Fraser River Basin Assessment Program : Final Workshop Report

by : David P. Bernard
ESSA
1993

Fraser River Basin Assessment Program

Final Workshop Report

Prepared for

Environment Canada
Environmental Surveys Branch
224 West Esplanade
North Vancouver, B.C. V7M 3H7

by

David P. Bernard
Trent M. Berry
David R. Marmorek

ESSA Environmental and Social Systems Analysts Ltd.
Suite 300, 1765 West 8th Avenue
Vancouver, B.C. V6J 5C6

February 5, 1993

Citation: **Bernard, D.P., T.M. Berry, and D.R. Marmorek.** 1993. Fraser River Basin Assessment Program: Workshop Report. Prepared by ESSA Ltd., Vancouver, B.C. for Environment Canada, Environmental Surveys Branch, North Vancouver, B.C. 38 pp.

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Acknowledgements

The authors would like to thank all of the workshop participants for generously sharing their knowledge and information concerning the Fraser River system with us, and for their patience during the workshop. As well we would like to acknowledge our colleagues at ESSA, Karen Paulig for research, editing, and logistical assistance; and Susan Landriault and Gwen Eisler for their word processing expertise. Taina Tuominen and Bonnie Antcliffe provided comments on the first draft of this report. Special thanks are due to Taina, Bonnie, and Mark Sekela, all of Environment Canada, for their guidance and financial support in this project.

1.0 Introduction

On June 1, 1991 the federal government announced the six-year, $100-million Fraser River Action Plan (FRAP). The goal of the FRAP is to reverse environmental degradation, rehabilitate the Fraser, and develop a management program to achieve sustainable development in the basin. The Environmental Quality Component of the FRAP is responsible for identifying current levels of contamination, developing information to anticipate and avoid pollution problems before they occur, and measuring changes in environmental quality due to pollution abatement measures. In order to help accomplish the above tasks, a new program, the Fraser River Basin Assessment Program (FRBAP), is now being designed for implementation starting in the next fiscal year.

1.1 Fraser River Basin Assessment Program

There are five main objectives that have been identified for the Fraser River Basin Assessment Program. These are to:

1. determine the current condition of the Fraser River Basin;
2. measure changes in the river over time, especially in response to abatement activities;
3. develop information to anticipate and avoid environmental problems;
4. produce data to support development of environmental quality objectives; and
5. advise the Research Component of the FRAP on matters pertaining to: (a) environmental monitoring and surveys, and (b) interpretation of research results.

The most immediate goal of the FRBAP is to begin monitoring work in the Fraser Basin during the next fiscal year. As a first step toward developing this field program, discussions were held in the Fall of 1992 between federal and provincial authorities regarding the potential scope and elements for the FRBAP. Next, a discussion paper was prepared providing relevant background information and raising key design issues for the field program (Bernard et al. 1992). Finally, Environment Canada (EC) sponsored a workshop in Vancouver from December 1-3, 1992 for around 40 participants. This workshop provided a forum for exchanging ideas, identifying assessment and monitoring (not research) priorities in the Fraser River Basin, and began the process of developing the FRBAP field program for implementation in FY 1993.

1.2 This Report in the Context of the FRBAP

This report records highlights from the plenary and subgroup discussions that took place during the December FRBAP workshop. A list of participants is provided in Appendix A, and the Agenda is reproduced in Appendix B. The report structure essentially follows the workshop structure. In Section 2, we report on the subgroup discussions that focused on describing stressors and abatement opportunities in the various Fraser sub-basins. Finally, in Section 3, we turn our

attention to the sub-group discussions that revolved around monitoring plans as a function of stressor type (e.g. point sources, non-point sources, and non-stress specific).

Current plans call for ESSA Ltd. to complete a *Draft Monitoring Design*, describing the proposed FRBAP field program, by mid March, 1993, and a *Monitoring Design* by the end of April, 1993. An outline for the Draft Report is provided in Appendix C.

2.0 Stressors and Monitoring Needs

After the initial workshop presentations were concluded, participants were divided into three subgroups, based on geographic subregions of the Fraser Basin. The three subgroups were: 1) Upper/Middle Fraser; 2) Thompson Basin; and 3) Lower Fraser. Each subgroup was instructed to examine the assigned subregion and to identify:

- major anthropogenic stressors on the river system;
- key scientific and policy questions pertaining to those stressors;
- existing programs that are generating data relevant to those questions; and
- a possible niche for the FRBAP (or FRAP).

2.1 Upper/Middle Fraser

This subgroup chose to cover three topics: 1) stresses and related monitoring needs for the Nechako-Stuart-Upper Fraser subregion; 2) stresses and related monitoring needs for the Middle Fraser subregion; and 3) non-stress specific monitoring needs and opportunities in the upper and middle Fraser subregion. Item (3) is covered in Section 2.4; the others are discussed below.

Nechako/Stuart/Upper Fraser

The subgroup identified four major issues for this sub-basin: 1) changes in hydrologic regime; 2) effluents from the proposed Vanderhoof pulp mill; c) sewage pathogens from sewage treatment plants; and 4) logging. In addition, the subgroup also identified old abandoned mine sites as a more regional, but stress-specific, issue.

