity. Cumulative Effects Assessment research.	$598,474
Toxic Substances Research Initiative (Health Canada & Environment Canada)	Development of Cumulative Assessment Strategy for the St. John River	$457,394
New Brunswick Wildlife Council	Studies of fish health in NB streams and lakes	$431,775
Dept. of Fisheries & Oceans	Potential impacts of seafood processing operations and bivalve aquaculture on estuarine and coastal environments	$416,331
Agriculture and Agri-Foods Canada	Contribution agreement for Canada/PEI national water program	$282,000
Irving Paper	Investigation of causes at two pulp mills of reproductive effects in fish; sex steroid disruptions in fish exposed to pulp mill effluent	$299,999
Maritime Road Development Corporation	MRDC Graduate Fund Memorandum of Understanding	$261,985
NB Dept Environment & Local Government	Information to stay abreast of emerging issues and advances in the areas of applied surface water research, and to increase scientific collaboration and technology transfer	$201,050
Indian And Northern Affairs Canada	Climate Variability and Change effects on Char in the Arctic; Arctic freshwater systems hydrology and ecology	$189,500
Parks Canada	Stock assessment & population ecology of Atlantic salmon; Food web enhancement studies	$183,966
J.D. Irving	An eco-hydraulics approach to increasing riverine production of wild Atlantic Salmon (CRD)	$177,500
Irving Oil	Little River Study	$141,565
Diavik Diamond Mines Inc.	Fish Health and Fish Population Assessment at Lac Grass in NWT	$137,880
SINTEF Energy Research	Contract research on the conditions on behavior & habitat of juvenile Atlantic Salmon	$127,000
NB Department of Transportation	Assessment of the fish community in the Grand Lake Meadows area	$107,500
Sir James Dunn Wildlife Research Fund	Development of cumulative effects stategy for the S.J. River; status of smelt scanning receivers; mercury and trophic level pathways in NB lakes	$101,500
Natural Resources Canada	Developing Regional Atlases of the St. John River for decision making	$99,898
	Total:	**$6,789,017**

Evolving local, regional or national industrial clusters

During the OMS visit, the Expert Panel heard the testimony of a representative from a national engineering consulting firm who clearly indicated the interest of end-users in developing further UNB's industrial research in water quality. However, aside from this contribution, there is no sign of an evolving local, regional or national cluster of partners in river ecology at this point.

5.2 Technology Transfer

Importance of technology transfer in this field generally	Low
Amount of technology transfer	Medium
Significance and value to users of technology transfer	Medium

The current research activities of the Canadian Rivers Institute are dominated by the biological sciences. At the present time, only a small proportion of the investigations (water treatment) fall under the engineering and technology dimension which lends itself better to technology transfer activities such as patents, licenses, etc. As indicated, the current efforts at the CRI are classified as knowledge transfer of other types and discussed in section 5.3 below.

5.3 Knowledge Transfer of Other Types

Importance of knowledge transfer of other types in this field generally	High
Level of knowledge transfer of other types	High
Significance and value to users of knowledge transfer of other types	High

UNB presented a very convincing list of other types of knowledge transfer to the end users, the public and the scientific community in general. The breath of knowledge transfer methods and the varied routes reflect the diversity of the end users as well as the broad range of research activities conducted in river ecology at UNB. The OMS visit made it clear that, compared to others in the field, the UNB researchers put a great deal of effort in communicating their findings and sharing their knowledge. Here are a few examples:

- Direct participation in major external user R&D projects;

- Provision of data or services to users (e.g., test facilities, analytic services, unique instrumentation);

- Consultation, "first point of contact" services;

- Input into models (e.g., financial markets, weather systems, ecosystems);

- Invited presentations at the user organizations, participation in working groups;

- Contributing to new product/process development;

- Contributing to new standards, policies, regulations, codes of practice;

- Improvement and dissemination of best practices;

- Improvements in professional practice;

- Public information and interaction (e.g. interactions with various media, collaborations with museums, on-line resources for public and educational use);

- Formal collaborations with and presentations to community and professional organizations.

5.4 Socio-Economic Benefits

Importance of socio-economic benefits	High

UNB also makes a very convincing argument regarding the importance for society of its research activities in river ecology. The strategic positioning of this theme area and the associated socio-economic benefits for Canada resulting are considered high. The key points put forth include the following:

- Water is the world's most important resource;

- Canada contains 20% of the world's freshwater reserves and its rivers discharge 7% of the world's renewable water supply;

- Freshwater research in Canada is internationally renowned;

- The multidisciplinary nature of the research conducted at the Canadian Rivers Institute impacts a wide range of issues related to water conservation.

