EVALUATION OF GENOME BRITISH COLUMBIA

FINAL REPORT

Prepared for: Genome British Columbia

Prepared by: BearingPoint

December 20, 2004

BearingPoint

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Introduction. This report presents the findings from the evaluation of Genome British Columbia (GBC). The study was carried out by BearingPoint under contract to GBC following Genome British Columbia's first three years of operation. The study objectives were to: (1) Meet the requirements of GBC's by-laws, which require GBC to conduct a "full-scale" evaluation after its first three years of operation; (2) Assess GBC's achievements against its formal objectives ; and (3) Provide information that can be used in GBC's upcoming strategic and business planning process.

Genome BC. Genome British Columbia is one of the five Genome Centres established by Genome Canada across the country in 2000. GBC invests in and manages large-scale genomics and proteomics research projects in the areas of health, forestry, fisheries, ethics, agriculture and the environment. It also provides the necessary research infrastructure to support the projects through five science and technology platforms (microarrays, proteomics, sequencing and mapping, technology development, and bioinformatics). Over 300 researchers are supported. GBC's goals include developing a coordinated approach and genomics strategy to allow BC to become a world leader in selected research areas, and addressing public awareness and concerns regarding genomics.

Methodologies. (1) A review of performance measurement (RMAF) data; (2) A web survey of GBC researchers; n = 21 (38% response rate); (3) Interviews with 32 stakeholders, members of the GBC Board and Business Advisory Committees, and Canadian and international experts; and (4) Four case studies.

Findings. GBC has, in a short period of time, become an "anchor franchise" for BC's genomics efforts. In the opinion of almost all stakeholders Genome BC has been markedly successful overall, having had strong impacts in areas appropriate to its mandate and goals. Its successes are very strong, especially at this stage of its development and given that both Genome Canada and GBC represent new models for supporting research. GBC has clearly added considerably to the BC genomics research effort: there is more than the usual sense of excitement seen with a "typical" new program—in fact, there is a palpable sense of excitement in BC's genomics research community.

The GBC strategy is comprehensive and generally sound, and GBC has undertaken effective collaboration and consultation with stakeholders. One result is that GBC has been able to obtain significant amounts of co-funding. The Centre's impacts on the quality of genomics science and infrastructure have been very strong, and several initiatives (e.g., the Genome Sciences Centre and its sequencing of the SARS virus, the research in forestry and fisheries) and individuals were cited as clearly being world-class. Over the long term there is potential for tremendous socio-economic (S-E) benefits (although it is far too early for these to be realized), and most of the factors required to successfully identify and exploit important innovations are in place or in development. Already the quality and nature of training is substantially improved compared to the previous situation. There have been explicit efforts to address ethical, environmental, economic, legal and social (GE^3LS) issues in connection with its research projects and platforms, and to effectively communicate the risks and rewards of genomics to the general public. The Centre has strong, entrepreneurial leadership and there are many effective management mechanisms in place. Many respondents regard GBC as being one of the two strongest Genome Centres in Canada (the other being Genome Québec).

There are some "teething" problems, although these are greatly outweighed by GBC's successes. The nature of most of these problems is not unexpected for such an initiative in early stages and most are very similar to what is "typically" heard—e.g. no researcher likes to be "managed", everyone dislikes reporting and paperwork, the R&D timeframe is always lengthy, management of large and complex research projects and platforms is difficult (especially early on), and commercialization of research is fraught with difficulty. However, some complaints are more pointed than usual, and perhaps the most important strategic item to address in the near term is to better define GBC's role in adding value to BC's genomics research initiative and to the existing commercialization and exploitation mechanisms of the many strong stakeholder organizations. Other items needing attention are ensuring long-term sustainability of genomics funding, assisting researchers in obtaining co- funding, improving business management (especially at the platforms), reducing GBC's perceived micro-management, and managing unrealistic expectations regarding the timeframe for S-E benefits. Several of these problems require input and effort from other stakeholder organizations, not just GBC.

In sum, GBC has had notable success meeting its goals to date and is a very important addition to BC's life sciences cluster. This is an appropriate time to refine its business model to ensure its long-term relevance and to maximize the value GBC can add.

1.0 INTRODUCTION

1.1 The Study

This report summarizes the results of the evaluation of Genome British Columbia (GBC). This study was conducted by BearingPoint under contract to GBC, and was carried out over the period September 2004, through December 2004. The evaluation was overseen by an Evaluation Steering Committee of the Board of Directors. The objectives of the study were to:

- Meet the requirements of Genome British Columbia's Corporate By-Laws, which require GBC to conduct a "full-scale" evaluation after its first three years of operation;
- Assess the Centre's achievements against its formal objectives ; and
- Provide information regarding the Centre's operational and management strengths and potential areas for improvement that can be used in its upcoming strategic and business planning process.

It should be noted that this study has not involved the evaluation of individual Genome British Columbia research projects, or of individual GBC researchers. It is a review of GBC as a whole, focusing on its achievements, operations, and management.

1.2 Evaluation Issues

The main issues examined by the evaluation study were tied to GBC's mandate and objectives, and were defined during the design stage of the study[1]:

1. **Has Genome BC developed a coordinated and integrated strategy for BC's genomics research?**
   - 1.1. Does GBC have a strategy that is relevant, complete, appropriate, and adds value?
   - 1.2. Is GBC "on track" to enable BC to become a world leader in selected genomics research areas?
   - 1.3. What factors facilitate or inhibit the Centre's progress in becoming a world leader?
2. **Has Genome BC participated in national genomics strategies?**
   - 2.1. To what extent has GBC participated in national approaches and strategies?
   - 2.2. How effective has this participation been at strengthening national genomics research capabilities?
3. **Does the Genome BC Centre have the potential to generate significant socio-economic (S-E) benefits for BC and for Canada?**

[1] *Design Report Evaluation of Genome British Columbia. BearingPoint. October 25, 2004.*

3.1. Has a Genome Centre been established in BC?

3.2. Do the GBC research programs and projects have the potential to generate significant S-E benefits for BC and Canada?

3.3. Has the Centre offered researchers access to the necessary research infrastructure to allow this socially and industrially relevant research to proceed effectively?

3.4. What barriers exist for generating S-E benefits for BC or Canada?

3.5. Has the Centre supported or facilitated the training of scientists, students, and technicians in genomics?

4. Has Genome BC established appropriate contractual and/or collaborative relationships with relevant stakeholders?

4.1. Does an appropriate contract exist with Genome Canada?

4.2. Do appropriate contractual and/or collaborative relationships exist with other significant stakeholders?

4.3. Have these arrangements succeeded in providing adequate financial support for the Centre?

5. Has Genome BC addressed public concerns re: GE^{3}LS issues?

5.1. What activities has GBC taken with respect to addressing public concerns about GE^{3}LS issues?

5.2. What have been the impacts of these activities on the level of public concern?

6. Has Genome BC increased public awareness of the need for, and benefits and risks of, genomics research?

6.1. What activities has GBC taken with respect to addressing public understanding of genomics and its risks and rewards?

6.2. What have been the impacts of these activities on the level of public understanding and support?

2.0 OVERVIEW OF GENOME BC

Genome British Columbia is one of the five Genome Centres established by Genome Canada across the country in 2000. Genome British Columbia invests in and manages large-scale genomics and proteomics research projects in the areas of health, forestry, fisheries, ethics, agriculture and the environment[2]. It also provides the necessary research infrastructure to support the projects through its five science and technology platforms (microarrays, proteomics, sequencing and mapping, technology development, and bioinformatics). In total, these projects and platforms involve more than 300 researchers and technicians and provide training to numerous students and post-doctoral fellows. By working collaboratively with all levels of government, universities and industry, Genome British Columbia is attempting to be a catalyst for a vibrant genomics-driven life sciences cluster in BC, with far-reaching social and economic benefits for the province and Canada.[3]

Genome British Columbia has six specific objectives[4]:

a) Development and establishment of a coordinated approach and integrated strategy in British Columbia to enable BC to become a world leader in selected areas of genomics research, including research relevant to agriculture, aquaculture, the environment, forestry and human health, among others, by bringing together universities, research hospitals, other research centres and industry, as well as government and private agencies for the benefit of British Columbia,

b) Participation in national approaches and strategies to strengthen genomics research capabilities in Canada for the benefits of all Canadians,

c) Creation of a genome centre in BC (the "Genome Centre") to ensure that all researchers can undertake research and development projects offering significant socio-economic benefits to BC and Canada, to provide access to necessary equipment and facilities, and to provide opportunities for training of scientists and technologists,

d) Establishing a contractual relationship with Genome Canada, and contractual and collaborative relationships with others (including private and voluntary sectors and federal and provincial governments) in order to provide financial and personnel resources for the Genome Centre,

e) Addressing public concerns about genomics research through the organization of intellectual resources regarding ethical, environmental, legal and societal issues related to genomics,

f) Increasing public awareness of the need for genomics research and of the uses and implications of the results of such research, thereby helping Canadians understand the relative risks and rewards of genomics.

---

[2] *There were 16 such projects at the time the report was written, but this figure is fluid as GBC modifies its research portfolio.*

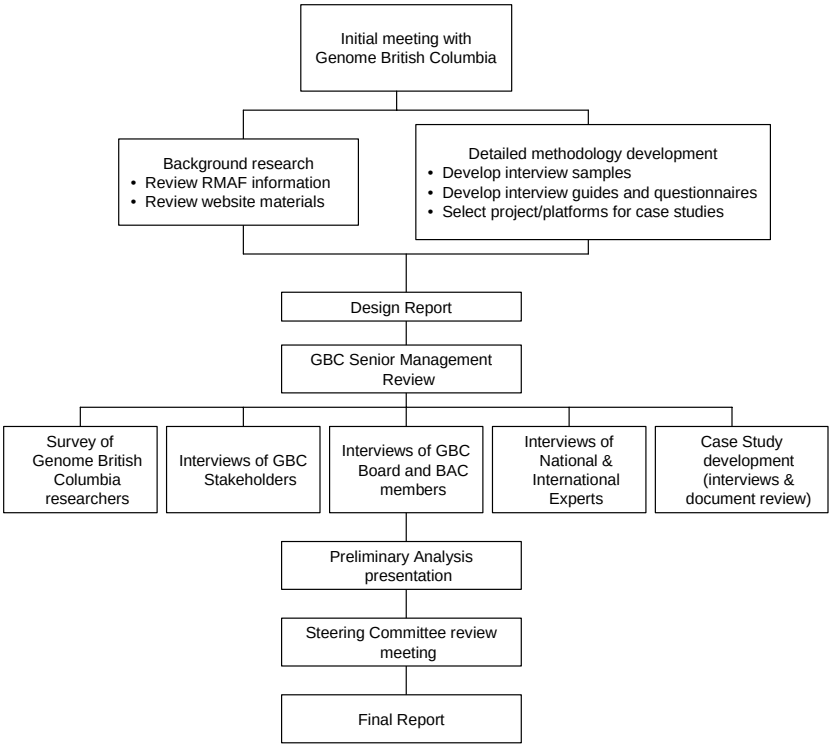
[3] *Section 2.0 ("Objectives of the Corporation"), Genome British Columbia General By-Laws*

[4] *Ibid*

3.0 STUDY ACTIVITIES AND METHODOLOGY

The work plan for this study is illustrated in Figure 3.1. The top five activities are largely self-explanatory. There were four major groups of methods: (1) document and data review; (2) key informant interviews; (3) case studies; and (4) a web survey. The study was designed based on examination of multiple lines of evidence that would support each issue. The purpose of this was to ensure that any significant findings presented in this study are corroborated by a number of different data sources, thereby increasing confidence in the validity of the findings.

Figure 3.1: Work Plan for the Evaluation of Genome British Columbia



3.1 Review of RMAF Information

Genome British Columbia collects data for a results-based management and accountability framework (RMAF[5]) developed by Genome Canada and in line with current Treasury Board policies. The main part of this RMAF is a plan for on-going performance measurement. These data were reviewed at the beginning of the study in order to fully understand Genome British Columbia and its activities in relation

[5] *RMAFs are on-going performance measurement systems and metrics tied to an evaluation plan.*

to the evaluation issues. Certain RMAF data have been incorporated throughout this report as part of the analysis.

3.2 Survey of Genome British Columbia Researchers

This was a web-based survey of the researchers involved in GBC's large-scale projects and platforms. All evaluation issues were addressed to greater or lesser degree. The initial sample for this survey consisted of 55 senior investigators and was compiled by Genome British Columbia. The survey process was as follows:

- The researchers were contacted by e-mail by GBC's senior management encouraging them to participate.
- One e-mail reminder was sent to the entire sample prior to the survey closing.

The responses received were as follows:

	Respondents (% response)
Project Leaders	10 (48%)
Platform Directors	3 (14%)
Principal Investigator	5 (24%)
Other	3 (14%)
Total	21 (38%)

The survey questionnaire is contained in Appendix A.

3.3 Interviews of GBC Stakeholders

Representatives of GBC stakeholder organizations were interviewed by telephone or in-person. These organizations included the government of BC, the BC Cancer Agency, the Michael Smith Foundation, The University of BC, Simon Fraser University, the Vancouver Coastal Health Authority, the University of Victoria, Western Economic Diversification, and Genome Canada. These interviews primarily addressed the suitability and effectiveness of formal and informal arrangements that had been made with their institutions (e.g., regarding use of infrastructure, intellectual property), socio-economic implications, and appropriateness of GBC's overall strategy. Eleven representatives of these organizations were formally interviewed. Two additional respondents were interviewed more informally. A copy of the interview guide is contained in Appendix A.

3.4 Interviews of GBC Board and BAC members

Nine of the 11 external[6] Board members were interviewed. These interviews were conducted both by telephone and in person and dealt with all evaluation issues. There were eight Business Advisory Committee (BAC) members identified for the sample and seven interviews were completed. This respondent group also addressed all evaluation issues. The interview guide for the Board/BAC members is contained in Appendix A.

3.5 Interviews of National/International Experts

This sample was developed in consultation with Genome British Columbia and contained 14 potential interviewees. This respondent group was interviewed by telephone and in-person. Opinions from this group were primarily sought to gain a perspective from the national/international genomics community. Four experts inside Canada were interviewed.

Some of the individuals outside Canada identified a potential conflict of interest situation as they are/have been involved with Genome Canada scientific review panels (which review GBC applications). The study team communicated Genome Canada's opinion that these individuals would not be in conflict from Genome Canada's perspective and again sought their participation. These attempts proved to be unsuccessful and only one international expert could be contacted. The interview guide is contained in Appendix A.

3.6 Case Studies

Four case studies were selected from a potential sample of six provided by Genome British Columbia. These four cases represented two projects, one sub-component of a program and one platform. The case studies were mainly used to contribute to the understanding of the issue relating to potential socio-economic benefits. Each case study included a short review of project documentation and interviews with four to five respondents. The target sample for the case studies was 25 respondents, of whom 22 were available to complete the interview. The interview guide is contained in Appendix A. The case study reports can be found in Appendix B.

[6] *That is, not inclusive of representatives from GBC.*

4.0 FINDINGS BY EVALUATION ISSUE

4.1 Issue 1—Has Genome BC developed a coordinated and integrated strategy for BC's genomics research?

4.1.1 Summary of Findings

- Overall, GBC is seen as a very valuable addition to BC's life sciences cluster, and there is a palpable sense of excitement within the research community as to BC's capability and the long-term potential of genomics.
- Genome British Columbia has been successful in developing a relevant and comprehensive strategy for BC genomics research that is supported by Genome Canada.
- One of Genome British Columbia's most notable successes is in being instrumental in establishing a more coordinated and integrated genomics network across multiple stakeholder organizations in the province.
- Genome British Columbia has had a substantial impact on BC researchers being increasingly viewed as world leaders in the genomics research community, and several initiatives (e.g., physical mapping and expression mapping, fisheries, forestry) and individuals were commonly-cited as being at this level. The amount of funding, the quality of platforms, and the strong leadership of project and platform leaders and of GBC management were cited as key contributing factors.
- Genome British Columbia needs to further define and refine its role regarding how it adds value to the BC genomics research community (especially at the individual researcher level), and clearly communicate this to partners and stakeholders. It may wish to increased the direct involvement of researchers in strategy development.
- If possible, GBC should streamline administrative and reporting requirements.
- There is opportunity for GBC to collaborate with other major stakeholders to help develop a unified joint strategy. This would allow the genomics community to "speak with one voice" to the BC and federal governments, Genome Canada, and the public. It would also help it deal more effectively with the needs of non-GBC researchers.

4.1.2 Discussion of Achievements

Strategy development. Most of the findings are very positive on the creation of genomics strategy. Genome British Columbia has been able to develop an appropriate, relevant, comprehensive strategy for genomics research in the province. The strategy drives the focus of its activities and has been successful in moving the organization forward to achieve its goals. Stakeholders and the established advisory Boards contribute significant expertise to help shape the direction of the strategy. The Board of Directors is seen as containing influential community leaders with both technical and business expertise, and the Board and GBC senior management have been able to obtain good cooperation from major stakeholders,

promoting buy-in, relevance and credibility to the organization. Many interviewees noted that the strength of GBC's senior executives and their ability to define the right vision for genomics in the province has been instrumental in developing strong networks and an integrated genomics community, in turn helping accelerate BC's success in this research field. GBC's role in obtaining support from, and visibility with, the provincial government was seen as another key strength.

Collaboration with stakeholders. Stakeholders, researchers, and Board members noted a high level of collaboration as a major strength of Genome British Columbia. There has been significant progress in creating linkages with other Canadian and international organizations. For example, Genome BC hosted a forum for the scientific community of British Columbia that invited the audience to provide feedback on the Centre. Feedback was positive and many expressed interest in future working group sessions hosted by GBC. A government relations strategy has also been developed that ensures the profile and potential benefits of genomics is communicated to all levels of government. As a result of these efforts, GBC has become a major partner in the provincial life sciences strategy.