With respect to changes in hydrologic regime, this issue was deemed to be relevant at multiple scales, from small tributaries to the entire basin. Participants identified three main questions:

1. how do changes in hydrological regime due to any of several factors (e.g. Kemano, water withdrawals, climate, logging) affect biota (e.g. fish survival, fish and benthic community structure) or dilution of pollutants?
2. how do air temperature, sunlight, and wind affect hydrologic regime and water temperature?
3. what are appropriate water **quantity** regulations and control options?

Several programs are already generating data relevant to these questions. These include: Kemano Completion Project (KCP), federal-provincial stations on the Nechako at Prince George, Department of Fisheries and Oceans (DFO) temperature criteria, federal flow stations, and the National Hydrological Research Institute (NHRI) macrophyte study. A suggested niche for the FRAP (not just the FRBAP), relative to this particular issue, would be to:

- develop a simulation model capable of predicting flow and temperature from climate inputs;
- extend the flow/temperature record upstream from the Stuart confluence;
- fill gaps in the KCP and DFO fish monitoring programs; and
- add benthos and primary production monitoring.

Concerning potential effluents from the proposed Vanderhoof pulp mill, participants deemed this to be a local scale issue, with the main question pertaining to chronic toxicity of released compounds to aquatic organisms. Existing programs include Canadian Wildlife Service (CWS) osprey studies, B.C. Ministry of Environment, Lands, and Parks (MELP) baseline studies and permit-related studies by the proponent. Participants indicated that there is probably no need for FRAP to be involved in this issue.

Pathogens contributed to the Fraser River from sewage treatment plants are probably a local scale phenomenon, but the key question is the spatial variation in the presence and abundance of these organisms. The existing provincial compliance monitoring programs were deemed adequate and there is no need for FRAP involvement.

With respect to the issue of logging effects on the Fraser River, the appropriate scale varies from the tributary up to the regional level and the key scientific question, relative to the FRBAP mandate, is: "what are the past, present, and future **aquatic** ecosystem effects of logging?" Concerns focus mainly on nutrients, suspended sediments, and carbon and the consequences of changing concentrations and availability on primary producers (e.g. algae), benthos, and fish. A few existing programs that may generate data and information pertinent to this question were identified, including:

- the Stuart-Takla headwater study (c.f. Steve MacDonald, DFO, West Vancouver); and
- an extensive survey of benthic invertebrate responses to watershed activities in the coastal Western Hemlock region of the Lower Fraser valley (c.f. Bill Neill, U.B.C., and John Richardson, S.F.U.).

A suggested niche for the FRAP would be to examine regional scale effects of logging, although the participants were unclear on an appropriate method or approach. One useful starting point is to begin by reviewing other, ongoing work, to assess the suitability of approaches used elsewhere (e.g. U.S.A.).

Although participants concluded that there was no suitable niche for the FRAP in dealing with the issue of old, abandoned mine sites, they did indicate that there are important scientific questions pertaining to acid rock drainage (ARD) that need to be answered for the Fraser Basin. Currently there are no projects to provide answers to these two key questions: (a) how many sites are there in the basin, and (b) what is the extent and severity of ARD impacts?

Middle Fraser

The main issue discussed for this portion of the basin was the discharge of pulp mill effluents. Participants indicated that this is a local to regional scale issue and that the two main scientific questions are:

1. what is the chronic toxicity to aquatic organisms of released compounds; and

2. what affect will future abatement activities have on aquatic communities, and will this constitute "recovery"?

Currently there are four programs in operation generating data that can help answer these questions:

- federally-mandated environmental effects monitoring (EEM) at the pulpmill;
- provincial permit requirements (to be finalized June 1993);
- native fish surveys; and
- CWS studies of mink, otter, and osprey.

Participants saw a number of important and substantial opportunities for FRAP involvement in this issue, including:

- testing effluent toxicity on wild fish;
- determining fish distribution to help select species to use in monitoring and toxicity testing;
- assessing the extent of impacts beyond the near-field zone (except for dioxins/furans in fish flesh where such studies are already regional in extent);
- assessing benthic sampling techniques (substrates, statistical power);
- mapping sediment deposition areas and monitoring suspended sediment levels; and

- increasing the power of the EEM program[1] by adding points to the time series for fish and benthos.

2.2 Thompson Basin

The general issues identified in this sub-basin were:

- forest land development;
- urban development;
- agriculture;
- highway development (linear developments in general);
- a pulp mill; and
- mining (very localized).

The group mapped all existing point stressors in the Basin and the major regions for non-point stressors. The group also identified the location of existing federal-provincial water quality monitoring stations as well as the location of major provincial monitoring programs. It was noted that the Thompson River Basin probably represents one of the **most well-studied portions of the Fraser Basin** with potentially good historical data bases to support assessment and the design of a monitoring program.

The existing monitoring/research programs in this sub-basin include:

- **Canadian Wildlife Service:** An osprey study and diving ducks study (on Kamloops Lake) are planned this spring to look at blood contaminant levels;

- **Weyerhauser:** Benthic structure is monitored at two sites (upstream and downstream from the mill) in February and March; water chemistry is monitored weekly or biweekly downstream of the lake. This program will be altered somewhat when EEM comes into effect;

- **B.C. MELP and Pulp Mills:** This is a joint program to monitor dioxins/furans and fish tissue (Suckers, Trout, Crayfish and Mountain Whitefish);

- **DFO:** The group thought there must be data from federal hatcheries in the region and from fish surveys by DFO (also escapements);

- **NHRI:** NHRI has conducted studies on trophic production gradients (up to Dace) downstream of the mill. They have also conducted flume studies on UV effects, grazer/biofilm interactions and dioxins;

[1] Only sampled every three years (e.g. 1994, 1997).