A number of examples were presented during the OMS visit to further illustrate the high socio-economic impacts of the CFI investment in river ecology at UNB:

- UNB has been providing assistance to the Federal Government through research support for the Environmental Effects Monitoring (EEM) program;

- UNB provides assistance regularly to the private sector in identifying the origin/extent of environmental contamination associated with industrial processes;

- UNB is currently developing an online data atlas.

Challenges

> **"Meeting the increasing demands and expectations of partner organizations is challenging as our research expertise and technical infrastructure become more sophisticated."**

During the OMS visit, the Expert Panel heard the views on the key challenges from Dr. Greg Kealey (Provost and Vice-President Research), Dr. Kelly Munkittrick (CRI Fellow and the Project Leader of the larger CFI-funded project) and Dr. Katy Haralampides (CRI Fellow and Professor of Civil Engineering, and also a PL).

Highlighted below are the main elements of the global challenges facing the Institution in sustaining its research accomplishments in general and more specifically in the river ecology thematic area:

- UNB is an important academic player in the region, conducting 80% of the university research and almost 50% of all research in New Brunswick. Over the past eight years, its research revenues have doubled to $50 million annually—the third highest growth rate among comprehensive universities in Canada. Yet, in the national context, UNB is a relatively small institution that is located in a province with limited prospects for growth. In many respects, UNB has reached its maximum potential in terms of active researchers eligible to participate in major granting programs and contract research with public and private sector partners. Getting to the next level, even with continued success in securing CFI support, will be extremely challenging.

- The main challenge in taking advantage of the CFI program was, and will remain, securing matching funds with which to complement the 40% provided by the CFI.

- The lack of funding for operating and maintenance costs, particularly for sophisticated analytical equipment, is an ongoing challenge.

- The financial impact on the institution of one-time capital grants with no provision for upgrading or replacement is a challenge that is already affecting UNB since its potential to reinvest in CFI funded infrastructure is limited.

- Within a very competitive global environment, attracting and retaining HQP, CRCs and other highly productive researchers at UNB is a constant challenge.

Other challenges that are more directly related to the future of the Canadian River Institute were also brought up during the OMS visit. This led to an interesting discussion during which the Expert Panel shared its observations from the two-day visit at UNB. In a sense, this discussion was somewhat outside the specific mandate of the Expert Panel but it provided a forum for both sides to discuss in a candid fashion the difficulties of establishing research institutes and sustaining their activities. Highlights are provided below:

- UNB has made some very good decisions regarding hiring of staff during the past decade but not to a level that would secure its recognition as Canada's premier river research institute. For such recognition to take place, UNB first needs to fill in certain expertise gaps.

- Conversely, UNB has already identified two major needs to address in order to maintain its positioning as a leading river ecology research centre: dedicated project management and ecological modeling. The modeling dimension will not be easy to resolve because such scientists usually need to interact with other modellers to challenge each other and maintain their expertise level at the fore-front of knowledge.

- Currently, the persons in charge of the CRI are focusing on immediate needs and finding resources to build and operate the infrastructure (more day-to-day operations). The Expert Panel believes that they should be more focused on the long term mission and goals of the CRI so as to progress from the present level of development to a level that will truly put them at the leading edge nationally and in the world. In a sense, this is not an option but rather an urgent obligation because the competition, even inside Canada, is going to increase over the next five years.

Conclusions

The Expert Panel believes that the attainment of a world-class nucleus of river researchers is within grasp.

Based on the evidence provided in the Institutional Data Document and the observations made during the site visit, the Expert Panel reached the conclusion that the CFI investment at the University of New Brunswick in river ecology had a high degree of impact in this thematic area. It was vital in developing the research capacity of the Canadian Rivers Institute (CRI) and in securing UNB's national recognition in this field. The CRI is solidly inscribed on a path to an international recognition.

The river ecology thematic area has been a long standing priority at UNB. The strategic research planning that was initiated in the late 1990s set a solid foundation for the creation of the Canadian Rivers Institute as both a national research and training endeavour. Through the years, UNB remained highly committed to this strategic area through substantial financial contributions, sustained hiring and the attribution of 30% of its Canada Research Chairs to this thematic area (and the CRI in particular).

The impact of the CFI's investment on research capacity, research productivity and the training of highly qualified personnel have all been judged to be high. The CRI and its dedicated researchers have also had a very high impact on socio-economic issues. It is duly noted that the CRC program was also largely instrumental to the success of the research conducted at UNB in river ecology.

From the institution's standpoint, the biggest challenge remains the securing of the partner funding required for the CFI funded infrastructure. From the Expert Panel's standpoint, the key challenge for the CRI will be the recruitment of the new researchers it needs to complement existing expertise so as to be recognized as an internationally competitive institute in rivers research. This could be achieved through partnership and collaboration with other institutions in Canada and abroad.