These linkages have been enhanced by the high level of collaboration encouraged by GBC among researchers within different institutions and organizations. The right skills and expertise are seen to be starting to come together. These skills are increasingly multidisciplinary: it was mentioned by many stakeholders, as well as by several members of the Board of Directors and GBC researchers, that the GBC projects have considerably expanded the genomics research community in the province, having brought together researchers and experts from many disciplines, including statistics, computer science, biology, economics, law and ethics. There is a genuine sense of excitement in the community about how BC's genomics research is progressing and the emergent successes arising.

> *There's world-class science in BC and Canada. GBC can nurture it as one of the vehicles . . . helping bring parties together around BC's competitive advantage.*
>
> *- Major stakeholder*

Many respondents noted that GBC has been able to build on the existing foundation of the strong base of genomics research and infrastructure that already existed in the province, such as the BC Cancer Agency (BCCA), the BC Cancer Research Centre (BCCRC), the Michael Smith Foundation (MSF), the University of BC (UBC), Simon Fraser University (SFU), University of Victoria (UVic), the Centre for Molecular Medicine and Therapeutics (CMMT), Vancouver General Hospital (VGH), St. Paul's Hospital, etc.. In leveraging these strengths, GBC can enlarge and accelerate select areas of genomics research. GBC has additionally been instrumental in leading and shaping genomics research areas where there was little or no genomics activity in the province prior to the establishment of GBC (e.g., in natural resources).

Strength of the BC genomics research community. International and national experts noted that GBC has been instrumental in helping establish interactions and collaborations that have allowed BC research in select genomics areas to obtain the depth and breadth required for world-class research. The creation of the Genome Sciences Centre (GSC) at BCCRC was cited as a good example of a world-class research centre that that would not exist without GBC as an "anchor franchise". Even though somewhat small compared to some international centres, these are highly-regarded and represent excellent mechanisms to forge a world-class reputation[7]. The "altruistic" scientific and management leadership of several of the key project and platform leaders was cited as crucial to the success of the research, just as the forward-

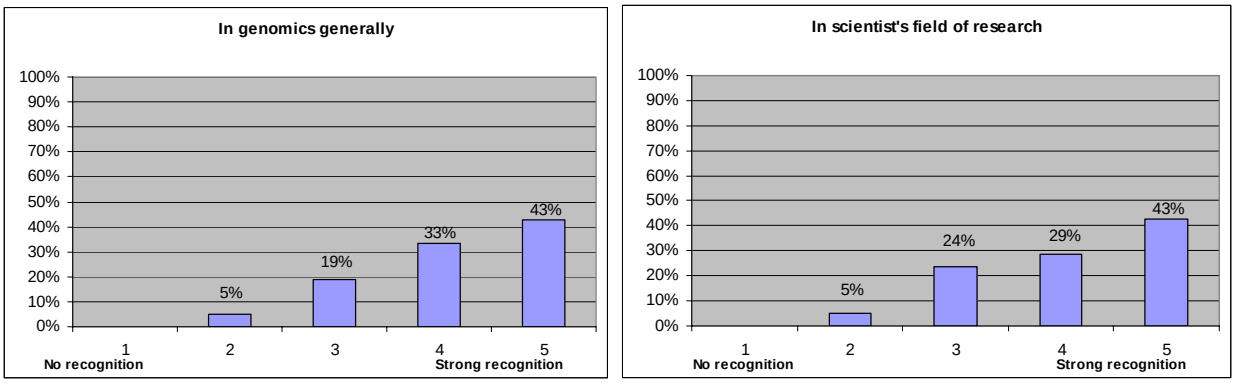
[7] *One respondent referred to these as "small 'c' centres".*

looking approach being taken by GBC senior management is seen as critical to being able to eventually exploit the research findings. The province is now seen by many knowledgeable respondents as leading in several selected genomics areas. For example, the Forestry and Fisheries areas were noted numerous times to be at the "cutting edge", with researchers recognized as international leaders in these fields, the GSC being first to sequence the SARS virus was a major coup, and the GE^{3}LS work is seen as highly-visible.

> *"[BC is] now a world leader . . .not just a follower".*
>
> *- Expert*

The web survey results demonstrate strong recognition of British Columbia researchers by the international genomics community. Figure 4.1.1 shows that 43% of respondents felt that BC researchers were seen as world leaders both in the researcher's specific field of activity and in genomics research in general[8].

Figure 4.1.1—Degree to which British Columbia researchers are seen as world leaders—% of survey respondents

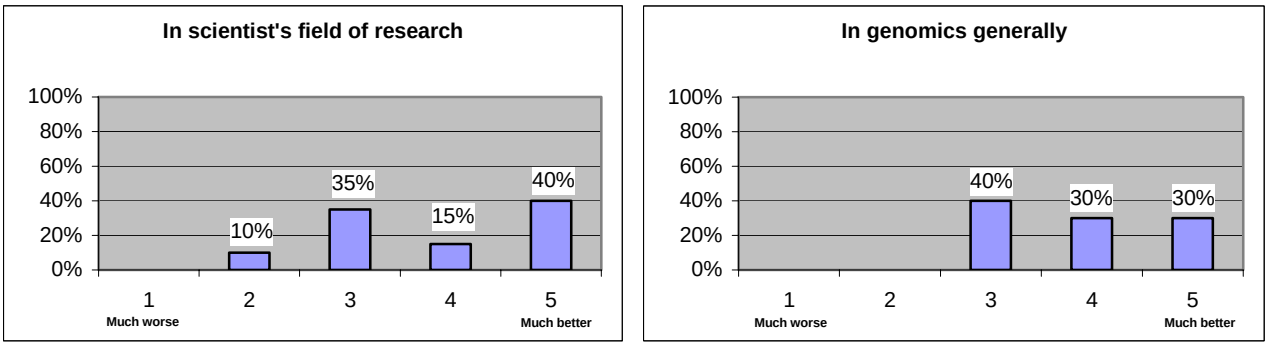


In addition, 95% of web survey respondents noted that there has been an improvement in how BC researchers are regarded over the last three years. Figure 4.1.2 shows that GBC is seen, on average, as having had a strong impact on this change in perception (the average ratings in both areas was 3.9 on a 1 – 5 scale).

---

8 This may seem like a self-serving result, but for several reasons the study team is confident that it reflects reality:; (1) Very similar comments were made across the board by our respondents; (2) Researchers are inherently conservative, value honesty highly, and are entirely willing to be quite critical of shortcomings; and (3) In numerous other BearingPoint S&T studies in which extensive independent reviews of research quality were conducted (e.g., bibliometrics, international peer review), the results always confirmed the researchers' self-ratings.

Figure 4.1.2—Impact of GBC on BC researchers being seen as world leaders—% of survey respondents



The high levels of funding and the high quality of the research platforms have been instrumental in these achievements. Stakeholder organizations have also benefited from better ability to attract top-quality researchers to BC from other regions. Many respondents noted that the appointment of a Chief Scientific Officer has greatly enhanced communications between researchers and GBC and has fostered increased respect and credibility of GBC both nationally and internationally.

International collaborations. A majority of respondents, including researchers, Board members and stakeholders, noted that GBC's focus on international collaboration and relationships is one of the major strengths of the strategy. International collaborations with world experts/leaders were seen as vital for research to be considered as being at the highest level. GBC actively pursues international connections and assists researchers identify appropriate international partners. (See also section 4.4.)

Value-added to researchers. GBC undertakes proactive efforts to position researchers to secure Genome Canada funding, as well as often (but not always) assisting researchers to raise the co-funding required. Many respondents commented that BC researchers have been very successful in obtaining Genome Canada funding on a per capita basis (about 20% of funding, with 13% of the population). GBC undertakes great efforts to ensure alignment with Genome Canada expectations; this support was viewed as beneficial by some, but not by all.

4.1.3 Discussion of Challenges

In the context of these successes, there are some challenges for GBC. Many can be seen as "teething" problems, and partially reflect that Genome Canada and the Genome Centres represent new models for supporting Canadian research (and international research, for that matter). Thus many strategic, structural, and operational details remain to be optimized. These issues do not detract from GBC's successes, but need to be addressed (in some cases by Genome Canada as well) if the Centre is to maximize its effectiveness.

Role of GBC in the research process. Some respondents view GBC as having little or no added value in the research process, including at the application stage. These individuals see GBC as more of a "middle man" between researchers (and their organizations) and Genome Canada, simply adding unnecessary administrative burdens and redundancies. Many complaints (especially at the researcher level) focused on "heavy bureaucratic and administrative requirements" and "too much oversight and reporting requirements."

The study team notes that there are really two issues here. First, complaints about reporting, red tape, and bureaucracy are common to all "managed" research programs (i.e., as opposed to those that support essentially free, investigator-driven work). In the case of GBC, many scientists are now responsible for multi-million dollar programs or platforms, where under previous granting council support they managed projects worth a small fraction of this. There are clear signs that a few organizations underestimated the amount and quality of management required for large-scale, collaborative research, or equally for managing large-scale platforms (especially on a quasi-business basis), and their associated administrative and financial affairs. Further, Genome Canada funding derives from Industry Canada (IC), which has its own agenda as to the ultimate socio-economic impacts expected of the work. This poses concomitant requirements for assuring IC that these goals will be met. Thus there is an unavoidable amount of extra administration and reporting required. Having said this, it is easy to "go overboard" on this score, and Genome Canada and GBC should carefully review the administrative and reporting requirements to pose the least possible burden on researchers and their institutions.

The second issue is more substantive, and is the most pointed of the challenges to GBC identified in this study—to what degree does GBC's "corporate headquarters" add value to the research process[9]? Here there was often a clear distinction between the views of senior officials of partner organizations versus those responsible for conducting the research. The former focused on GBC's valuable activities in terms of BC's overall genomics effort, while the latter were often critical of the Centre's role, seeing considerable bureaucracy and "micromanagement' (though many respondents recognized that some of this flowed directly from Genome Canada) but little value added to preparing applications to Genome Canada, finding co-funding, conducting and managing the research, or helping with administrative and financial matters. Overall, there was a feeling from these individuals that GBC's approach was too much on the "What have you done for me lately?" side, and too little on the "What can I do for you today?" side.

While this can be seen as a teething problem for a new organization, it is potentially dangerous if allowed to continue and it suggests that GBC has not yet optimised its strategy for helping at the level of BC strategy, or at the individual project and platform level. More than one respondent suggested that having "on site" project managers was preferable to having them at "corporate headquarters", and this is one option that should be investigated.

Independent entity, or arm of Genome Canada? This issue is also related to GBC's strategic role. In sum, does GBC act as:

- Genome Canada's delegate in BC, serving Genome Canada goals (more or less exclusively); versus:
- An independent entity, which (mainly) serves BC's goals, and represents BC's genomics community to Genome Canada, other federal bodies, and the province.

The balance between these different aims will be reflected in how GBC adds value to the research process, and should be explicitly considered within that framework.

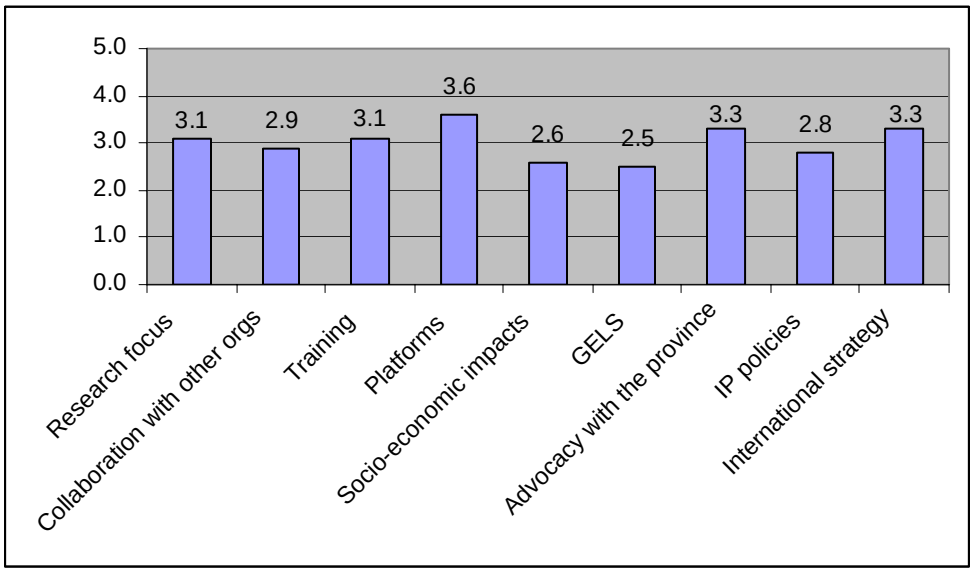
Relevance of strategy to researchers. When asked how well the various elements of GBC's strategy responded to researchers needs and priorities, the web survey findings revealed a few areas for possible

---

[9] *And to the commercialization and exploitation process, a very similar issue which is discussed in section 4.3.*

improvement, as seen in Figure 4.1.3. On a scale of one to five (where one equalled "not at all responsive" and five equalled "very responsive") the only area that was rated more than moderately responsive, on average, was the platform element. All other elements were rated, on average, as moderately responsive or less by researchers. Some of these rating are perhaps understated because many of the respondents could not comment or provide a rating. This is a finding in itself, suggesting that the strategy is not well known by, or communicated to, researchers.

Figure 4.1.3—Responsiveness of GBC strategy to researcher needs—avg. survey ratings on 1 – 5 scale



One comment from a web survey respondent and two experts was that increased direct participation of researchers in the development of strategy would be welcomed. GBC already attempts to take advantage of scientific strengths to define long term goals for the province in genomics, both industrially and socially, and direct scientist involvement was seen as a valuable addition to this push.

4.2 Issue 2—Has Genome BC participated in national genomics strategies?

4.2.1 Summary of Findings

- GBC is seen as one of the more active regional centres working with Genome Canada and contributing to the national genomics effort and network.
- However, there is no true integrated national genomics strategy at present, either within Genome Canada or outside it.
- As one of the "bookend" successes within Genome Canada, GBC could take on a greater role with respect to helping foster a national genomics strategy.

4.2.2 Discussion of Achievements

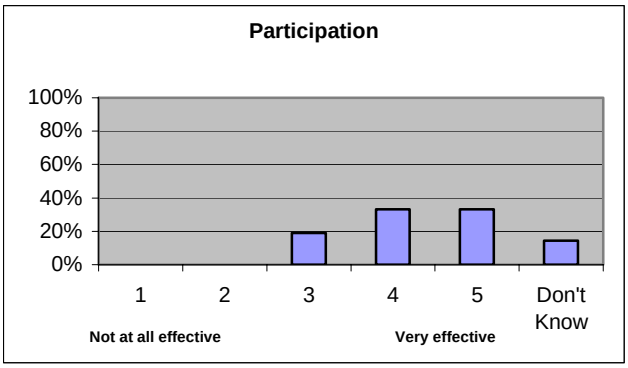
Participation and effectiveness. One of the key goals of GBC is to develop national networks and links for Genome BC to be able to participate in and contribute to national strategies and direction for the genomics field. They are viewed by respondents as one of the stronger regional centres by international/national experts, Board members and researchers, all of who see GBC working closely with Genome Canada to foster a national approach.

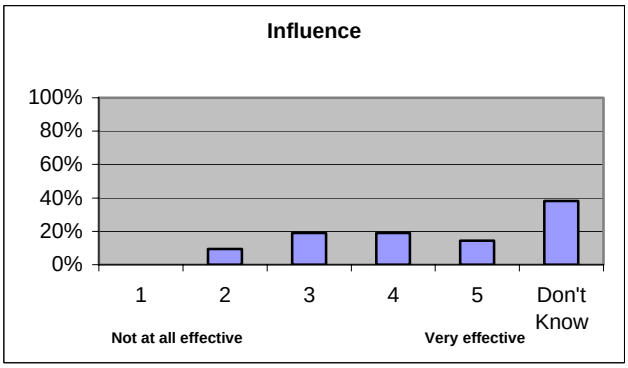
> *GBC is one of the bookends in the national strategy, along with Genome Québec.*
>
> *- Major stakeholder*

GBC participates in building their profile by partaking in numerous meetings and conferences that showcase BC's genomics attributes. For example, it participated in Genome Canada's First National Science Meeting in Montreal and BIO2002 in Toronto. The Centre also sponsors genomics related events and speakers, such as the Gairdner Awards in 2002 and a BIO2002 speaker for seminars and discussions relating to Vancouver's Life Sciences Cluster development. It uses these opportunities to facilitate peer interaction and promote genomics to stakeholder and potential investors and collaborators. The collaboration and communications undertaken by GBC at the executive level with the other regional Centres was also felt to be comprehensive, although increased interactions among researchers in different Centres was noted as an area where GBC could facilitate activity.

The web survey results shown in Figure 4.2.1 indicate that the great bulk of researchers believe that GBC has been effective or very effective in their participation in national genomics activities, but their influence in development of national genomics strategies was less recognizable. The majority of respondents (38%) could not actually answer the latter question (probably more due to lack of a national strategy than being a comment on GBC's role)

Figure 4.2.1—GBC participation in, and influence on, national genomics strategies—% of survey respondents





4.2.3 Discussion of Challenges

Lack of true national strategy. Respondents noted that there was not enough structured activity surrounding a national genomics strategy whereby issues and research in general could be discussed. Just as section 4.1.3 notes there are opportunities for GBC to take on a more independent identity in presenting BC issues to Genome Canada, and in fostering collaborative development of an integrated BC genomics strategy, there appears to equally be an opportunity for GBC—as one of the most successful Centres—to help foster a national genomics strategy.