- **Lake sediment cores:** A sediment core was taken (and analyzed?) in Kamloops Lake 2 years ago;

- **Archived samples:** There are numerous samples from this region taken by from mills and the provincial government which have been archived and require analysis;

- **Environment Canada:** EC has collected samples for contaminated suspended sediments this fall and will collect samples this winter; and

- **BC MELP:** MELP has conducted more sporadic and localized sampling throughout the region on a number of parameters.

The group also discussed the main contaminant sources in the sub-basin and the types of contaminants of concern. Contaminant sources included:

- the pulp mill;
- sewage treatment plants;
- urban runoff;
- livestock;
- forestry;
- agriculture;
- mining; and
- LRTAP.

The types of contaminants of concern included **toxics**, **nutrients**, **suspended solids**, **suspended sediments** and **pathogens** (indicated by coliform bacteria).

Some **specific questions** identified by the group which may potentially be addressed by FRBAP include:

- Are toxic contaminants at "problem levels" (i.e. are persistent compounds bioaccumulating to levels which may cause harm or are less persistent compounds causing detrimental changes in organisms physiology, behaviour, etc.)? Are concentrations of these compounds in various environmental media (and/or releases of these compounds) increasing? decreasing? or moving around?

- How does spatial or temporal variation in nutrients (measured, for example, by organic C) change trophic structure and function? Do nutrients have to be controlled? What is the relative importance of heterotrophic vs. autotrophic processes in biofilms?

- Do most contaminants move in and out of the basin at times of episodic sediment transportation? Are there localized effects from sediment episodes? Are there effects not related to episodes?

Throughout the discussion it was clear that one important role of FRBAP may be coordination of existing programs. A complimentary niche for FRBAP may be filling in data

gaps. The goal of both coordination and filling data gaps should ultimately be characterization of ecosystem condition. In order to make such an assessment, **baseline information** on community variables, discharge sources and a history of effluent discharges and their effects may be required. It was clear that assessment will require not only monitoring but also additional **research and inventory.**

2.3 Lower Fraser

This subgroup identified five contaminant-related stressors of key importance in this portion of the basin: agricultural chemicals, woodwaste leachate, urban runoff, atmospheric deposition, and municipal wastewaters. They also discussed the fate of contaminants from "upstream" sources that flow into this sub-basin. Finally, the group identified a number of non-contaminant issues, such as riparian zone damage or loss, water withdrawal, and chemical spills or leakage, that can also affect the integrity and function of the Fraser ecosystem. Each of these topics is discussed in the following sections.

Agricultural Chemicals

Participants identified chemicals from agricultural activities and golf courses as a concern in this portion of the basin. The key scientific and policy question was: "are contaminants from these sources present at 'problem' levels, with respect to (a) water quality, (b) sediment accumulation, and (c) biota?" A number of existing programs are already in place that deal with this issue, including:

- water quality monitoring at the Federal/Provincial station on the Fraser River at Hope and on the Sumas River;
- water quality monitoring by the Fraser River Estuary Monitoring Program (FREMP) for ammonium, nitrates, nitrites, and pesticides (at selected sites);
- a study of pesticides in Fishtrap Creek (of transboundary concern);
- pesticide problem assessments pertaining to the 10 meter zone;
- groundwater investigations for pesticides, nitrates, and nitrites;
- provincial (?) agricultural waste regulations; and
- provincial (?) environmental guidelines.

Participants saw two potential niches for the FRAP: 1) monitoring at tributaries; and 2) integration, synthesis, and interpretation of results from other studies. With respect to the first option, participants suggested that before monitoring is initiated, discussions should be held with Agriculture Canada. If monitoring is to be done, then it should be carried out at the first flush following low flow conditions. Moreover, participants suggested beginning such work with an in-depth pilot study before attempting a broader program.

Woodwaste Leachate

Leaching from woodwaste storage sites was another contaminant source identified by participants as a concern in the lower portion of the Fraser basin. The key scientific and policy question identified was: "are contaminants from this source present at 'problem' levels, with respect to (a) water quality, (b) sediment accumulation, and (c) biota?" In the past, there have been several important "problem/solution"-type projects dealing with this issue. Now there are DFO/EC guidelines to protect fish and fish habitats from these chemicals. Consequently, there are only occasional compliance samples now being taken. Participants recommended against FRAP involvement in this issue.

Urban Runoff

There are many sources of urban runoff in this portion of the river, and a very wide array of contaminants are introduced through these discharges. Participants wanted to have an answer to the question: "are contaminants from urban runoff present at 'problem' levels in the lower Fraser and associated tributaries, and are these contaminants degrading water quality, accumulating in the sediment, and affecting biological communities?" Several programs are already in place dealing with physico-chemical aspects of urban runoff, but apparently there are none that are focusing on the biological consequences. Existing programs include:

- Greater Vancouver Regional District (GVRD) monitoring at outfall locations;
- combined stormwater/sewage outfall monitoring;
- provincial urban stormwater guidelines; and
- municipal regulations.

Participants suggested two possible activities for the FRAP: 1) investigate the fate and effects of urban runoff in an urban tributary, as a first step toward more comprehensive studies and modelling; and 2) determining the "chemical signature" for specific stormwater sources. Having "chemical signatures" for stormwater sources would then permit scientists to use sediments to help determine the fate and effects of chemicals from specific urban runoff sources as a prelude to possible abatement.

Atmospheric Deposition

It was suggested that in the lower Fraser basin, the atmosphere may be a source of metals, pesticides, and hydrocarbons to tributary streams that flow into the Fraser River. There is a small amount of work presently being done on this topic, notably:

- measurements of atmospheric inputs of chlorinated hydrocarbons and pesticides into Kanaka Creek; and
- studies of acidic deposition into Jacobs Lake.

Someone also indicated that the GVRD may be doing some work related to this topic. Participants felt that this topic was interesting, but not to the FRAP. However, there was some interest in seeing limited, pilot level, work done to determine the mass balance for levels of metals, pesticides, and hydrocarbons in stormwater runoff for a tributary stream.

Municipal Wastewaters

There are numerous sites along this portion of the river where municipal wastewaters are discharged from sewage treatment plants (STP) following collection and treatment. Participants in this subgroup agreed that an important question pertinent to this issue is: "are municipal wastewaters present at 'problem' levels in the lower Fraser River, and are contaminants from this source degrading water quality, accumulating in the sediments, and affecting biological communities?" Several programs are already in place dealing with this issue, including:

- compliance monitoring, carried out in fulfilment of terms specified in each wastewater discharge permit;
- monitoring by the GVRD for special factors (e.g. ammonium, bacteriological conditions, metals) at selected sewage outfalls and sediment accumulation zones; and
- special receiving-water studies at sites around the Iona plant including biological studies at Sturgeon Banks.

Subgroup participants suggested three possible activities for FRAP: 1) dilution zone definition, especially for tidally reversing waters; 2) biological studies to verify bioaccumulation predictions; and 3) fate and effects studies for STP effluents.

Contaminant Fate

An important question for the lower Fraser valley is: "what contaminants are being transported into this sub-basin, where does it end up, and what are the environmental effects?" Existing programs that are providing information and data relevant to this question include:

- federal/provincial water quality stations on the Fraser River;
- FREMP and predecessor program(s);
- contaminant studies on salmon and other fishes looking at body burdens and responses through biochemical and physiological pathways; and
- contaminant studies on birds such as heron, cormorant, and eagles.

Four distinct opportunities were identified for FRAP/FRBAP involvement in this issue: 1) develop information on contaminant **loadings**, as opposed to concentrations; 2) speciation of compounds in the water column and associate them with particular sediment fractions; 3) locate

sediment deposition zones in this portion of the river; and 4) determine residence time for compounds passing through or deposited in this portion of the basin.

Non-contaminant Issues

Five non-contaminant issues also surfaced during these subgroup sessions. None of the following issues were advanced as being a critical part of either FRAP or FRBAP, but are mentioned here mainly for completeness:

1. **riparian zone damage or losses:** This was identified mainly as a fisheries issue. It was noted that the DFO is already developing guidelines that may help reduce the importance of this issue for the Fraser River ecosystem;

2. **water withdrawal:** Participants pointed out that licensing for surface water withdrawal does not consider in-stream, non-human uses. Thus, withdrawals can have an important effect, especially during low flow periods. Again, DFO is already working on this problem;

3. **global climate change:** Changing global climate patterns may affect both flow and temperature of the Fraser mainstem as well as tributary streams. While this is a potential factor affecting Fraser basin aquatic ecosystems, participants were quick to point out that this is a research issue, and outside the scope of FRBAP;

4. **increasing human population:** One of the FRBAP objectives is to "develop information to anticipate and avoid environmental problems". One of the largest driving variables affecting the status and integrity of lower Fraser River aquatic ecosystems is changes in human population. Participants commented on the potential usefulness of an "assimilative capacity" model that could link development levels with changes in aquatic indicators; and

5. **spills and leakage:** Finally, but certainly not least, subgroup participants indicated that FRBAP may need to use existing records of chemical spills and leakage to help develop loading values.

2.4 Basin-Wide Issues

There were a number of big questions that surfaced during the first portion of the workshop. These included:

- should the FRBAP be developed using a bottom/up (stress - response) or top/down (response - stress) approach to monitoring?

- how can the FRBAP make decisions while other programs (e.g. EEM, KCP) are still being finalized?

- what is the relative emphasis in FRBAP on determining condition and assessing trends versus improving understanding?

- can a variety of different programs by different agencies that are "coordinated" by FRBAP produce an **integrated** assessment? (For this to happen, FRBAP would need a blueprint for the integration process).

Participants in all subgroups seemed to echo a general need for baseline monitoring in order to characterize ecosystem condition. However, research is still required to develop an understanding of how to characterize basin-wide condition and to identify appropriate indicators of condition. As illustrated in Table 1, the level of our understanding and the quality of our data vary greatly, depending on the investigated subject and the location of the study.

Table 1: Relative understanding and data quality for addressing chemical and biological questions in the Fraser mainstem and smaller tributaries.

Location	Chemistry	Biology
Headwaters and Smaller Tributaries	Poor Data	Good Understanding
Mainstem	Good Data	Poor Understanding

Assessment will ultimately have to be tied to the process of goal development and objective setting in the basin. In the meantime, most subgroups felt that FRBAP should focus on issues that we already understand (at least relatively) and for which there is wide-spread concern and interest, such as contaminant fate and effects, and changes in contaminant concentrations and effects with implementation of abatement measures. An additional role for FRBAP may be to fill in data gaps (sampling gaps or variables not currently monitored) in existing monitoring programs.