> *There isn't really a national genomics approach; instead there's a lot of people working for themselves. This is an historical approach.*
>
> *- Board member*

> *There are two solitudes: Health Canada and Industry Canada don't have the same goals, and probably don't talk to each other. I'm not sure if they're collaborative in any way.*
>
> *-Major stakeholder*

4.3 Issue 3—Does the Genome BC Centre have the potential to generate significant socio-economic (S-E) benefits for BC and for Canada?

4.3.1 Summary of Findings

- Projects and platforms supported by GBC have the potential for eventually creating tremendous S-E benefits within many different sectors, and GBC has a strong role in this effort. Most of the factors required to identify and exploit useful innovations are in place or in active development.
- The program has already realized some short-term, quantifiable social and economic benefits, and it is relatively easy to see how some of these impacts may eventually prove very important indeed. Sequencing of the SARS virus is a notable achievement and example.
- There have been few specific industrial benefits derived as yet, although it is far too early to expect much.
- GBC has greatly improved the research infrastructure in both the platforms and in other laboratories—the infrastructure is now comparable to that in other world class programs, and is a good base from which to attempt to create S-E impacts.
- GBC has contributed to the significantly increased amount and quality of training in genomics, in turn improving the chances that highly qualified personnel (HQP) will remain in British Columbia.
- Further definition and refinement of GBC's role in adding value to commercialization activities and other forms of practical exploitation is required. The opportunity exists to clarify how GBC fits into what is currently being done by existing organizations and what mechanisms would provide the most benefit. More outreach to potential user organizations is one example.
- GBC (and other stakeholders) must ensure realistic S-E expectations are held by funding agencies (e.g., IC, Treasury Board, Finance). Within this, clarification of the exact nature of what S-E benefits are being targeted needs to be conveyed to all stakeholders, and suitable metrics established to measure them. Long-term sustainability of funding is a must if such benefits are to be achieved.
- The scale of effort in many areas (e.g., human health) is still very small compared to some international efforts, and GBC must continue to carefully target niches where it has competitive advantages. The effort in the resources sectors (e.g., fisheries, forestry) should not be neglected in this search for appropriate targets.
- GBC should not neglect identifying, supporting, and fostering S-E impacts that arise through "indirect" means.

4.3.2 Discussion of Achievements

"Practical" achievements to date. There are high expectations on the part of Genome Canada and the federal government regarding the attainment of socio-economic and industrial benefits from GBC (and other Genome Centre) projects. However, GBC projects have been operational for a maximum of three

years. It is, as all interviewees have stated, far too early to expect to garner all of the possible benefits and impacts that are anticipated from these projects. Any significant socio-economic and industrial benefits will be derived over a much longer term. (See also section 4.3.3.) Nonetheless, in the same token all interviewees answered "yes" when asked if GBC projects and platforms had the potential to achieve significant socio-economic impacts. Genome British Columbia has been able to build on existing scientific and institutional strengths, creating a combined investment that is demonstrating real potential.

The case study findings (see Appendix B) showed that GBC projects and platforms are likely to wield considerable influence on future research into a number of disciplines that will ultimately benefit Canadian society (and the world) in numerous quantifiable and qualitative ways. These impacts will occur in various sectors, including environmental, industrial, fisheries, forestry, agriculture and health. It was widely recognized by all respondents that the research would be useful to Canadian and international partners and stakeholders of these projects/platforms. There is already significant Canadian and international interest in the GBC projects and the findings that they are generating. Figure 4.3.1 summarizes data from the case studies.

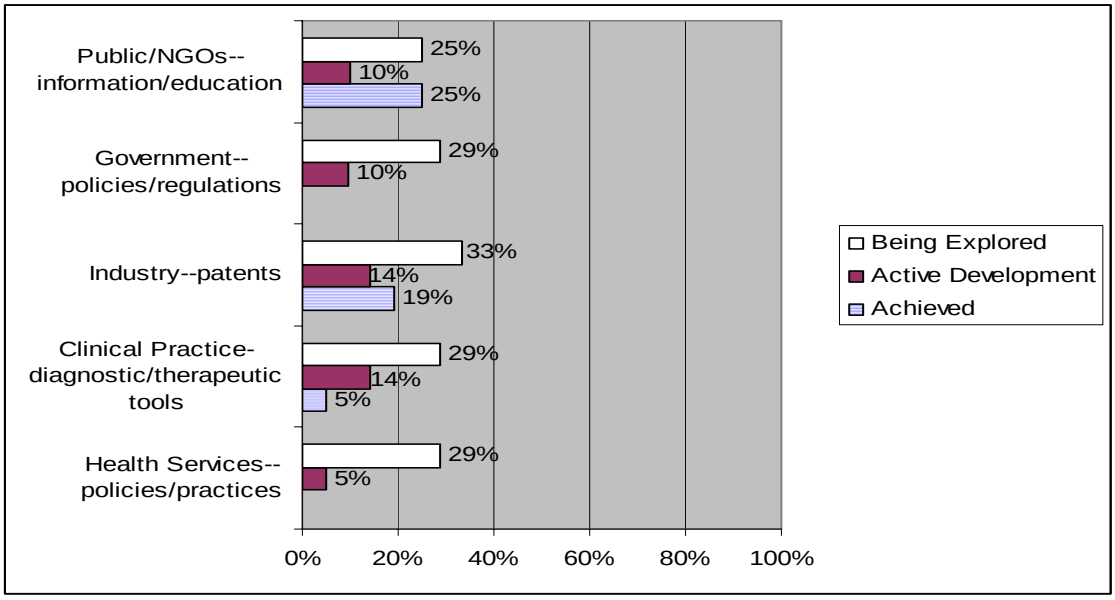
Figure 4.3.1—Nature of "practical" socio-economic benefits—Case study data	
Cancer Genomics	The goal is to contribute to "personalized" medicine, made possible by the ability to identify genomic changes in human tissues affected by diseases such as various cancers, using comparative genomic hybridization (CGH) techniques. CGH technology is specifically relevant to the analysis of solid early stage lesions and tumours, and may support the possibility to diagnose these cancers (and possibly other diseases) very early, and know exactly what type of cancers they are and what stage they're at. It may also be used as a therapeutic and prognostic tool, with the potential to provide better ideas of which individual people will benefit from which individual treatments, all changing according to what stage the cancer is at. In some cases, individual genes might be targets for therapeutic methods. The Cancer Agency is in discussions with several companies regarding non-exclusive licensing of this patented technology. BCCA is selling the technology now to other researchers on a cost recovery basis for non-commercial use. The earliest timeframe for realizing some of these benefits would be 5 years in diagnostic areas and 10-15 years for therapeutics and new medical products.
Fungal genomics	The increase in reported cases of a sometimes fatal lung and central nervous system fungal infection in Vancouver Island provided part of the incentive for this project. The goal is to identify the mechanisms by which Cryptococcus causes disease in humans. In collaboration with the GSC, the project has recently released the draft genome sequence of Cryptococcus neoformans variety gattii. The research is aimed at eventually having better and faster ways to diagnose fungal infections, and developing new antifungal drugs and vaccines to treat these infections. A key milestone is the completion of the gattii genome sequence. Once this is in hand, the comparative studies against the other strains can begin. Significant additional research beyond the scope of this project will be needed to be undertaken before realizing benefits. It is estimated that this research would take 5-10 years before any commercial benefit would be realized.

Figure 4.3.1—Nature of "practical" socio-economic benefits—Case study data	
Microbial envirogenomics	The program aims to exploit the physiology and functioning of environmentally important bacteria through genomic approaches. This program sought to apply high-throughput methodologies to further understanding of Rhodococcus sp. RHA1, including sequencing the bacterium, as it had been identified as having interesting bio-pathways and enzymatic activity. Through better genomic knowledge of RHA1 it is hoped that the potential for environmental, industrial and public good applications could be tapped. A number of industrial and commercial applications have been identified; e.g., it is believed that this organism could be important in environmental cleanup, bioremediation, and pharmaceutical applications (e.g., new enzymes may enable faster, more economical chemical processes, including development of new antibiotics and medications) The RHA1 organism has been completely sequenced and some novel enzymes and bio-pathways have been identified. Work is ongoing to identify other areas for potential application.
Sequencing and mapping platform	Genome BC built on the expertise and infrastructure at the Genome Sciences Centre to create critical genomics sequencing and mapping resources. The goal of the Sequencing and Mapping Platform is to provide the infrastructure, support, and expertise for GBC projects. The sequencing and mapping platform is not just a service provided to the projects, it is truly collaborative. The platform provides advice and recommendations and shares information across projects for added value. It has supported work for, e.g.: ➢ Envirogenomics—sequencing the genome of Rhodococcus RHA1 (see above) ➢ Fisheries & forestry— including genomics related to disease resistance ➢ Cancer genomics—comparing tumour cells to normal cells in order to determine how genomes are expressed differently in disease cells ➢ Fungal pathogenomics—sequencing the genome of a Cryptococcus strain ➢ Although not a Genome BC-initiated project *per se*, the Genome Sciences Centre platform was the first to sequence the SARS virus. The time scale to a clinical application or any commercial application is likely 10-15 years; however all of the projects that have been supported do have commercial applications.

Web survey respondents were asked to identify and categorize the "practical" applications resulting from their projects. As can be seen in Figure 4.3.2, researchers noted a fair amount of activity even at this early stage[10].

[10] *For comparison, exactly the same question was asked of health researchers during a recent review of the Operating Grants Program (OGP) of the Canadian Institutes of Health Research (CIHR). The equivalent percentages of CIHR researchers answering "achieved" or "in active development" were: Public and NGOs: 27%; Government: 11%; Industry: 32%; Clinical practice: 33%; Health services: 15%. As the OGP is a longstanding program (essentially dating back to the early days of Medical Research Council programming), while GBC is very new, these results are very positive. Reference:* Bearing Point Formative Evaluation Study of the [CIHR] Operating Grants Program Final Report: Survey and Interview Findings. *BearingPoint. March 30, 2004.*

Figure 4.3.2—Nature of "practical" socio-economic benefits—% of survey respondents



The review of RMAF material also demonstrates that GBC has supported projects and platforms that have had some early success in the achievement of S-E benefits. Some key indicators of benefits achieved as of October 2003[11] include:

Innovations brought to market	2
New or improved products, services and processes	25
Invention declarations on File	6
Number of Patent Applications	4
Number of Patents Issued	2
Jobs created	184
Researchers trained	202
Highly Qualified Personnel	180

There are a few specific examples where research findings are already expected to have impacts both socially and economically. For example, GBC-supported research results are anticipated to be included in international therapeutic management guidelines for hereditary gastric cancer, and one of the case studies has identified a microarray technology that is expected to help deliver "personalized medicine" to patients suffering a variety of cancers (and that is currently being sold on a cost recovery basis). Again, please see Appendix B.

[11] *This data can be found in the GBC RMAF binder under Table Output 7 (d).*

Managing for S-E benefits. Genome BC realizes that commercialization goals are realistically long-term due to the nature of the science and associated product market, and has tried to develop an approach to maximize the potential S-E benefits as opportunities arise; e.g., by addressing these issues in applications to Genome Canada, by identifying opportunities through the Business Advisory Committees (BACs), and by including individuals on the GBC Board's commercialisation sub-committee who have extensive experience in early-stage development. The latter committee intends to identify potentially interesting IP, commercial opportunities, and commercialisation strategies to bridge the gap from universities to venture capitalists. This committee is also mandated to assist GBC in securing external funding for the purpose of technology commercialization. A business development team has also been established that works with the BACs to align project activities and provide feedback relating to industrial activities. In other words, GBC is taking a highly-active approach to commercialization.

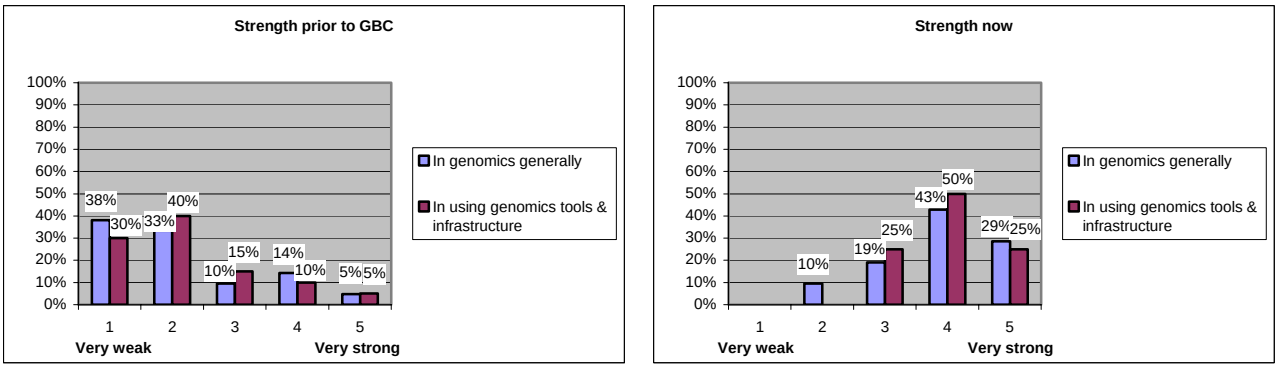
The approach has evolved to focus on industrial relevance more broadly (i.e., not just direct technology transfer but also how to enhance industry's ability to move ahead in world markets) The study team notes that highly-important socio-economic impacts of R&D commonly arise through "indirect" means such as improvements to the competencies of individuals and organizations involved in the research; through knowledge transfer of novel approaches, methodologies, and uses of infrastructure; through application of research results and approaches to entirely different disciplines and applications; through improvements to the innovation system overall; etc. These indirect mechanisms are particularly important when non-commercial impacts such as changes to government policies or health care procedures, or improvements to diagnostics, prognostics, or therapeutics are involved. Thus we encourage GBC in continuing to identify and foster these more indirect impacts.

Training. One of the most immediate benefits noted by interviewees is the increased training of researchers in the province. GBC projects and platforms can demonstrate success in the area of increasing the amount and quality of training in genomics, both in general training and in using genomics tools and infrastructure. It was noted by interviewees that these scientists would have otherwise been trained elsewhere and there are significant benefits to training and keeping these resources in Canada. The genomics field is relatively young and the increased addition of new people, with new knowledge, ideas and technologies can only serve to enhance success. (Some of the increase was felt to be naturally inherent in the level of funding now being received.)

Web survey respondents were asked to rate the strength of genomics training (e.g., quality, amount) for scientists, students and technicians prior to GBC and now. Figure 4.3.3 shows a significant increase in the strength of training efforts. Prior to GBC, training was rated by approximately 70% of researchers to be weak to very weak, whereas 72%-75% of researchers believe that training is now strong to very strong[12].

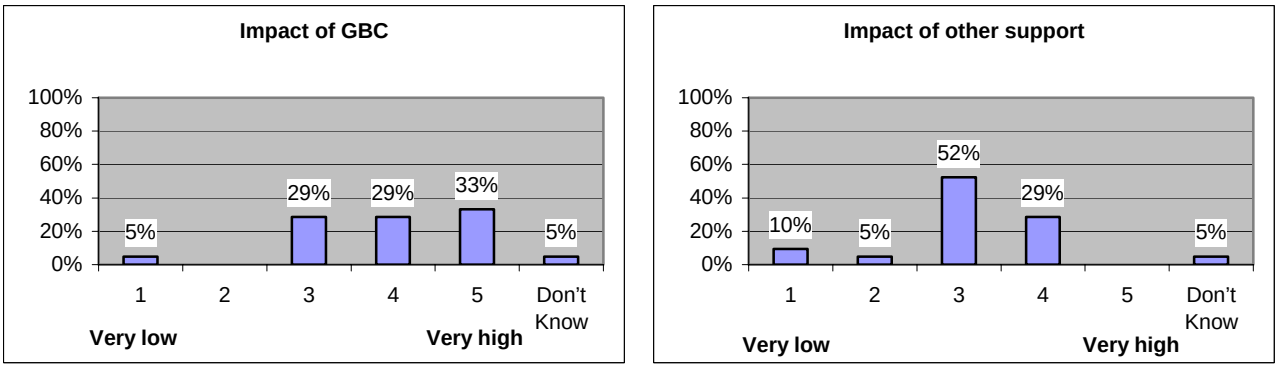
[12] *Interpreting a rating of 2 as "weak", 3 as "moderate", and 4 as "strong".*

Figure 4.3.3—Strength of genomics training—% of survey respondents



When researchers were asked to what extent this increase in strength of training was due to GBC as opposed to other sources of training support, 62% rated the impact of GBC at "high" or better. See Figure 4.3.4.

Figure 4.3.4—Impact of GBC versus other organizations on genomics training—% of survey respondents



These training and attraction/retention impacts are significant because the genomics research community in Canada was relatively small compared to other countries at the inception of the Centre, and one of the major aims of this initiative (implicit in several of the objectives) has been to build up Canada's genomics research capability.

Strength of the genomics research infrastructure. In some cases, the platforms existed (at least in part) prior to Genome British Columbia, and some contained world class elements. However, interviewees noted that GBC has helped to make them even stronger by building capacity and enabling growth. According to these interviewees and case study findings, the Genome British Columbia platforms are fulfilling an important need in genomics research, with the contributions of the platforms being seen as a key success factor in facilitating collaboration among researchers and providing significant contributions to advancing research. The platforms are viewed as now containing some of the best equipment in the world.