There was also general recognition of the tension between monitoring in order to **test** specific hypotheses and monitoring in order to **generate** hypotheses. The former will require more intensive studies very near known stressors (i.e. stress-specific monitoring). The latter is characterized by an extensive monitoring program to answer questions about general trends in condition and potential stressors or causes of changes. When extensive monitoring indicates a decline in overall condition or an undesirable change in some valued ecosystem component, hypotheses regarding potential causes may be generated if existing or potential stressors have also been monitored. These hypotheses may then be tested through additional, intensive studies (such an approach was recommended by the non-point stressor subgroup in the second half of the workshop). It was also noted that efforts to assess the impact of local stressors and affects of abatement measures may be confounded by global change (e.g. global warming and ozone depletion).

One subgroup developed a conceptual model illustrating the roles and uses for both quantitative and conceptual models in FRBAP (Figure 1).

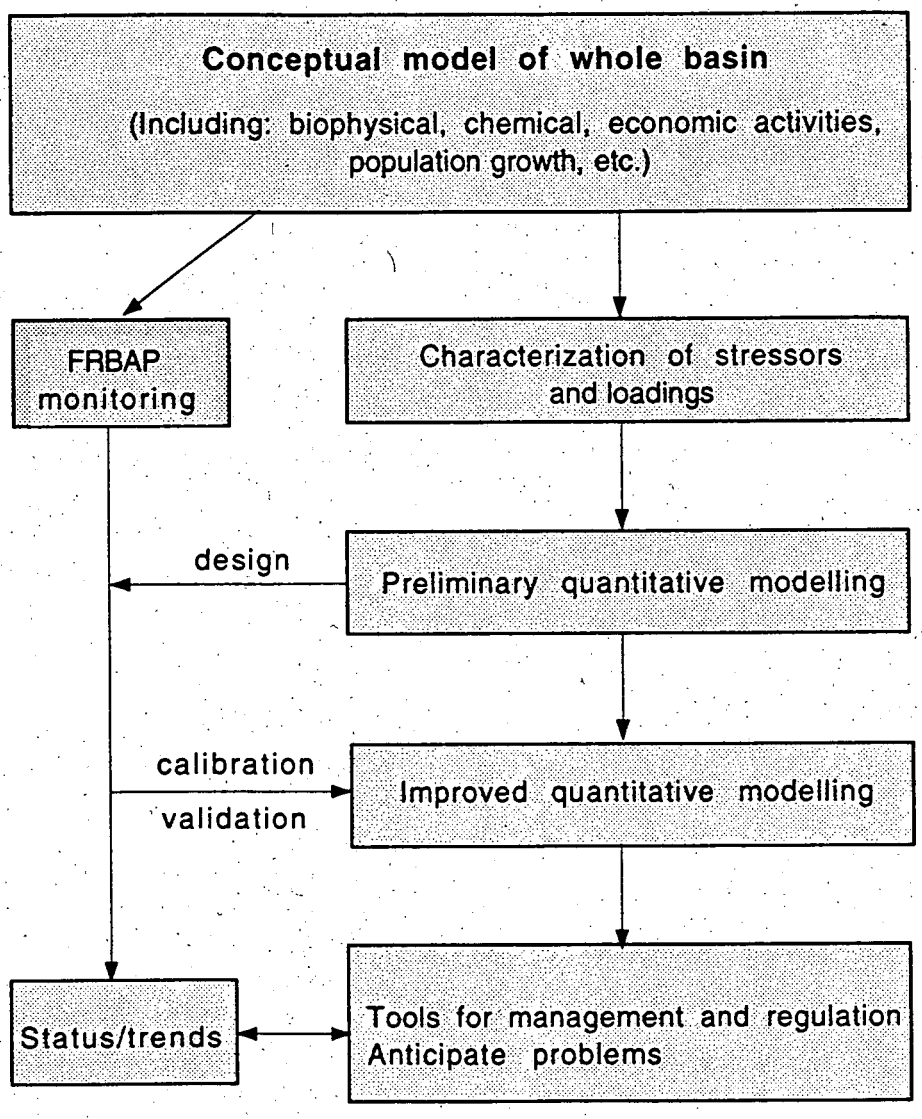

Figure 1: Uses for models in FRBAP.

3.0 FRBAP Monitoring

After hearing presentations from each of the three subgroups, it became clear that the participants had implicitly identified a two-by-two matrix of studies, as shown in Table 2. In cases where the available time frame is relatively short, as in FRBAP, studies will generally need to focus either on known point- or known non-point sources, depending on the spatial scale of interest. To adequately address non-stress specific, more regional level issues not only would require a longer time period, but also a more sophisticated, intensive, and statistically-rigorous sampling scheme.

Table 2: FRBAP monitoring options.

	Local Spatial Scale	**Regional Spatial Scale**
Shorter Time	Point-Source Studies (1)	Non-Point Source Studies (2)
Longer Time	Special Studies (3)	Non-Stress Specific Studies (4)

Part two of the workshop was devoted to making a first attempt to sketch out the major elements of a FRBAP monitoring program. For this part of the workshop, participants were again divided into three subgroups, with each assigned to examine one of cells (1), (2), or (4) in the above matrix. Participants were specifically instructed to answer these questions, pertaining to FRBAP monitoring:

- what to sample? what size change to detect?;
- where to sample? (scale, approximate number of sites, but not specific locations);
- how will the data be integrated?; and
- how will the data be presented?