The existence and operation of infrastructure allows projects to be undertaken that, without the operating infrastructure, would be unthinkable

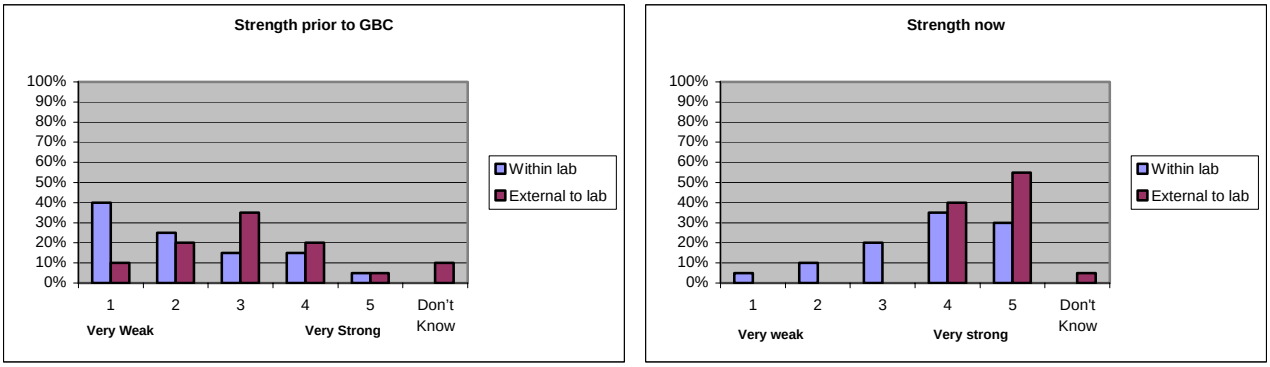
- GBC Board member

A concrete example is the SARs-CoV genome sequencing effort undertaken by the Michael Smith Genome Sciences Centre (GSC) that received world attention. This research provided immediate evidence of potential social and economic benefits. In response, an influx of funding was received from the province to support development of the SARS Accelerated Vaccine Initiative (SAVI). This specific example was cited by numerous interviewees and was clearly seen as an outstanding success—and even a surprising one, given the relative size of BC's genomics community compared to international efforts.

Supporting the interview findings are the results of the web survey. About 88% of respondents indicated that their research requires access to major research infrastructure such as sequencing and mapping instrumentation, mass spectrometry technologies, and informatics services. In addition, 73% of respondents identified a strong reliance on service required from GBC platforms in particular.

Researchers thought that the overall strength of the genomics research infrastructure has increased dramatically compared to three years ago, both in the GBC platforms and more generally, as shown in Figure 4.3.5. The average ratings prior to GBC were "weak" for infrastructure within the researchers' labs and departments and "moderate" externally; whereas average ratings now were "strong" in the labs and between "strong" and "very strong" externally. Perhaps most significant is how few respondents rated the current infrastructure strength as less than "moderate". Given that research infrastructure is regarded world-wide as a crucial enabling factor for top-flight research, this is a key finding[13].

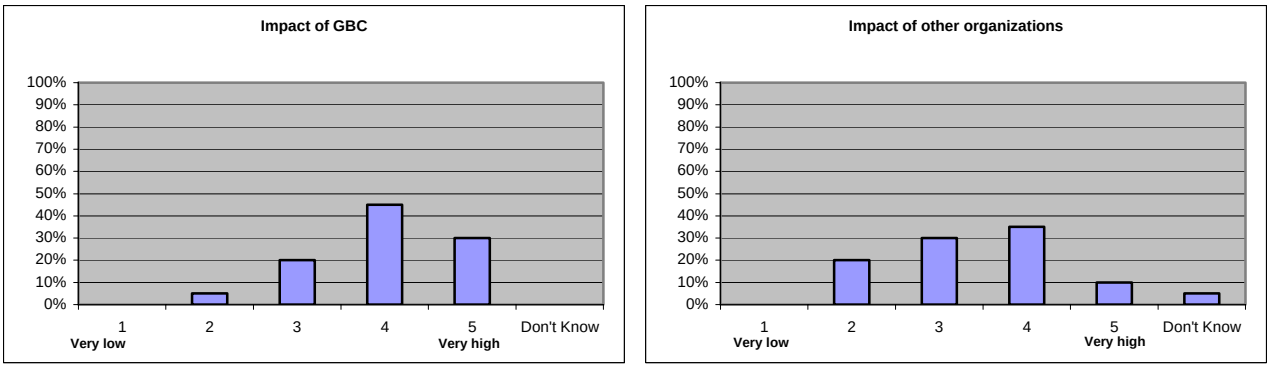
Figure 4.3.5—Overall strength of genomics research infrastructure—% of survey respondents



[13] *See, for example,* ***Equipping Science for the 21st Century,*** *John Irvine ed., Edward Elgar Publishing, Chettanham, UK, 1997.*

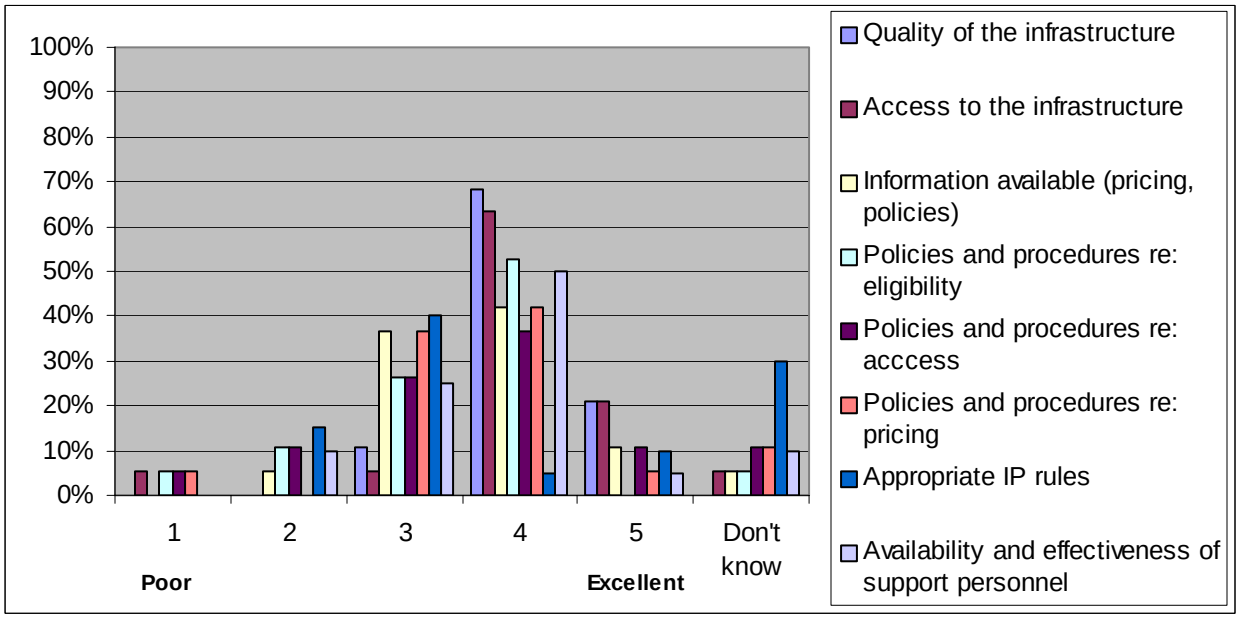
According to the survey data, this improvement is due in large part to the efforts of GBC, as seen in Figure 4.3.6, although the efforts of other organizations were also important.

Figure 4.3.6—Change in strength of infrastructure attributable to GBC



Platform policies and management. Overall, responses to the web survey were moderately positive regarding the GBC platform policies and guidelines. Figure 4.3.7 details several attributes of the platforms and their average ratings by respondents. The majority of respondents rated these attributes to be "moderate" or better, but there is clearly some room for improvement in many of these areas.

Figure 4.3.7—Platform attributes—% of survey respondents



By all accounts, most GBC platforms are now comparable to, if not exceeding, other world class programs. The major exception to this is the Proteomics platform; increased attention to, and investment in, this area was mentioned by many respondents.

4.3.3 Discussion of Challenges

The findings under this evaluation issue are for the most part very positive and GBC has made some significant impacts to foster the achievement of socio-economic benefits. There are significant challenges apparent, most of which are common to all S&T organizations, but some of which are Genome Canada- or GBC-specific.

Role of GBC in adding value to commercialization. The role that GBC intends to play in commercialization activities was noted to be unclear and not as effective as it could be. (This is the corollary to the issue of GBC's role in adding value to the research process discussed in section 4.1.3.) The main point of contention is what GBC's role (and that of the BACs, which to date are not seen as having been very effective) should be when dealing with organizations that have internal industry liaison and/or technology development mandates, functions, offices, and staff. GBC does not itself own the IP arising from GBC projects and platforms, nor does it necessarily have as much expertise to commercialize or otherwise exploit it as these other organizations (at least in their own estimation). Because both Genome Canada and GBC have undertaken to IC that they will create S-E benefits, this has naturally created some pressure to demonstrate that they are effectively managing to create such benefits. This has essentially "stepped on some toes" and has contributed to the perception of micromanagement. The issue is whether GBC mainly sees it role as being to:

- Catalyse, promote, and support BC genomics research (which is the GBC role by far preferred among stakeholder organizations); versus
- Attempting to direct, own, and manage the research and associated intellectual property (IP).

Part of the issue is "who gets credit" for the long-term results. Here the study team notes that, in situation where there are many R&D collaborators, many recent and rigorous economic assessments of impacts focus on the roles of all players, not just one organization alone; if the contributions of all organizations are understood (and usually all are crucial to creating the impacts) the issue of assigning credit is much less serious. Overall, there is considerable room for further definition and refinement of how GBC can add value to the commercialization process.

> *As a catalytic, collaborative organization, GBC has definitely provided benefits, and clearly some projects have proceeded that wouldn't have without it. Plus the GBC management has, in fact, to some degree driven higher performance—there's just too much of it.*
>
> *- Major stakeholder*

One possible example of a value-added role would be to increase the outreach of GBC to potential user sectors and organizations, many of which will be completely ignorant of the potential benefits of genomics. GBC's ability to educate and to foster collaboration could be invaluable here.

Nature of S-E benefits. There appears to be some misunderstanding among stakeholders and researchers about the nature of S-E benefits that GBC is intending to create. Potentially, this misunderstanding could extend upwards to Genome Canada and IC. The issue is that commercialization tends to be seen as the main (and to some observers, the only) route by which GBC intends to achieve these benefits. In fact, of course, genomics is likely to have many important non-commercial impacts such as improvements to diagnostic and therapeutic methods, quality of life, the environment, etc. Although some of these may

also involve commercial products and processes, many will not, and even where commercialization plays a role it may not provide the lion's share of the societal benefits. (Improvements to cancer treatments, for example, will almost certainly provide most benefits in terms of improved health, although there may also be concomitant sales of, say, diagnostic equipment or drugs.) Without diminishing the importance of creating commercial benefits where they are feasible, GBC needs to ensure its researchers and major stakeholders understand this important distinction, and work equally to achieve important non-commercial impacts[14]. This is an opportunity for where GBC can add value for Canada, because non-commercial impacts are unlikely to be addressed by, say, university industry liaison offices (UILOs). On this point, impacts in BC's resource sectors (e.g., fisheries, forestry, the environment) should not be neglected, as there are potentially large benefits (e.g., cost savings) to end-users that could flow from application of genomics, but that may not necessarily involve substantial revenues from the commercial sale of new products and processes.

Management of expectations. There are likely some unrealistic expectations surrounding the timeframe for practical impacts, especially in the human health areas. These researchers are looking at very long-term horizons before benefits manifest themselves. These expectations need to be clarified, controlled and managed with all stakeholders. Increased monitoring and communication of benefits and impacts expected (and achieved) may help, and GBC can play an important role working with researchers to deal with these issues. While GBC can assist in accelerating technology and knowledge transfer (and has a strong mandate to do just that), it is important for Genome Canada and IC to understand and accept the likely timeframes involved.

Sustainability. Within this long-term scenario, the short-term project funding arrangements (1-4 years) do not support the practical time horizons for genomics research to have impacts, especially for such an advanced area of science that is at an early stage of evolution. With no guarantee of continued funding, there is a risk of losing out on huge investments if projects are not supported in future years. So-called "stop and start" science significantly impedes progress towards achieving S-E benefits and also hinders the ability to sustain a role as a "world leader." This was a major concern of many interviewees, including researchers and stakeholders.

> *If there is no continuing federal funding, then the whole thing grinds to a halt.*
>
> *- Major stakeholder*

Research focus. In another related matter, the recent increased focus of Genome Canada on applied research was thought to perhaps come at the expense of shutting out some fundamental research. The nature of science is that the greatest discoveries tend to come serendipitously through curiosity-driven research[15]. Programs ideally require a portfolio of long-term, fundamental research projects, supplemented by shorter-term applied projects to fully maximize their impacts. A suggestion made several times was to consider engaging a larger number of smaller projects as opposed to a few very large

---

[14] Although IC is a major funder of Genome Canada and has a strong focus on industrial development and competitiveness, in practice IC also understands and values non-commercial benefits when evaluating program performance.

[15] There are many, many well-known examples of this. We will not bore the reader with them.

ones. Interviewees, particularly researchers, noted that there were many interested groups working in genomics areas that do not have the volume or capacity to delivery multi-million dollar projects but who were still doing very relevant work. Perhaps there are missed opportunities here. However, GBC is bound by the policies set by Genome Canada in terms of the type of applications that will be considered.

Barriers to exploitation. Although significant barriers were identified to achieving practical impacts, these do not appear much different from those plaguing virtually all other Canadian science and technology program—i.e., there does not appear to be anything "special" about genomics, at least compared to other health-related research. Barriers mentioned included finding sufficient research funding and subsequent development funding, the speed at which the research progresses, the need for substantive involvement of scientists in the technology and/or knowledge transfer process, and difficulties with the interest and receptor capability of the province and Canadian industry. One potential problem more pertinent to genomics is the potential conflict between IP protection and open publication (especially regarding open source bioinformatics software), although this does not appear to have caused concrete difficulties to date.

Co-funding. Although not a direct result of GBC's strategy, and for the most part outside GBC's control, are the difficulties relating to obtaining co-funding. This was a major bone of contention with researchers, but also noted by stakeholders and commented on by the international/national experts as well. The efforts required obtaining co-funding take substantial amounts of time and energy. Many respondents commented that GBC could usefully increase their efforts to support the researchers in pursuing and securing co-funds, rather than leaving so much of effort to be done at the project level.

4.4 Issue 4—Has Genome BC established appropriate contractual and /or collaborative relationships with relevant stakeholders?

4.4.1 Summary of Findings

- GBC has successfully negotiated funding and collaborative agreements with numerous investors and research partners.
- Although often difficult to initially negotiate, GBC's relationships and contracts appear generally strong and appropriate.
- GBC is viewed as a very collaborative organization, having undertaken proactive consultation with its major stakeholders both private and public, and having obtained strong support through international collaborations. These relationships have been helpful at the project level as well.
- There have been serious management problems in two of the platforms, and improvements are required for both scientific and business management in these platforms. This is jointly the responsibility of GBC and the partner organizations.

4.4.2 Discussion of Achievements

GBC has been able to establish formal relationships with numerous key stakeholders to date. Investors include Genome Canada, the province of British Columbia, the Michael Smith Foundation for Health Research, and Western Economic Diversification Canada. Research Partners include: UBC, BCCA, SFU, UVic, VGH, St. Paul's Hospital, and CMMT. GBC also collaborates with the other Genome Canada centres, including Genome Prairie, Genome Quebec and Genome Atlantic to undertake joint project delivery and bi-directionally share information.

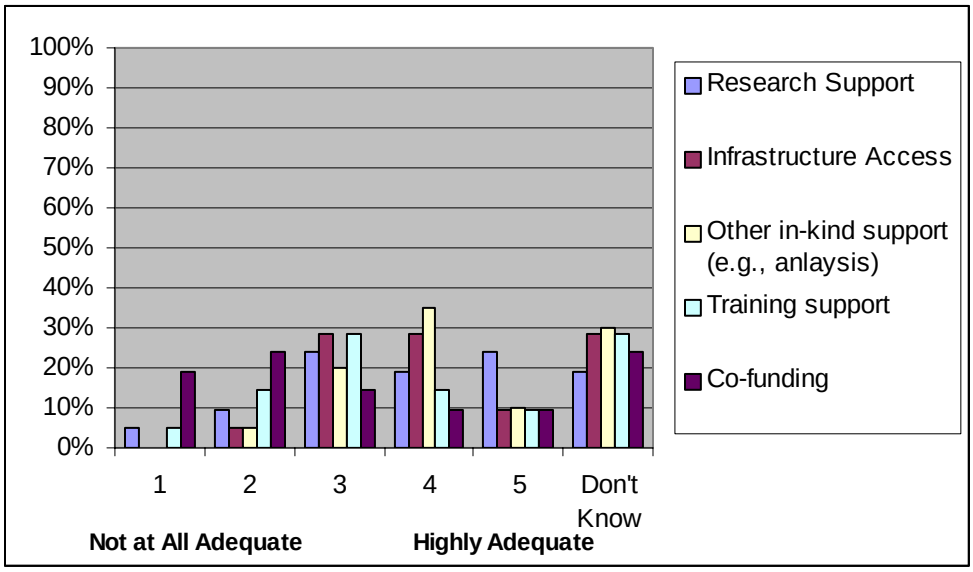
Appropriate formalized agreements (e.g., material transfer agreements, IP arrangements) have been addressed up front when the association is first established. Although negotiating these agreements with major BC stakeholders was in many cases a "Herculean" task, especially regarding IP and revenue sharing, the study team's experience with other programs with similarly-complex agreements (e.g., the Networks of Centres of Excellence) is that these other agreements were no less difficult to develop.