3.1 Monitoring Terminology

Before reporting results from this portion of the workshop, it is worth trying once again to encourage the use of a more universal set of terms to refer to "monitoring". Macdonald et al. (1991) have provided a set of seven distinct terms that refer to different aspects of what is generally referred to as "monitoring; these terms are described and explained in Appendix D. Generally, though, monitoring consists of gathering a series of observations over time, generally for the purpose of detecting change through time. It is this repetitive nature that sets monitoring apart from either inventory or assessment activities. Inventory or assessment programs can use information and data consisting of single measurements or observations, although a series of

observations can be used to better estimate the parameter(s) of interest. Information from an assessment or inventory can serve as an important first step in designing a monitoring program. For example, estimates of temporal or spatial variability are required for development of an efficient statistical design.

3.2 Monitoring for Point-Source Stressors

This subgroup identified 13 separate types of point-source stressors within the Fraser basin, in nor particular order:

- pulpmills;
- sewage treatment plants;
- stormwater outfalls (from municipal and anti-sapstain activities);
- combined sewer outfalls;
- land fill sites;
- mines;
- dams;
- cement plants;
- paperboard recycling plants;
- metal finishing plants;
- chemical plants;
- food processing facilities; and
- fish hatcheries.

Of all stressor types, point-sources have the largest number of existing programs already in operation. Basin-wide, here are most of the major studies and programs that are currently generating data and information pertinent to point-source issues:

- federal provincial water quality monitoring program;
- permit monitoring;
- water quality objectives monitoring;
- Fraser Port monitoring;
- FREMP;
- contaminant/fish studies (DFO);
- studies on large-scale suckers (SFU);
- studies on leaches, water, and sediments (UBC);
- Phase II of the dioxin study; and
- contaminants in fish below Prince George.

There are also relevant data and information from these sources:

- Environmental Assessment and Review Program (EARP) documents;
- studies that were done on sediment quality as a first step toward ocean dumping; and
- reservoir studies by B.C. Hydro.

Workshop participants, while acknowledging that the existing federal-provincial water quality program is well suited to helping meet the FRBAP objectives, recommended that changes be made in the program, as follows:

1. **Evaluate suitability of existing sites:** All local influences should be documented and the suitability of each site re-examined. Participants suggested that, in some cases, better sites may be available nearby.

2. **Upgrading all stations to full status:** This involves adding flow measurements to the provincial station at Stoner; ensuring that all stations tested for the full suite of variables; adding sampling for sediments (bed and suspended); carrying out pilot studies to determine the suitability of using benthos for routine monitoring; sampling fish during the low flow period and measuring for growth, reproduction, and demographics; carrying out pilot studies to determine the suitability of using primary producers (e.g. algae, aquatic plants) for routine monitoring; and sampling every five years for contaminants in fish.

3. **Additional parameters:** Total dissolved carbon should be added to the suite of tests administered to samples taken under this program. As well, participants recommended that the policy of periodic reviews be continued to identify parameters or sampling methods that can be replaced, and ones that should be added.

4. **Additional stations:** In order to estimate loadings, it will be necessary to have a new station near Lytton (above the confluence with the Thompson River).

5. **Coordinate sampling across programs:** This involves ensuring consistency from one program to another in sampling timing and methods, analytical procedures, and data reporting formats, among other considerations.

In the case of provincial water quality objectives monitoring (WQOM), participants noted that this program is not well suited to supporting the assessment aspects of FRBAP, since the WQOM program deals with only a few regulated chemicals. However, the WQOM program could provide useful background data in some cases, and may be helpful in determining abatement effectiveness for certain locations. In contrast, for those parameters included in the WQOM program, the data may prove suitable for trend detection, especially in those (limited) cases where there are now five years data. A role for FRBAP, relative to the provincial WQOM program, might be to test for biological effects at the same sites. As well FRBAP may wish to add parameters to those that are already part of the WQOM program.

Permit monitoring (PM) occurs at many point-sources throughout the basin, but is generally restricted to loading information for a limited number of parameters, although in some cases PM may include ambient measurements. Moreover, while loading measurements are continuous in some cases, in others they may be as infrequent as monthly, or less. Currently, Westwater is compiling an inventory of all permit monitoring results. Workshop participants suggested that, from an assessment standpoint for FRBAP, PM results are most valuable as a planning tool and might be useful later in modelling efforts. As well, in some (limited) cases,

permit monitoring data may be useful for trend detection. An appropriate niche for FRBAP could be in sampling between periods required in the permit or EEM program, and providing additional control sites for comparative purposes.

The Fraser Port and FREMP programs can be useful to the FRBAP in providing sediment data that are useful for both assessing baseline chemistry and toxicity, as well as evaluating trends through time. The fish dataset is also potentially useful for trend detection. Overall, information and data collected by this program could serve to help FRBAP locate stations in the lower Fraser river.

In the area of aquatic biota, there are a large number of current and past projects that could be useful in performing an assessment under the FRBAP. Unfortunately, to date there has been little synthesis, with the possible exception of DFO which is now performing this function for some fish studies. For trend detection, there is some longer-term biological work being done (e.g. at pulpmills, and DFO fisheries work), but again, there has been few attempts to pull these data together to determine whether or not there are any discernible trends. Thus, there are two tasks that need to be done. The first involves "tracking" ongoing studies, but this is probably best left to the new Fraser River Board. The second involves synthesizing results, and might be appropriate for the FRBAP. Synthesis and tracking should probably both be done on a sub-basin basis, and then integrated upward to the basin level.