These agreements have varied according to the policies and needs of individual stakeholder organizations. For example, UBC maintains ownership of all IP arising from the projects, consistent with its normal practice, whereas MSF does not retain any IP whatsoever, again consistent with its internal policies. With respect to revenue sharing, this also varies from agreement to agreement; e.g., BCCA has agreed to share revenues from innovations with GBC, whereas with UBC this will likely depend on the degree to which GBC actively helps in the commercialization process.

Many other collaborative working relationships and formal MOUs have been established through the projects individually and include universities, industry, federal government departments, hospitals and international organizations. Examples include: Oklahoma Medical Research Facility, Kelowna General Hospital, Enchira Biotechnology Corp., Environment Canada, Department of Fisheries and Oceans, the Australian Genome Research Facility and Genoma Espana.

GBC is very well connected—it has been proactive in establishing the "right" connections with relevant organizations and is very well known in the provincial genomics community. This topic is also in section 4.1. Here we note that these relationships have been useful at the project level. Figure 4.4.1 shows that researchers obtained moderate to strong research support, infrastructure access, other in-kind benefits (e.g., analytic assistance), and training support from these collaborative relationships.

Figure 4.4.1—Adequacy of support from collaborators in GBC projects and platforms—% of survey respondents



4.4.3 Discussion of Challenges

Platform management. Two of the platforms (proteomics and microarrays) have suffered from management problems that were occasionally severe, although these problems were of different types (mainly accounting, rate structures, and cost recovery for the former[16]; and throughput, timing, perceived quality of services[17], and payment delays for the latter). These difficulties were considered to be partially attributable to GBC and partially to the sponsoring organizations. Active efforts have been made to rectify these problems (e.g., through creation of a joint task force).

A second potential problem is that ownership of the platforms reverts to the host institutions in 2005, or after three years, whichever comes first. At that point they are potentially not available for GBC use, not even the part bought with GC funding. If the platforms are to "stay ahead of the curve", they need significant renovation every three to five years. So to keep them state-of-the art, not only is new equipment needed, but new strategies for using them.

---

[16] *Particularly with respect to full accounting of costs for the partner institution.*

[17] *Although verification of results by an independent laboratory later confirmed the platform's analyses, and seems to have eliminated this issue.*

Overall, these problems point to the need for strong leadership on both the scientific and business sides, as the platforms are far from being scientific "business as usual".

Communications with stakeholders. Although most respondents commented that GBC did a good job of communicating with its major stakeholders, some individuals noted that its messages were occasionally unclear or inconsistent (although it was believed that this was partially due to Genome Canada "changing the rules" over time), or lacked transparency (e.g., as to how decisions were being made, or details of platform agreements).

4.5 Issue 5—Has Genome BC addressed public concerns re: GE3LS issues?

4.5.1 Summary of Findings

- Genome British Columbia has an explicit and thorough GE^{3}LS approach in place, and is pursuing leadership in the GE^{3}LS area.
- GBC could increase its involvement and support of projects and platforms regarding GE^{3}LS issues.
- The GE^{3}LS activities undertaken by Genome British Columbia appear to be comprehensive; however, there have been no studies or surveys carried out to assess their effectiveness at addressing public concerns (although these would pose significant methodological challenges).

4.5.2 Discussion of Achievements

GBC has committed to address genomics-related ethical, environmental, economic, legal and social (GE^{3}LS) issues in connection with its research projects and platforms, and to effectively communicate the risks and rewards of genomics to the general public. GBC has specifically included GE^{3}LS issues as part of its public communications strategy, and has not shied away from tackling potentially controversial topics. The overarching goal of GBC is to foster transparency, dialogue, and mutual learning among scientists, stakeholders and the general public on GE^{3}LS issues.

To this end, GBC has established a broad-based Ethics Advisory Committee that hosts a membership of 14 individuals including scientists, stakeholders, universities and the general public. This committee functions to:

- Review GE^{3}LS issues related to Research Projects and Platforms and make necessary recommendations to the Board.
- Ensure the existence and continuity of educational programs regarding GE^{3}LS issues within the scientific community and the general public.

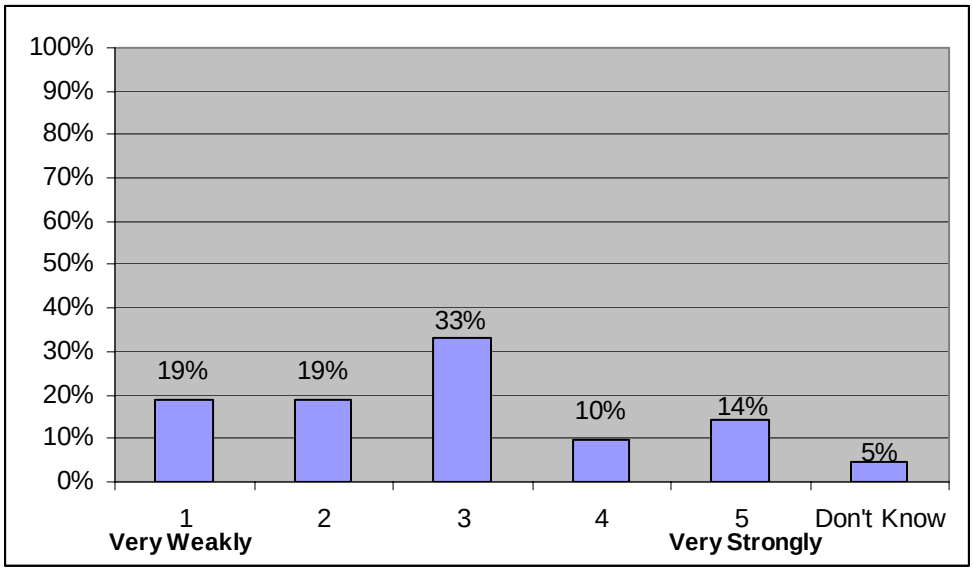
Interviewees noted Genome British Columbia is beginning to demonstrate leadership in the GE^{3}LS area. One interviewee noted that GBC was thought to be potentially demonstrating leadership on international scales, commenting that GBC has a much more comprehensive approach than either the UK or the US, and was often approached for insights into these other programs. The Board's Ethics Advisory Committee is currently focussing on developing new strategies and approaches to policy standards for genomics research and genomics IP that (once approved by the GBC Board of Directors) will be shared with other research organizations, including academia.

> *The GELS work has been very valuable and there's much added value—there needs to be more of it, and more far-reaching.*
>
> *- Major stakeholder*

Part of the GBC GE^{3}LS strategy was supporting a dedicated postdoctoral fellow whose role was to provide GE^{3}LS assistance and advice to scientists funded by GBC, support the Ethics Advisory Committee and provide the linkages between affiliated institutions, GE^{3}LS projects and GBC corporate activities. A review of GE^{3}LS activities within each of the GBC funded projects and platforms was undertaken in early in 2003. By working through this process, the committee found that this approach to supporting their GE^{3}LS strategy was not as effective as was originally anticipated, or providing the projects with the necessary GE^{3}LS expertise. The Committee is now focussed on bringing a GE^{3}LS expert on Board on a full-time basis to try and help bridge the gap and eventually lead to a GE^{3}LS strategy more in line with their intentions.

The web survey findings regarding the extent to which GE^{3}LS issues and concerns were addressed within GBC projects and platforms was rated as moderate, although Figure 4.5.1 shows that only 24% of respondents rated the extent as "strong" or "very strong". However, this finding is still quite positive in the sense that few "normal" biomedical research projects specifically address GE^{3}LS topics at all, nor does every project and topic require such input.

Figure 4.5.1—Extent to which GE^{3}LS issues are addressed within projects and platforms—% of survey respondents

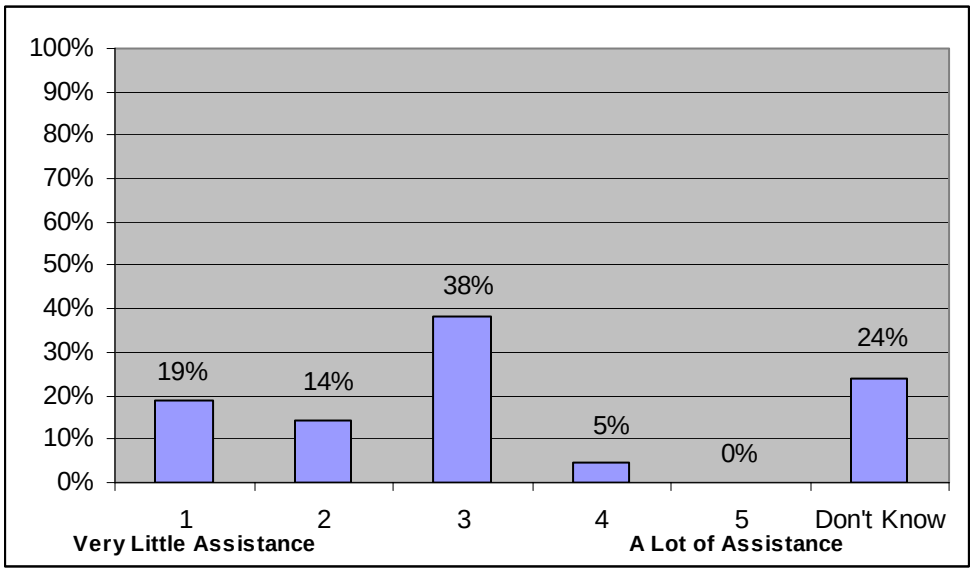


4.5.3 Discussion of Challenges

GE^{3}LS assistance to projects and platforms. Although the focus of GBC's efforts has been towards educating and supporting scientists with respect to GE^{3}LS issues in projects, GBC could provide even more direct support to projects and platforms surrounding GE^{3}LS issues. It was noted that scientists do not always hold the expertise required to address these types of issues and it was felt that GBC should be taking a lead role.

Figure 4.5.2 shows that researchers believe GBC has not provided researchers with much assistance in this area. (This was, in fact, almost the only area in which the survey findings were less than strongly-positive.)

Figure 4.5.2—Extent that GBC assists projects with GE^{3}LS issues—% of survey respondents



Although GBC has made some effort to get more involved with projects and platforms regarding GE^{3}LS issues, there still seems to be some additional endeavours required. Greater interaction with the actual GE^{3}LS research team members would likely prove beneficial.

Impact on the public. As for all public communication and education efforts, it is very difficult to assess whether the activities undertaken by GBC have succeeded in responding to or alleviating public concern. Genome British Columbia has not, to date, undertaken a study or survey to determine the impact of their activities (and to be fair, very few organizations would attempt such a study). A few interviewees, including Board members and researchers, mentioned that perhaps an alternative approach to addressing GE^{3}LS issues with the public should be considered. Instead of "educating the public" there is a need to better engage the public and understand the concerns and perspectives prior to GBC directing their own efforts.

4.6 Issue 6—Has Genome BC increased public awareness of the need for, and benefits and risks of, genomics research?

4.6.1 Summary of Findings

- GBC has acknowledged their educational responsibilities and a detailed communications plan is in place.
- Numerous activities are undertaken and have increased over the last three years directed to various stakeholders.
- GBC could increase efforts that target opportunities for education as well as bi-directional engagement with the public, and efforts outside the Greater Vancouver and Victoria areas.
- The activities undertaken by Genome British Columbia appear to be comprehensive; however, there have been no studies or surveys carried out to assess their effectiveness in increasing public awareness.

4.6.2 Discussion of Achievements

Genome BC has developed a very explicit external stakeholder communications plan, using a detailed matrix showing target groups, target messages, timelines, intended impacts, and an implementation plan. The main objectives of GBC's communications strategy are to:

- Position Genome BC as a leader in BC's emerging life science strategy.
- Position genomics as the heart of BC's life sciences economy.
- Establish Genome BC as the province's objective, trusted and credible source and resource on genomics research.
- Engage the scientific community in Genome BC's vision.
- Establish Genome BC as an open and transparent organization regarding ethical, legal and social issues.
- Build profile for Genome BC as part of a national genome strategy.
- Assist in the raising of funds for genomics R&D.

Genome BC has two full-time staff members in place who are dedicated to the Centre's communications efforts. In addition, an Education Committee has been formed that collaborates with Science World and the University of British Columbia Biomedical Laboratory to provide information to students and science educators. Among other things, this has included the launch of an education website for teachers, students and the general public. The site features support for education programs, in-class exercises, quizzes, games and a comprehensive glossary of genomic terms. For the most part interviewees, including Board members and stakeholders, were very impressed with the communications activities

undertaken by GBC and found the activities to be better than average. Figure 4.6.1 provides a sample of the communications activities that have been undertaken by Genome British Columbia.

Figure 4.6.1—Communications at Genome British Columbia (October 2003)

Media Relations	Public & Educational Programs / Special Events	Multimedia (Website/ Electronic Communications)	Publications and Advertising	External Relations (Government Affairs, Business and International Development
▪ Media plan ▪ Media kit ▪ Press releases ▪ Media contact ▪ Media training	▪ Business Association presentations ▪ VIP reception ▪ Gairdner Awards ▪ Speaking engagements ▪ Christmas party ▪ Business lunches ▪ Science Symposium ▪ Distinguished speaker program ▪ Annual General meeting ▪ Board meetings	▪ Corporate presentation ▪ Web site ▪ Information email distribution ▪ Newsletter ▪ Website career section	▪ Corporate identity program ▪ Sponsorship program ▪ Corporate brochure ▪ Newsletter ▪ Ambassadors Kit ▪ Annual Report ▪ Banners/signage ▪ Print media advertising ▪ Contribution to GC Bi-weekly ▪ Contribution to GC GE^{3}LS newsletter	▪ Government presentation re: Life Science op ▪ Government meetings ▪ Provincial relations strategy

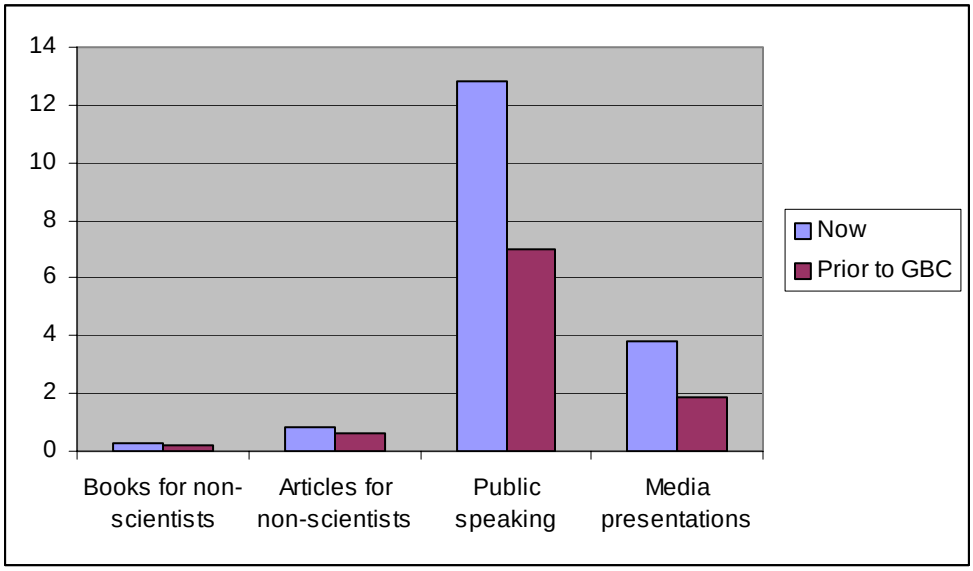
GBC strives for regular interaction with the science community aiming to pave the way for bridging gaps between university and industry, encouraging collaboration. Regular discussions with Genome Canada were also mentioned as a way to identify links into the national communications and outreach program and determine any gaps that need to be addressed.

Communications and public outreach activities are also undertaken at the project level. Each of GBC's funded projects and platforms are actively involved in conference events, media events, opening facilities for tours to interested parties and communicating scientific outputs through scientific (peer reviewed) publications, books and articles that were not peer reviewed, citations, awards, patents filed, patents awarded and number of invitations as guest speakers at major international conferences/congresses.[18]

GBC has contributed to increasing these public communications activities of the genomics researcher community. Web survey respondents noted an increase in communications activities in all categories survey, and the average respondent is now doing approximately 80% more "non-scientific" communications in total, the largest being directed toward the general public with public speaking events (increasing on average by 80%) and media presentations (increasing by 100%), as seen in Figure 4.6.2.

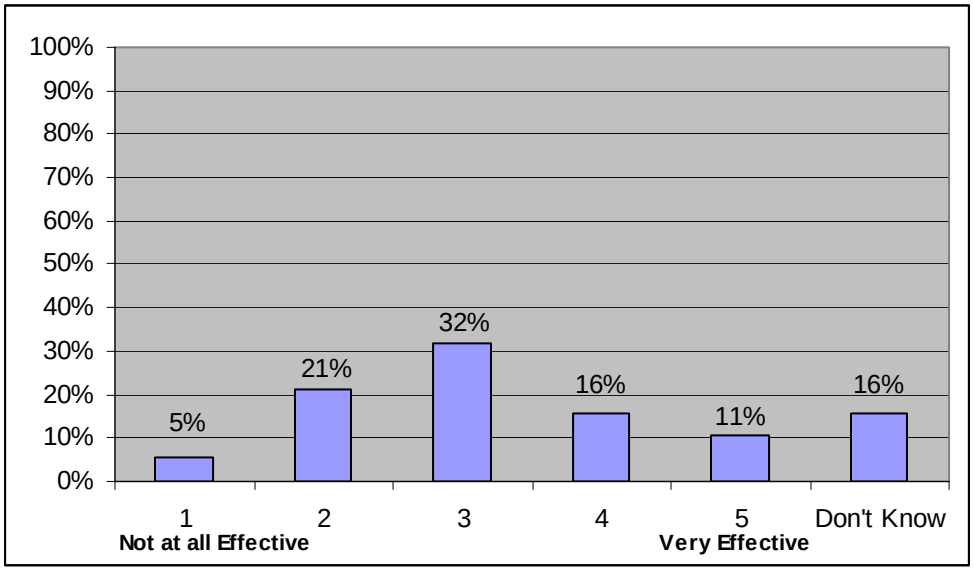
[18] *Available under Table Output 3(a) of the Genome British Columbia RMAF binders.*

Figure 4.6.2—Non-scientific communications undertaken over three year period—avg. number per survey respondent



Results of the web survey indicate that, on average, these communications activities are seen as being moderatly effective, as shown in Figure 4.6.3, although of course the respondents' ability to measure true effectiveness is limited.