3.3 Monitoring for Non-Point Stressors

During discussions with this sub-group, it became clear that there are really four groups of tasks required for an overall assessment. A prerequisite for any non-point stress monitoring program is a conceptual model of the impact of a particular non-point stressor. However, it became clear during our deliberations that these models must be spatially stratified. That is, a conceptual models for impacts at a variety of scales are required (e.g. local, a tributary, a sub-basin). It is not clear that a single model can simply be scaled upwards. Each of these models can then be used to generate impact hypotheses at a variety of scales. The scale of interest will determine which impact hypothesis is most relevant. Research (or research-oriented monitoring) may then be undertaken to verify hypotheses. These models and impact hypotheses can then be used to build a quantitative model which can serve as a guide for parameter selection (e.g. identify most rapid response variables for early detection), and to serve as a guide for site selection (e.g. where impacts are most likely to show up first). a model is also useful in overall experimental design (i.e. number of replicates and samples, and the frequency or spatial extent of sampling).

An important parallel task in this process is producing an inventory which provides both potential baseline data, as well as one means of verifying the model. The sub-group identified the following inventory needs with respect to non-point stressors (not an exhaustive list):

Forestry

- road construction (e.g. length and rate)
- logging practices (e.g. clearcut or selective)
- silvicultural practices (e.g. herbicide or fertilizer use)

Agriculture	• crop types and rate of land conversion
Urban Development	• population density • type and extent of zoning
Recreation	• type, density and intensity • foreshore impacts
Linear Developments	• development type • proximity to water • length • risk

The group also had some recommendations regarding the location of monitoring stations and types of parameters which should be measured. The group agreed that the federal/provincial stations should be maintained but that some additional variables should be added at some (e.g. agricultural regions such as the Sumas, Nicola, Thompson, Salmon, and Bonaparte Rivers):

- periodic measurements of pesticides in sediments (biota?);
- coliforms;
- primary productivity (periphyton and suspended; chlorophyll-a; TOC).

The group recommended sediment monitoring at all of these stations. The reason for sediment monitoring was not to detect impacts of non-point sources, such as forestry. It was pointed out that erosion of Quaternary sediments within the channel itself cause specific sediment yield to increase until basin areas of about 10,000 km^2. This means that any signal from non-point sources would be drowned by tremendous noise in the mainstem. Sediment monitoring at existing stations was seen, instead, as an important means of assessing impacts of sediment on water quality (e.g. contaminant fluxes). It was pointed out that sediment monitoring at Hope stopped just as the province began water quality monitoring. Thus the two data sets do not overlap and a relationship cannot be determined (such as the one between water yield and quality).

The group recommended initial monitoring in medium-sized tributaries to detect impacts from non-point sources (e.g. sediment inputs). If impacts are measured, monitoring may move up the channel to lower ordered streams to test hypotheses regarding the relative contribution from different non-point sources and different intensities of non-point activities.

3.4 Non Stress-Specific Monitoring

The goal of non-stress specific monitoring is to define the overall condition of the Fraser River basin. The subgroup identified a number of general principles to guide this regional characterization work:

- in selecting sites, try to avoid the biases induced by choosing site- or stress-specific locations;

- choose sites that are as close to regionally representative as possible;
- focus monitoring efforts on well-mixed areas in the rivers;
- provide data for statements of overall basin or sub-basin condition, not just for the Fraser mainstem;
- work top-down (and upstream) in terms of indicators' diagnosis of problems;
- position regionally representative sites so that they can also act as reference sites for stress-specific monitoring;
- provide results in a format that can also be used in State-of-Environment reporting;
- recognize that bigger rivers and demonstration watersheds "wash out" variation, and that additional work in small basins may be necessary to complement work in larger systems;
- consider both lakes and streams;
- either capture "basin-wide" influences (e.g. long range transport of atmospheric contaminants), or flag them as "ignore, beyond our control", or control for these effects in the monitoring design;
- attempt to capture cumulative effects that are apparent sub-basin- or basin-wide;
- consider biota, sediments, water quantity and quality and temperature;
- whenever possible, build on the existing federal-provincial water quality network;
- use a gradient of drainage areas;
- involve volunteers (e.g. for small stream event sampling); and
- maintain flexibility.

Determining "Condition"

The subgroup identified five questions that can be used to judge "condition": 1) can I swim in it; 2) can I drink it; 3) are the fish safe to eat, and do they look, smell, and task OK; 4) does the water look, smell, and taste OK; 5) is the ecosystem healthy? The last question involves determining whether or not fish populations are thriving, there is an adequate food base for the fish, and that the ecosystem productivity is maintained through time.

After carefully examining all 13 sub-basins outlined by Dorcey et al. (1991), participants in this sub-group identified 12 possible new FRBAP sites that would be suitable for non-stress specific monitoring (Figure 2). These sites were selected using sub-basins as a stratification option. However, the basin could be stratified on the basis of ecozones, streams and lakes, stream order, land use, or some combination of the above. The site selection procedure was to place stations at the junction with the main-stem for tributaries. An alternative would be to use a grid approach for smaller tributaries.