Figure 4.6.3 Effectiveness of increasing public awareness of genomics and genomics research—% of survey respondents



4.6.3 Discussion of Challenges

Impact on the public. Again, the effectiveness and impacts of communications activities geared towards the general public are difficult to gauge. GBC conducted a public opinion poll in 2003 regarding public

awareness of genomics in the province, its importance to the economic future of BC and the impact and importance of genomics to our lives. The survey found that 8% of BC residents claimed to be very familiar with the subject of genomics and another 42% identified that they were somewhat familiar. With regards to the importance of on-going genomics research to the province's economic future, 18% indicated that on-going genomics research was very important and another 35% considered it to be somewhat important. An interesting finding of the survey was that the perceived importance of genomics to the province's economic future was very much linked to respondent familiarity with the subject. One half of those very familiar with genomics considered it to be very important to the province's future.[19]

The study team is not aware of any follow-up surveys to measure the impact of activities. A follow-up would provide insight into the actual impacts being made, but caution needs to be taken when attributing results. There would be many factors contributing to an increase in understanding, with GBC likely just being one of them.

Reach. It was noted that this area required increased effort if GBC is to reach their stated communications goals. Current efforts were noted to focus mainly on researchers and those in the genomics community—a very small population. The reach and focus of communication and education activities needs to be broadened, including accelerating the efforts in schools, and more effort outside the Greater Vancouver and Victoria areas. Another potential target is industry in order to inform and educate firms of the potential benefits of genomics.

[19] *March 2003 BC-Wide Consumer Scope: Genome BC Survey, Synovate, March 2003.*

5.0 CONCLUSIONS

5.1 Clear Overall Successes

A clear picture emerges of GBC being highly-successful in creating a structure that has a strong potential to achieve its goals. GBC has, in a short period of time, become an "anchor franchise" for BC's genomics efforts. In the opinion of almost all stakeholders Genome BC has been markedly successful overall, having had strong impacts in areas appropriate to its mandate and goals. Its successes are very strong, especially at this stage of its development and given that both Genome Canada and GBC represent new models for supporting research. GBC has clearly added considerably to the BC genomics research effort: there is more than the usual sense of excitement seen with a "typical" new program—in fact, there is a palpable sense of excitement in BC's genomics research community.

Some of the Centre's more notable achievements to date are that:

- The GBC strategy is comprehensive and generally sound.
- GBC has undertaken effective collaboration and consultation with stakeholders. One result is that GBC and GBC researchers have been able to obtain significant amounts of co-funding.
- GBC has greatly improved the research infrastructure in both the GBC platforms and in other BC laboratories. (Much of the genomics infrastructure available to GBC scientists was relatively weak prior to GBC, whereas some elements are now comparable to those in other world class programs, and have built upon the existing BC strengths.)
- The Centre's impacts on the quality of genomics science have been very strong. Several initiatives (e.g., the Genome Sciences Centre and its sequencing of the SARS virus, the research in forestry and fisheries) and individual researchers were cited as clearly being world-class.
- Over the long term there is potential for tremendous socio-economic benefits (although it is far too early for these to be realized), and most of the factors required to successfully identify and exploit important innovations are in place or in development. The Centre is recognized as having a strongly entrepreneurial approach.
- Already the quality and nature of training is substantially improved compared to the previous situation. Combined with the stronger life sciences cluster in BC that is evolving, this should lead to more retention of these highly-qualified personnel.
- There have been explicit efforts to address ethical, environmental, economic, legal and social (GE^3LS) issues in connection with its research projects and platforms, and to effectively communicate the risks and rewards of genomics to the general public.
- The Centre has strong, entrepreneurial leadership and there are many effective management mechanisms in place.
- Many respondents regard GBC as being one of the two strongest Genome Centres in Canada (the other being Genome Québec).

5.2 Challenges to Address

5.2.1 Overview

There are some "teething" problems, although these are greatly outweighed by GBC's successes. Below we discuss the most significant challenges with the intent to provide enough detail to feed into GBC's strategic and business planning. That the list seems long should not be misinterpreted: the nature of most of these problems is not unexpected for an S&T initiative in its early stages and most are very similar to what is "typically" heard—e.g. no researcher likes to be "managed", everyone dislikes reporting and paperwork, the R&D timeframe is always lengthy, management of large and complex research projects and platforms is difficult (especially early on), and commercialization of research is always fraught with difficulty.

5.2.2 Major Challenges

- The most important strategic item to address in the near term is to better define GBC's role in: (1) Adding value to BC's genomics research initiative, especially at the individual project/platform and researcher level (e.g., helping find co-funding, assisting with S-E and GE^{3}LS issues at the Genome Canada application stage, assisting non-GBC researchers, helping create more "small 'c' centres", implementing more BC collaborations outside the Greater Vancouver and Victoria areas, continuing with international collaborations, reviewing the appropriateness of "on-site" project/platform management, etc.); and (2) Adding value to the commercialization and other exploitation mechanisms already in existence in GBC's stakeholder organizations (e.g., refining the role of the BACs, helping find industrial receptors, adding value to innovations before they are commercialized, helping develop non-commercial uses, involving BC's resource sectors more, etc.). This refined role must be clearly communicated to stakeholder institutions and researchers

- GBC and other stakeholders must work to ensure long-term sustainability of genomics funding or—given the long timeframes involved—it is unlikely that these initiatives will realize significant socio-economic impacts.

- That GBC also intends to foster and create significant non-commercial socio-economic benefits must be clarified for all stakeholders, and GBC should work to identify and foster these impacts (including those that arise through indirect means such as knowledge transfer).

- GBC, Genome Canada, and IC should review their administrative and reporting requirements to ensure that the burden on researchers and their organizations is as low as possible.

- Effort should continue to be devoted to developing and applying appropriate scientific and business management practices for the platforms.

5.2.3 Other Issues

- GBC and other stakeholders must manage any unrealistic expectations regarding the likely timeframe for S-E benefits, and develop appropriate performance measures and metrics for identifying short-, medium-, and long-term impacts.

- There is an opportunity for GBC and other BC stakeholders to more fully integrate their genomics effort and "speak with one voice". This would help optimize the research effort and make engagement with major funding partners easier.

- Better communication, clarity, and transparency of operations would be welcomed by some of GBC's stakeholders.

Appendix A
Interview Guides and Survey Questionnaire

Topics to be Discussed with GBC Board and BACs

BearingPoint (formerly KPMG Consulting) is providing Genome British Columbia (GBC) with consultative services for an evaluation of Genome British Columbia and its program. The main task of the evaluation is to assess GBC's achievements against its formal objectives.

You have been selected for this interview due to your knowledge and interaction with Genome British Columbia. **All information is confidential:** nothing that allows identification of individual respondents will be reported publicly or to GBC. The questions in this document are meant to guide our discussion, please feel free to provide any additional information where appropriate.

Background information

Name
Position and organization
Contact information (address, tel., e-mail)
Board

1. Please briefly describe your position and relationship with Genome BC?

2. Does Genome BC have a coordinated and integrated strategy for BC's genomics research?

    a. Is this strategy relevant to the issues facing the genomics community?

    b. Is there appropriate consideration of technology transfer, knowledge transfer and the training of highly qualified personnel?

    c. What mechanisms are used to develop and maintain the strategy (e.g., appropriate stakeholder involvement)?

    d. What opportunities exist for Genome BC to strengthen its genomics research strategy (e.g. other stakeholders that should be involved)?

3. What national Canadian genomics approaches and strategies exist? Has GBC participated and effectively contributed to these approaches and strategies? How?

    a. Has GBC's participation strengthened Canada's national genomics research capabilities? Examples?

    b. Are there opportunities for GBC to increase its participation in this area? Examples?

4. To what extent have GBC activities led to the province of British Columbia becoming a world leader in selected genomics research?

    a. How does the province of BC compare in strength to the Canadian genomics community?

    b. How does BC compare to the international genomics community? (e.g., to other similar, well established research programs?)

c. Are there specific factors that facilitate or inhibit the Centre's progress in becoming a world leader (e.g., what could be done to improve the Centre's ability to achieve this, are the appropriate management structures, policies and procedures in place, etc.)?

5. Does GBC have the potential to generate significant socio-economic benefits for BC and for Canada?

    a. Has GBC provided access to researchers to the necessary infrastructure to allow socially and industrially relevant research to proceed effectively? How does this compare with what was available prior to the existence of GBC? How does this compare to what is offered internationally?

    a. What factors affect the GBC research programs and projects in generating S-E benefits? (We are interested in both internal and external factors, including those that affect genomics research generally, not just GBC.)

6. Has GBC established an appropriate contractual relationship with Genome Canada?

7. Has GBC established appropriate collaborative/contractual relationships (e.g., funding mechanisms, IP arrangements, etc.) with stakeholders?

    a. Are these mechanisms effective?

    b. What kind of support is received from these stakeholders. Is this appropriate and adequate?

    c. Are there opportunities to establish linkages or relationships with other organizations?

8. What are the main activities that GBC has undertaken to address the GE^3LS concerns of the public? How effective do you think these have been?

9. What the main activities undertaken by GBC to improve public understanding of genomics and genomics research? How effective have these been?

10. Overall, what do you see as the main strengths of Genome British Columbia? The main weaknesses? What improvements would you suggest? What would you not want to see changed?

Topics to be Discussed with GBC Stakeholders

BearingPoint (formerly KPMG Consulting) is providing Genome British Columbia (GBC) with consultative services for an evaluation of Genome British Columbia and its program. The main task of the evaluation is to assess GBC's achievements against its formal objectives. Genome British Columbia invests in and manages large-scale genomics and proteomics research projects in the areas of health, forestry, fisheries, ethics, agriculture and the environment. It also provides the necessary infrastructure to support the projects through its five science and technology platforms.

You have been selected for this interview due to your knowledge and interaction with Genome British Columbia. **All information is confidential:** nothing that allows identification of individual respondents will be reported publicly or to GBC. The questions in this document are meant to guide our discussion, please feel free to provide any additional information where appropriate.

Background information

Name
Position and organization
Contact information (address, tel., e-mail)
Board

1. Please briefly describe your position and relationship with Genome BC.

2. Has GBC established appropriate collaborative/contractual relationships (e.g., funding mechanisms, IP arrangements, etc.) with its stakeholders?

    a. What mechanisms have been used to establish the relationships (e.g., involved in planning and/or participating in research projects)? Are they effective?

    b. Are there opportunities to establish linkages or relationships with other organizations?

3. To what extent have GBC activities led to the province of British Columbia becoming a world leader in selected genomics research?

    d. How does the province of BC compare in strength to the Canadian genomics community?

    e. How does BC compare to the international genomics community? (e.g., to other similar, well established research programs?)

    f. Are there specific facilitators or impediments that influence the Centre's progress in becoming a world leader (e.g., what could be done to improve their ability to achieve this, are the appropriate management structures, policies and procedures in place, etc.)?

4. Does GBC have the potential to generate significant socio-economic benefits for BC and for Canada?

b. Has GBC provided access to researchers to the necessary infrastructure to allow socially and industrially relevant research to proceed effectively? How does this compare with what was available prior to the existence of GBC? How does this compare to what is offered internationally?

b. What factors affect the GBC research programs and projects in generating S-E benefits? (We are interested in both internal and external factors, including those that affect genomics research generally, not just GBC.)

5. Does Genome BC have a coordinated and integrated strategy [see attached] for BC's genomics research?

    a. Is this strategy relevant to the issues facing the genomics community?

    b. Is there appropriate consideration of technology transfer, knowledge transfer, and the training of highly qualified personnel?

    c. Have you had input in defining research activities and do you feel your level of involvement is appropriate? Are there other stakeholders that you feel should be more involved?

    d. What opportunities exist for Genome BC to strengthen its genomics research strategy?

6. What national Canadian genomics approaches and strategies exist? Has GBC participated and effectively contributed to these approaches and strategies? How?

    a. Has GBC's participation strengthened Canada's national genomics research capabilities? Examples?

    b. Are there opportunities for GBC to increase its participation in this area? Examples?

7. Overall, what do you see as the main strengths of Genome British Columbia? The main weaknesses? What improvements would you suggest? What would you not want to see changed?

Major Genome British Columbia Strategic Elements

Vision

To be the catalyst for a life sciences cluster of genomics-related research institutions and companies working together for the socio-economic benefit of British Columbia and Canada.

Pathways to Success

•Building the foundation with Canadian large-scale science— Over $160M CDN funding for projects and platforms has been awarded through Genome Canada competitions.

•Achieving world-wide recognition through international partnerships

•Strategic investment for commercialization

•Private and venture capital investment

Specific Objectives

Lead the development of a vibrant and innovative genomics community in BC by:

•Developing the strategy for a strong genomics cluster

•Managing approved projects and platforms

•Assisting in the commercialization of resulting IP

•Raising funds to match approved projects and to make strategic investments

•Establishing the international links required to advance the global competitiveness of Genome BC activities

•Ensuring BC's leadership in selected ethical, legal and social issues related to genomics

•Communicating the results of Genome BC's research to the public

•Facilitating a public outreach program encouraging public education and involvement

Projects:

Human health	Early stages of cancer; Mouse development gene expression; Mammalian gene expression bioinformatics; *C. elegans* knock-out facility & expression profiles; Fungal genomics; Pathogenomics of mucosal immunity; Genomic tools for mental retardation; Clinical biomarkers and novel therapies for iron metabolism disorders; Genotype-specific approaches to therapy in childhood; Comparative genomic hybridization arrays for clinical use in cancer; Pharmacogenomics for rational chemotherapy of lung cancer; Biomarkers for acute and chronic allograft rejection
Agriculture	Bovine genomics; Grape genomics
Environment	Microbial envirogenomics

Ethics	Democracy, Ethics and Genomics
Fisheries	Genomics Research on Atlantic Salmon
Forestry	Forestry genomics

Platform Facilities (available to all GBC researchers, plus external users)

•Sequencing & Mapping

•Arrays

•Proteomics

•Bioinformatics

•Technology Development

International Strategy:

•Leverage BC and Canadian investments to enable greater scale and scope of research endeavours

•Identify new sources of co-funding for projects, including International Consortium Initiatives

•Facilitate scientific exchanges and recruiting

•Maintain awareness of emerging trends in technologies and applications

•Increase the presence and profile of BC's Life Sciences cluster on the world stage.

Topics to be Discussed with National and International Experts

BearingPoint (formerly KPMG Consulting) is providing Genome British Columbia (GBC) with consultative services for an evaluation of the Genome British Columbia and its program. The main task of the evaluation is to assess GBC's achievements against its formal objectives. Genome British Columbia invests in and manages large-scale genomics and proteomics research projects in the areas of health, forestry, fisheries, ethics, agriculture and the environment. It also provides the necessary infrastructure to support the projects through its five science and technology platforms.

You have been selected for this interview due to your knowledge and interaction with Genome British Columbia. **All information is confidential:** nothing that allows identification of individual respondents will be reported publicly or to GBC. The questions in this document are meant to guide our discussion, please feel free to provide any additional information where appropriate.

Background information

Name
Position and organization
Contact information (address, tel., e-mail)
Board

1. Please briefly describe your relationship with (or knowledge of) Genome BC.

2. Has GBC established appropriate collaborative/contractual relationships (e.g., funding mechanisms, IP arrangements, etc.) with stakeholders?

    a. Are these mechanisms effective?

    b. How do these mechanisms compare to those in other Canadian programs? In similar international programs?

    c. Are there opportunities to establish linkages or relationships with other organizations?

3. To what extent have GBC activities led to the province of British Columbia becoming a world leader in selected genomics research?

    g. How does the province of BC compare in strength to the Canadian genomics community?

    h. How does BC compare to the international genomics community? (e.g., to other similar, well established research programs?)

    i. Are there specific facilitators or impediments that influence the Centre's progress in becoming a world leader (e.g., what could be done to improve their ability to achieve this, are the appropriate management structures, policies and procedures in place, etc.)?

4. Does GBC have the potential to generate significant socio-economic benefits for BC and for Canada?

    c. Has GBC provided access to researchers to the necessary infrastructure to allow socially and industrially relevant research to proceed effectively? How does this compare with what was available prior to the existence of GBC? How does this compare to what is offered internationally?

    d. What factors affect the GBC research programs and projects in generating S-E benefits? (We are interested in both internal and external factors, including those that affect genomics research generally, not just GBC.)

5. How do GBC's strategic elements [see attached] compare to other national/international strategies? In your opinion, are these elements appropriate and complete? What opportunities exist for Genome BC to strengthen its genomics research strategy (e.g. other stakeholders that should be involved)?

6. What national Canadian genomics approaches and strategies exist? Has GBC participated and effectively contributed to these approaches and strategies? How?

    a. Has GBC's participation strengthened Canada's national genomics research capabilities? Examples?

    b. Are there opportunities for GBC to increase its participation in this area?

7. Overall, what do you see as the main strengths of Genome British Columbia? The main weaknesses? What improvements would you suggest? What would you not want to see changed?

Major Genome British Columbia Strategic Elements

Vision

To be the catalyst for a life sciences cluster of genomics-related research institutions and companies working together for the socio-economic benefit of British Columbia and Canada.

Pathways to Success

•Building the Foundation with Canadian large-scale science— Over $160M CDN funding for research projects and platforms has been awarded through Genome Canada competitions.

•Achieving world-wide recognition through international partnerships

•Strategic investment for commercialization

•Private and venture capital investment

Specific Objectives

Lead the development of a vibrant and innovative genomics community in BC by:

•Developing the strategy for a strong genomics cluster

•Managing approved projects and platforms. ("Platforms" provide the infrastructure and services for sequencing, bioinformatics, microarrays, proteomics, etc.)

•Assisting in the commercialization of resulting IP

•Raising funds to match approved projects and to make strategic investments

•Establishing the international links required to advance the global competitiveness of Genome BC activities

•Ensuring BC's leadership in selected ethical, legal and social issues related to genomics

•Communicating the results of Genome BC's research to the public

•Facilitating a public outreach program encouraging public education and involvement

Projects:

Human health	Early stages of cancer; Mouse development gene expression; Mammalian gene expression bioinformatics; *C. elegans* knock-out facility & expression profiles; Fungal genomics; Pathogenomics of mucosal immunity; Genomic tools for mental retardation; Clinical biomarkers and novel therapies for iron metabolism disorders; Genotype-specific approaches to therapy in childhood; Comparative genomic hybridization arrays for clinical use in cancer; Pharmacogenomics for rational chemotherapy of lung cancer; Biomarkers for acute and chronic allograft rejection
Agriculture	Bovine genomics; Grape genomics
Environment	Microbial envirogenomics

Ethics	Democracy, Ethics and Genomics
Fisheries	Genomics Research on Atlantic Salmon
Forestry	Forestry genomics

Platform Facilities (available to all GBC researchers, plus external users)

•Sequencing & Mapping

•Arrays

•Proteomics

•Bioinformatics

•Technology Development

International Strategy:

•Leverage BC and Canadian investments to enable greater scale and scope of research endeavours

•Identify new sources of co-funding for projects, including International Consortium Initiatives

•Facilitate scientific exchanges and recruiting

•Maintain awareness of emerging trends in technologies and applications

•Increase the presence and profile of BC's Life Sciences cluster on the world stage

EVALUATION of GENOME BRITISH COLUMBIA

RESEARCHER SURVEY

BearingPoint is providing Genome British Columbia (GBC) with consultative services for an evaluation of Genome British Columbia and its program. The main task of the evaluation is to assess GBC's achievements against its formal objectives.

BearingPoint will treat all completed questionnaires and data collected as strictly confidential. No responses will be reported that allow identification of any individual or organization. Should you have any questions about the survey, please contact BearingPoint at karen.croteau@bearingpoint.com or telephone (613) 212-3511 to speak to Karen Croteau.

INTRODUCTORY NOTE: In this survey the term "genomics" includes genomics, transcriptomics, proteomics and bioinformatics.

Please provide us with the following contact information in case we need to ask for clarification of any responses.

Your Name: _____

Name of Organization: _____

Telephone Number: _____

E-mail Address: _____

Please provide us with the following information on your Genome British Columbia project or platform. If you have been/are currently involved with more than one, choose a project or platform for which you are most knowledgeable.

Project or Platform Name: _____

Start Date: _____
(mm / dd / yyyy)

Your Role *(check one)*:

- ❑ Project Leader
- ❑ Platform Director
- ❑ Principal Investigator
- ❑ Other *(please specify)* _____

[For **non-Platform researchers only**.] Does your GBC project or your other genomics-related research require access to major research infrastructure (such as sequencing and mapping, mass spectrometry, and bioinformatics)?

- ❑ Yes
- ❑ No ***--> SKIP to Q.4***

If **Yes**, please rate where the need for such research infrastructure is required. *(Please circle one number for each of the following.)*

	Weak Need				Strong Need	Don't know
a) Required within your project.....	1	2	3	4	5	9
b) Required from GBC Platforms.....	1	2	3	4	5	9

Please rate the overall strength of genomics research infrastructure (e.g., quality, accessibility) prior to GBC and now? *(Please circle one number for each of the following.)*

	Very Weak				Very Strong	Don't know
Strength prior to GBC:						
a) Within your lab or department.....	1	2	3	4	5	9
b) BC infrastructure external to your lab or department	1	2	3	4	5	9
Strength now:						
c) Within your lab or department.....	1	2	3	4	5	9
d) BC infrastructure external to your lab or department	1	2	3	4	5	9

If there has been a change in the strength of genomic research infrastructure prior to GBC versus now, to what extent is this due to GBC, as opposed to other sources of infrastructure such as CFI? *(Please circle one number for each of the following.)*

	Very Low				Very High	Don't Know or N/A
e) Impact of GBC.....	1	2	3	4	5	9
f) Impact of other organizations.....	1	2	3	4	5	9

With regards specifically to the GBC platforms how would you rate each of the following items:
(Please circle one number for each of the following.)

	Poor				Excellent	Don't know	
g) Quality of the platform infrastructure	1	2	3	4	5	9	
h) Access to the platform infrastructure	1	2	3	4	5	9	
i) Information regarding the platforms (services, pricing, policies)	1	2	3	4	5	9	
j) Policies and procedures regarding eligibility of users.....	1	2	3	4	5	9	
k) Policies and procedures regarding access (i.e., priorities).	1	2	3	4	5	9	
l) Policies and procedures regarding pricing.....	1	2	3	4	5	9	
m) Appropriateness of intellectual property rules	1	2	3	4	5	9	
n) Availability and effectiveness of support personnel.....	1	2	3	4	5	9	

o) Other (*please specify*)
..... 1 ___ 2 3 4 5 9

Are there opportunities for improvements to the GBC platforms or other GBC infrastructure? If so, please provide details.

_____
_____
_____

We recognize that it is "early days" for GBC, but we are interested in following up on any "practical" applications seen to date. Has your GBC project or platform led to any "practical" socio-economic benefits for BC and Canada? *(Please circle one for each of the following.)*

	Yes, already	**Yes, in development**	**Possibility being explored**	**No**	N/A	
p) In health services (e.g., better policies, programs, decision-making).....	1		2	3	4	9
q) In clinical practice (e.g., new diagnostic or therapeutic tools, methods, equipment, quality of care)	1		2	3	4	9
r) For industry (e.g., patents, licenses, cost savings, copyrights, spin-offs, etc.)	1		2	3	4	9
s) For government (e.g., cost savings; or better policies, regulations, decision-making)	1		2	3	4	9
t) For the public & NGOs (e.g., better information, education, access to expertise).....	1		2	3	4	9
u) Other *(please specify)* _____	1		2	3	4	9

If impacts have already occurred, or are in active development, please describe:

_____
_____
_____
_____
_____

May we contact you for further information?

- ❑ Yes (If **Yes**, please ensure "contact information is provided earlier)
- ❑ No

Are there barriers to generating socio-economic benefits within your GBC project or in your research field generally? *(Please circle one number for each of the following.)*

	No Barriers				Strong Barriers	Don't know
v) Barriers within your project.....	1	2	3	4	5	9
w) Barriers in your field generally.....	1	2	3	4	5	9

If there are significant barriers, please provide details.

_____
_____
_____
_____
_____

What is your specific research field?

_____
_____

Please rate the strength of genomics training (e.g., quality, amount) for scientists, students, and technicians prior to GBC and now? *(Please circle one number for each of the following.)*

	Very Weak				Very Strong	Don't know
Strength prior to GBC:						
x) Training in genomics generally.....	1	2	3	4	5	9
y) Training in using genomics tools & infrastructure (e.g., instrumentation, software, etc.).....	1	2	3	4	5	9
Strength now:						
z) Training in genomics generally....	1	2	3	4	5	9
aa) Training in using genomics tools & infrastructure (e.g., instrumentation, software, etc.).....	1	2	3	4	5	9

If there has been a change in the strength of genomics training prior to GBC versus now, to what extent is this due to GBC, as opposed to other sources of training support such as normal research grants, Chairs program, etc.? *(Please circle one number for each of the following.)*

	Very Low				Very High	Don't Know or N/A
bb) Impact of GBC.....	1	2	3	4	5	9
cc) Impact of other support	1	2	3	4	5	9

Please estimate the number of individuals trained in your project or platform to date.

Type of trainee	**No. trained to date**
Graduate students	_____
Postdoctoral fellows	_____

Technicians _____

Other *(please specify)*

_____ _____

Please identify the adequacy of support received from collaborators who participate in your GBC project or platform. *(Please circle one number for each of the following.)*

	Not at All Adequate				**Highly Adequate**	Don't know or N/A
dd) Research support	1	2	3	4	5	9
ee) Infrastructure access	1	2	3	4	5	9
ff) Other in-kind support (e.g., analysis)	1	2	3	4	5	9
gg) Training support	1	2	3	4	5	9
hh) Co-funding	1	2	3	4	5	9
ii) Other *(please specify)* _____	1	2	3	4	5	9

To what extent are GE^{3}LS issues or concerns addressed within your project or platform? *(Please circle one number*)

Very Weakly				**Very Strongly**	Don't know
1	2	3	4	5	9

To what extent has Genome BC assisted you in addressing GE^{3}LS issues or concerns (e.g., in conducting your research, or in your communication with the public)? *(Please circle one number*)

Very Little Assistance				**A Lot of Assistance**	Don't know or N/A
1	2	3	4	5	

How many public communications and outreach activities have you personally undertaken over the past three years since GBC began (i.e., mid-2001 to mid-2004)? How many similar activities did you engage in during the 3 years prior to when GBC began (i.e., 1998 to 2000). *(Please fill in appropriate number.)*

	No. During GBC (mid-2001 to mid-2004)	**No. Prior to GBC** (1998 to 2000)
Books for non-scientists (author or contributor)	_____	_____
Articles for non-scientists (author or contributor)	_____	_____
Public speaking or engagements, special events, etc. (speaker or major contributor)	_____	_____
Media presentations	_____	_____

Other *(please specify)*

_____ _____ _____

In your opinion, have these activities been effective in increasing public awareness of genomics and genomics research? *(Please circle one number*)

Not At All Effective				**Very Effective**	Don't Know
1	2	3	4	5	9

How well do various elements of the Genome BC strategy respond to your needs and priorities? *(Please circle one number for each of the following.)*

	Not at All Responsive				**Very Responsive**	Don't Know
jj) Research focus	1	2	3	4	5	9
kk) Collaboration with other research organizations	1	2	3	4	5	9
ll) Training	1	2	3	4	5	9
mm) Platforms	1	2	3	4	5	9
nn) Socio-economic impacts	1	2	3	4	5	9
oo) GE^{3}LS	1	2	3	4	5	9
pp) Advocacy with the province	1	2	3	4	5	9
qq) IP policies	1	2	3	4	5	9
rr) International strategy	1	2	3	4	5	9

Overall, how much impact has Genome BC had on BC's overall strategy to support genomics research, and on BC's overall strategy to exploit these research findings for social and economic benefits? *(Please circle one number for each of the following.)*

	Much Worse Because of GBC				**Much Better Because of GBC**	Don't Know
ss) BC's strategy for research	1	2	3	4	5	9
tt) BC's strategy for exploitation	1	2	3	4	5	9

Could the GBC strategy be improved? If so, please provide details.

_____
_____
_____
_____
_____

How effective has GBC been in participating in national genomics activities? How effective has it been in influencing the development of national genomics strategies? *(Please circle one number for each of the following.)*

	Not at All Effective				Very Effective	Don't Know
uu) Participation	1	2	3	4	5	9
vv) Influence.....	1	2	3	4	5	9

Are there opportunities for GBC to increase its participation in this area, or to be more effective in influencing national strategies? If so, please provide details.

_____
_____
_____
_____
_____

In your view, are British Columbia researchers seen as world leaders in genomics?

	No Recognition				Strong Recognition	Don't Know
ww) In your field of research.....	1	2	3	4	5	9
xx) In genomics generally	1	2	3	4	5	9

Has there been a change over the past three years in how BC researchers are regarded?

- ❑ Yes
- ❑ No ***--> SKIP to Q.25***

If **Yes,** how strong an impact has GBC had in causing this change? *(Please circle one number for each of the following.)*

	Much Worse Because of GBC				Much Better Because of GBC	Don't Know
yy) In your field of research.....	1	2	3	4	5	9
zz) In genomics generally	1	2	3	4	5	9

What factors facilitate or inhibit progress in becoming seen as world leaders:

aaa) In your field of research?

Factors that Facilitate Progress—_____
_____
_____
_____
_____

Factors that Inhibit Progress— _____
_____
_____
_____
_____

bbb) In genomics generally?

Factors that Facilitate Progress—_____

_____

_____

_____

_____

Factors that Inhibit Progress— _____

_____

_____

_____

_____

Overall, please provide your comments on Genome British Columbia:

a) What are the main strengths?

_____

_____

_____

_____

_____

_____

_____

b) What are the main weaknesses?

_____

_____

_____

_____

_____

_____

_____

c) What improvements would you suggest?

_____

_____

_____

_____

_____

_____

_____

d) What would you not want to see changed?

_____

_____

_____

_____
_____
_____
_____

Thank you for your participation.

Please send all completed surveys to BearingPoint as soon as possible. If you do not complete this questionnaire on-line, mail your response to the following address:

Genome British Columbia Survey
c/o Karen Croteau
BearingPoint
150 Metcalfe Street, Suite 700
Ottawa, Ontario
K2P 1P1

or fax it directly to BearingPoint at (613) 238-3698, Attention: Karen Croteau.

Case Study Questions

Case study: _____

1. For this case study, please describe the goals and objectives.

2. Who are the intended beneficiaries of this research?

3. What organizations have been involved, and how?

4. To what extent does this project have the potential to lead to social or economic benefits:

    a. Development of high social or public good? Please discuss nature and anticipated size of the impact, type and number of organizations or individuals affected, need for dissemination to potential users, likelihood of take-up by users, barriers (e.g., regulatory, need to inform practitioners), etc.

    b. Translation to commercial application? Please discuss nature and anticipated size of commercial benefits (e.g., new products and processes, revenues and cost savings), anticipated markets, likelihood of success, stage of exploitation (e.g., patented? has R&D capital been raised? Etc.)

    c. How feasible is the functional application of this research and the practicality of potential impacts being achieved? What would need to happen for these benefits to be reached? What is the estimated timeframe to realization?

    What have been the factors for success or barriers to achievement?

5. How important were the GBC platforms in helping make these impacts possible?

6. Would this project have been executed in the absence of GBC? Would it be likely to have as much "practical" impact? Why or why not? Would anything have been different (e.g. reduced scope, longer time to application)?

7. To what extent has this project led to the development of new and/or improved R&D capacity among the targeted community (e.g., training of researchers, infrastructure development, establishment of new networks)?

8. Has this project contributed to BC becoming a world leader in select genomics research areas? (If appropriate, discuss internal/external influences, specific Canadian constraints, governance, etc.)

9. Are there other "lessons learned" that might be applied in future?

10. Who else should we speak to regarding this project?

Thank you!

Appendix B
Case Studies

GBC: Cancer Genomics: BAC CGH Development

A. Scope of Project/Platform

Goals & Nature of Project/Platform	▪ This project was one component of the Cancer Genomics project initiated during Competition I. The project was identified as a potential revolutionary way to engage in personalized medicine. The project aimed to develop an array technology that identifies genomic changes in human tissues affected by diseases such as various cancers. These changes include, e.g., transposition of individual genes on the genome, enhanced or reduced expression of individual genes, etc., completed in a single experiment using comparative genomic hybridization (CGH) techniques. ▪ Technology development goals were to improve the existing array CGH technology, by increasing resolution and the development of a hybridization method, to enable the analysis of minute microdissected cell populations. This was specifically relevant to the analysis of solid early stage lesions and tumours and would have significant impacts on advancing the research of cancer and possibly other diseases. ▪ The product itself is two slides, plus some reagents and dyes, and custom software. The CGH array technology allows much finer and more detailed investigation (i.e., millions of changes, right down to individual genes) than older technology (which detect gross changes, e.g., to whole genomes, or to multiple genes at once), as well as faster analysis. The slides come with custom software to help deal with the massive amount of data that is collected, and is user-friendly; e.g., a user can "expand" the view of specific, individual genome portions of interest. The data can also be compared to public databases of known human genes and disease-related changes. ▪ Filing of a full patent application titled "Methods for preparation of a library of submegabase resolution tiling pools and uses thereof" happened on June 14th 2004. The Cancer Agency is in discussions with several companies regarding non-exclusive licensing of the technology. ▪ Array CGH development as a research tool has been successfully completed and they are selling the slides now to other researchers on a cost recovery basis for non-commercial research use.
Partners Involved	▪ The BC Cancer Agency, Genome Sciences Centre provided support through the sequencing and mapping platform for the source material and fingerprinting. This collaboration was key to producing timely results. The BCCA also pays the salaries of the researchers. ▪ Collaboration with the University of California, San Francisco in the exploration of development methodology. This was a critical step for

	the project in demonstrating potential, removing doubt around ability to achieve success and merit of investment. ▪ Other international parties that shared knowledge.
B. Project/Platform Impacts	
Socio-Economic Benefits	▪ CGH array technology, as a research tool, may contribute to future health benefits by playing a part in the development of insights and potentially accelerate discovery of beneficial information in relation to various forms of cancer. ▪ It was noted to be a very exciting diagnostic tool, as it may support the possibility to identify cancers (and other diseases) very early, and know exactly what cancers they are and what stage they're at. Using the technology to test "normal" versus suspected "disease" tissue, from the same individual, would show the differences between gene structure and expression. ▪ It may also be used as a therapeutic and prognostic tool, with the potential to provide better ideas of which individual people will benefit from which individual treatments, all changing according to what stage the cancer is at. In some cases, individual genes might be targets for therapeutic methods. Overall, the hope is for customized, "personalized" diagnosis and therapy. ▪ The CGH array technology is expected to become the "new standard" for molecular diagnosis in labs. There is one competing technology, but even the firm involved in that one believes the CGH array technology is superior. ▪ Currently, it is being sold to other scientists (in the UK, US, but mostly in Canada) on a cost recovery basis in addition to having attracted industrial interest. The BCCA will likely commercialize this technology through an existing company. However, this has been a long time in development, and there are still some issues to resolve on the technical and cost sides in addition to dealing with IP issues. The IP situation is quite complicated because the technology relies on various methods developed by other universities; e.g., BAC (bacterial) clones, amplification methods, etc. Thus, would need to be licensed by BCCA or its partners, and some of these technologies may require cross-licensing with still other inventors. All of this is still being worked out. ▪ The earliest timeframe for realizing some of these benefits would be at least 5 years in diagnostic areas and 10-15 years for therapeutics and new medical products. ▪ One of the key success factors was the commitment and tenacity of researchers working on the project and their expertise with technology and tools (outside of pure research).

	▪ A potential barrier to commercialisation is that at the moment the technology is very expensive and requires specialized equipment and bioinformatics support that could possible preclude smaller labs from using it.
Contribution to international recognition	▪ It is believed that at the present time the current technology developed is the only one of its kind in the world. It is a unique resource. The resulting product has attracted significant interest internationally. ▪ During research and development of the technology, a collaborative relationship with two world leading investigators (US based) in BAC array technology was established. ▪ In collaboration with other sub-projects, a large number of manuscripts are now being prepared or have been submitted to high profile literature such as Nature Genetics and Nucleonic Research. As well, the researchers are receiving numerous invitations to present the technology to international forums such as the American Society for Human Genetics and the Canadian Federation of Biological Sciences. ▪ The resulting end product has yielded a network of international collaborators. This was directly attributed to the technology developed, not the research project, and expected to lead to future grant applications.
Other Project Benefits or lessons learned	▪ The research is supporting other components of the Cancer genomics program (e.g., Oral cancer, lung and lymphoid malignancies, prostate/breast cancer). This sub-project now participates in every solid tumour sub-project. This technology has become part of the core suite of tools available to researchers. ▪ The CGH array technology has provided the technical foundation for three of the new applied health projects that aim to use the technology in a clinical setting. ▪ A number of trainees in leading edge platform development were engaged in the project and they contributed to the increased capacity in bioinformatics in dealing with cancer related gene expression data.
Incrementality	▪ The project would not have been initiated without the funding provided by Genome Canada. The funding was noted as “critical” to this ambitious project and without the infusion of funds, would have perhaps taken twice as long to conduct and results would have been slower to materialize. This may have impacted the researchers ability to be “first in the world” in developing this technology. It was noted that without the funding, the scope would have also been reduced; they may have been able to array small pieces of the human genome, but certainly not the whole thing.

GBC: Fungal Genomics: Comparative and functional genomics of the human pathogen Cryptococcus neoformans

A. Scope of Project/Platform

Goals & Nature of Project/Platform	▪ An outbreak in British Columbia of a sometimes fatal lung and central nervous system infection caused by the Cryptococcus fungus prompted the BC Centre for Disease Control to issue a health alert in June of 2002. The increase in reported cases of cryptococcal disease in the Vancouver Island region provided part of the incentive for this project. ▪ The goal of the project is to identify the virulence mechanisms by which Cryptococcus causes disease in humans. The project aims to complete the sequencing of the gattii genome specifically because this was the variety attacking people with otherwise normal immune systems. This was a change in the paradigm and unique as other cryptococcus genome varieties attack only people with compromised immune systems (e.g., AIDS sufferers). The project would also participate in comparisons with two other sequenced Cryptococcus genomes (grubii and neoformans). Following the comparison of Cryptococcus varieties to determine which genes are present or absent, genome-wide expression studies of the estimated 8,000 to 10,000 genes would then be undertaken to identify which genes the fungus uses in order to infect humans. ▪ The intended beneficiaries of this research in the near term are other researchers who could leverage this work for future studies. ▪ In collaboration with the Genome Sciences Centre, the project has recently released the draft genome sequence of the pathogen Cryptococcus neoformans variety gattii. This provides important information to help identify the cryptococcal strains from Vancouver Island and around the world as well as identifying the genes in the fungus that may play a role in disease. They are currently trying to finish the final sequence. They have completed two rounds towards the final annotation.
Partners Involved	▪ Sequencing & Mapping Platform group at the BC Genome Sciences Centre, BC Cancer Agency. ▪ Some collaboration with The Institute for Genomics Research (TIGR), The Sangford Centre, Duke University, Washington University, Whitehead Institute for Biomedical Research, The Broad Institute, *C.neoformans* research community, BC Cryptococccus Working Group. All of the collaborators on this project donated information to

	allow the project to proceed more efficiently.
B. Project/Platform Impacts	
Socio-Economic Benefits	▪ The research is aimed at eventually contributing to the development of new antifungal drugs and vaccines to treat these cryptococcus infections and better/faster ways to diagnose fungal infections in people. It is of immediate importance to Canada because the cryptococcus fungus is responsible for an emerging infectious disease on Vancouver Island. ▪ A key milestone is the completion of the gattii genome sequence. Once this is in hand, the comparative studies against the other strains can begin, although the principal investigator has elected not to pursue this particular research project any further. It was meant to establish the base to stimulate the research process and further advance research in this area. ▪ Significant additional research beyond the scope of this project would need to be undertaken before realizing benefits. The project serves as the collection of data. Note that any impact or benefits resulting down the line might not be credited back to this project and its researchers because of the timeframe involved. ▪ In order to take this research to commercialisation, the project would need to partner with health and pharmaceutical company(ies). It is estimated that this research would take 5-10 years before any commercial benefit would be realized. ▪ The GBC platforms play an important role in the project. The platforms provide an opportune avenue to obtain the data required for the project at competitive rates. The platforms are well situated to the project needs. Being locally based provides for very convenient and cost-effective service. In addition, the strong relationship with the sequencing and mapping platform at the GSC has contributed to project success. It was noted that the working relationships between scientists were excellent. ▪ Another key success factor is the information that the project has been able to leverage from its other collaborators. The sharing of information was critical to the timeliness of results. ▪ A potential barrier to achieving some of the impacts may be that the focus of the scientists is first on the science and not necessarily as strongly on industrial application.
Contribution to international recognition	▪ One of the key success factors for this project is the very strong collaboration with both the national and international scientific community in this research area held by the PI. ▪ It was noted that there are only 5 or 6 places in the world that research pathogen genomics and this project puts them “in the club.”

	They now have a reputation for pathogen genomics—it is realized that Canada is working in this area. The project is focussed on developing this specific research area and is also contributing to influencing research in this area.
Other Project Benefits or lessons learned	▪ Additional researchers were brought in to work on this project who perhaps otherwise would not have had the opportunity to work in this field in absence of this research endeavour. The project is providing specialist training in emerging diseases and is helping to build up a competent Canadian team. A researcher from the US with experience working with cryptoccocus was recruited for this project. ▪ Training delivered through this project was considered to be of very high calibre due to the association and collaboration with world-class sequencing and mapping scientists. This group of scientists are very well known in their community. ▪ The matching funding for this project did not materialize. The original proposal had an Australian collaborator involved but when the partners funding fell through, the scope of the study was reduced whereby the project ended up focussing solely on the gatti strain. A new funding source was not identified and it was noted that the significant efforts that went into pursuing alternative matching funding slowed the project down. Project plans had to be adjusted accordingly to ensure that the project would be able to operate as a self-contained unit. This change in scope initially slowed start-up and progress of the research. This did not seem to impact the final result, it was noted that they achieved the results they wanted without full funding. This is in part due to sequencing and mapping costs significantly dropping (from $6.50, to $4.19 and recently to $2.77). This has provided a huge cost saving to the project and they do not have a need for further funds at the present time.
Incrementality	▪ It was noted that it would have been unlikely for this bench level research to be undertaken in Canada without support from GBC. It may have been possibly undertaken by other US based organizations (i.e., Whitehead) who have previously completed research in this area. ▪ Funding from Genome Canada was critical to the achievement of project results. There has typically not been this level of funding in Canada to support projects on this scale.

GBC: Microbial Envirogenomics

A. Scope of Project/Platform

Goals & Nature of Project/Platform	▪ The program aims to exploit the physiology and functioning of environmentally important bacteria through genomic approaches. Despite their critical importance, the physiology and ecology of the vast majority of bacteria remain poorly understood. This program sought to apply high-throughput methodologies to further our understanding of Rhodococcus sp. (RHA1). ▪ The main goal of this project was to sequence RHA1 as it had been identified as having interesting bio-pathways and enzymatic activity. Through better genomic knowledge of RHA1 it was hoped that the potential for environmental, industrial and public good applications could be tapped. ▪ The primary beneficiary of this research is science itself – the knowledge of an organism that has not been studied in this way before. ▪ More industrial/commercial applications have been identified. It is believed that this organism could be important in environmental cleanup, bioremediation, and pharmaceutical applications. ▪ The RHA1 organism has been completely sequenced and some novel enzymes and bio-pathways have been identified. Work is ongoing to explore these interesting findings and identify other areas for potential application.
Partners Involved	▪ GBC is the funding partner. ▪ Collaboration with Nagaoka University in Japan. One of the professors there is a world expert in RHA1 and was the source of the organism. They work closely with him. ▪ Some collaborations with Michigan State University, University of Madrid, University of Constance (Germany), MIT to list a few – these are mostly sharing knowledge and helping them drive the project forward. They have also had helpful discussions with Pacific Northwest National Lab and Oakridge Lab in the US. ▪ An industry partner has supplied them with some control material for testing purposes. ▪ UBC provides infrastructure and commercialization/technology transfer resources. UBC has also been very involved helping them plan interactions with GBC and GC. They also pay the salaries of the

	researchers. ▪ There are currently no industry partners although some key industry players have been involved in discussions and are interested in following the development of this project. ▪ This project utilized the sequencing and mapping platform and this was very important in their success. If the platform hadn't been able to sequence the genome for the researchers, the investigators would have had to go elsewhere to get this done at a much higher cost or waited until someone else sequenced it.
B. Project/Platform Impacts	
Socio-Economic Benefits	▪ The organism has two major areas of value identified to date: o Environmental Cleanup – links in with the Kyoto agreement although there is very little money out there to develop this. o Green Chemistry – using enzymes to carry out reactions in industrial feedstock production, rather than using toxic chemicals and/or catalysts (specific applications in the production of pharmaceuticals). ▪ They are developing new processes and have discovered some very novel enzymes but all of these need further development and this is not their role of expertise. Continued investment and work on this by a third party would be critical to the realization of these benefits. ▪ They have currently filed two patents as a result of this project, but the value of these patents are unknown. ▪ The earliest timeframe for realizing some benefits would be 3-4 years in some of the identified applications, others would be 5-10 years away. ▪ GC funds basic genomics research and this project is very far from commercial outcomes. ▪ Factors for success would be continued funding to advance these projects and follow the promising threads further (not necessarily through GBC). It is important to continue the good team dynamics and expertise that they have. It is also important to protect the IP at an early stage in order to garner interest from companies (although one respondent feels that they jumped the gun in this respect, what they have protected is not that valuable in its current state). ▪ Barriers include the need for stronger marketing and business development support from GBC, including development of realistic and appropriate milestones with industry, and more interaction with, and support to, the academic community.

Contribution to international recognition	▪ This project is not yet a world leader. However, it has built a good community in BC and BC has benefited from this. It has also increased international recognition for the work being done. ▪ They are getting a lot of requests to present at conferences and this to them is a good indicator that their work is well recognized internationally. Most of this recognition is focused on their microbiology expertise though, not the genomics side.
Other Project Benefits or lessons learned	▪ This project has definitely improved capacity, they have been able to hire new people and have increased collaborations internationally. A lot more people are being trained now at UBC and working with world-renowned experts – this is great for the development of HQP. ▪ There is a need to streamline the mechanisms when dealing with Universities, especially around economic benefits. ▪ Many of the issues were due to this project being supported in the first round of funding and GBC has learned a lot since then.
Incrementality	▪ The project would have gone forward without GBC, but the sequencing (which has greatly sped up the timeline of the research results) probably wouldn't have happened. Without GBC, therefore, they would not have found things at the same speed and been able to target their research as quickly. It would also have been completed at a smaller scope. GBC helped the university organize the project and keep things on track. ▪ Also the social and economic benefit to Canada would have been lessened – more work would have been done internationally and they wouldn't be as far ahead of the field.

GBC: Sequencing and Mapping Platform

A. Scope of Project/Platform

Goals & Nature of Project/Platform	▪ Genome BC is building on the unique combination of expertise and infrastructure that already existed at the GSC, to create key genomics resources for research related to cancer, fisheries, forestry, and economically important microorganisms. ▪ In the context of GBC, the goal of the Sequencing and Mapping Platform is to provide infrastructure, support and expertise for projects approved by Genome Canada. ▪ Two major projects of interest that this platform has supported are the Microbial Envirogenomics project that has involved sequencing the genome for RHA1 (noted to have many potential commercial applications) and the full sequencing of the SARS virus. ▪ The sequencing and mapping platform is not just a service provided to the projects, it is a true collaboration. They provide advice and recommendations and share information across projects for added value. ▪ Direct users of the platform would be the genome project leaders/researchers. Overall, most of the projects have a public good element. The platform work strives to get information to the public and research community so that it can be applied for the benefit of public good and the environment. ▪ The sequencing and mapping platform has supported work for fisheries (salmon genomics), forestry (related to disease resistance and wood quality), envirogenomics (sequenced the RHA1 organism), cancer genomics (comparing tumour cells to normal cells and determine how genomes are expressed differently), SARS (sequencing the SARS virus), fungal pathogen (sequencing the genome of a Cryptococcus strain).
Partners Involved	▪ The sequencing and mapping platform gets substantial monetary contributions from GC and two institutes within the National Institutes of Health (in the US). They also get funding (mostly equipment) from Western Economic Diversification . ▪ They do work on a smaller scale with some CIHR funded projects. ▪ Most of the collaborations are at the project level and there are too many to list (lots of collaborations with Universities in Canada, the US and internationally).

B. Project/Platform Impacts	
Socio-Economic Benefits	They are doing basic research, therefore the time scale to a clinical application or any commercial application is quite long (10-15 years), however all of the projects that they have supported do have commercial applications. Some examples are discussed below. ▪ SARS: the genome sequence is a key step in understanding what components of the genome should be used in vaccine candidates (this is well underway internationally). ▪ Forestry/fish genomics: this work includes studies of disease resistance, how to make organisms more resistant to various viruses, parasites, insects, etc.. ▪ Microbial Envirogenomics: understanding the genome could lead to applications in therapeutics and industrial applications. There is a great potential to find new enzymes to enable faster, more economical chemical processes (including development of antibiotics and medications). ▪ The platform also has economic benefits for the researchers. They are able to get this work done much faster and cheaper with the sequencing and mapping platform than using other alternatives. The affiliation with GBC also allows for some prioritisation of the work that would not occur if they went to one of the other labs (there are probably 6 others worldwide with the same capabilities – none in Canada). ▪ Barriers to success would include funding and retaining the appropriate expertise (both in intellectual capacity and infrastructure requirements).
Contribution to international recognition	▪ Although initially not a GBC project,the work on the SARS virus made a significant contribution to international recognition. This was a key piece of work that is being continuously developed by high profile researchers internationally. ▪ They are internationally recognized and have an excellent combination of technical expertise in specific research fields – mostly the resource industries (salmon and forestry in particular). In the area of cancer genomics they are not world class – this is a much more competitive area, but in niche areas that are specifically important to BC they are world leaders. ▪ All of the GC and GBC funding is directed towards applied genomics. All of the other major sequencing and mapping centres invest heavily in research on their own (to further develop instrumentation, training researchers, new methods etc.). Having this capacity would increase their international recognition.
Other Project Benefits or	▪ This type of work definitely provides an “economy of scale”. The

lessons learned	additional funding by GC allows them to create much more capacity in generating more data, quickly and cheaply (like an assembly line). ▪ There has been training of technical staff but they have not built the intellectual capacity to develop new methods (specifically for high throughput genomics). Being focussed on providing service does not leave room for development in this area so far (although they would like to pursue this model). ▪ GC funding has allowed the platform to expand the breadth of their capabilities. Before the funding came along they were very focused on human health oriented projects, now they are going into different areas (e.g., bovine).
Incrementality	▪ The sequencing and mapping platform has been critical to GBC projects in getting them good data to further their research. They are able to provide this service with a much faster turn-around time and much cheaper than alternative routes. ▪ In addition, the sequencing and mapping platform is providing experience in technologies that generally do not exist within individual projects. ▪ Without the platform, many of the projects would still have gone ahead but without the sequencing information, therefore it would be more “trial and error” approach or they would have to wait until others sequenced the genomes and use their data. The platform allows them to be in a position to be world leaders.