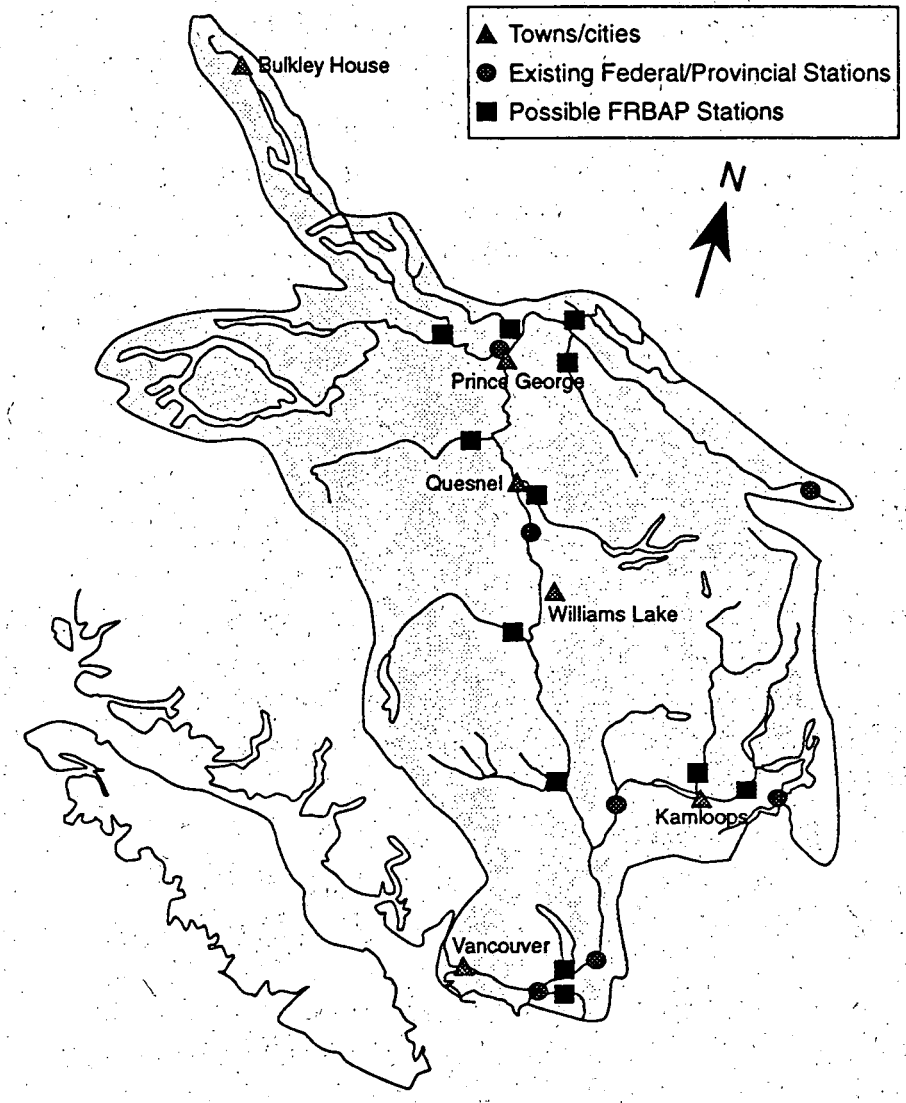

Figure 2: Location of existing federal/provincial stations and possible non-stress specific FRBAP stations.

The sub-group evaluated the existing federal-provincial program for suitability in determining condition and found that the stations are not truly regionally representative. In some cases they were selected for ease of sampling or proximity to flow stations. More importantly, some are not well mixed and are in locations where mixing is important (e.g. Hope, Hansard, Spences Bridge, and Sumas). The sub-group, therefore, recommended adding 2 to 5 new stations, systematically chosen on the main stem (e.g. Mission, Lilloet), some of which would be just for physical parameters (e.g. temperature, flow, conductivity). In addition, the group suggested reducing the sampling frequency, since only carefully selected seasonal samples are required to calculate an annual mean value. They also noted that it would be valuable to have some event-triggered samples.

A summary of the sub-group recommendations for what to monitor follows.

Federal-Provincial and FRBAP Tributary Sites

1. **Temperature, flow, conductance:** These three variables should be monitored to assess conditions in the tributaries and to document stress on fish. Monitoring should be continuous during July and August.

2. **Suspended sediment and/or turbidity:** These variables are not only considered contaminants in their own right, but they may be indicators of logging or agricultural land uses in the watershed. However, when monitoring it is important to recognize that about 90% of the suspended materials are moved in only about five days each year. Thus, it was suggested that monitoring for these variables be limited to about five tributaries. Monitoring for suspended sediments should be done during high flow, but turbidity could be monitored continuously.

3. **Benthos (biomass, trophic structure, indices):** The purpose for monitoring benthos is that this portion of the aquatic ecosystem integrates stresses through time. The recommendation was to standardize for the habitat type (e.g. rubble, sand), and to take five pseudo-replicates per station. Annual sampling was suggested, in the late summer or early fall.

4. **Small fish (e.g. sculpins):** These fish are ubiquitous residents, and they can be used to screen for contaminants. If contaminants are present, then investigations should continue upstream. Single sampling is adequate, unless problems are detected.

5. **Biofilm (chlorophyll a, ash free dry weight):** This is a good indicator of eutrophication, and sampling is only required once per year, each year.

6. **Water chemistry (ortho-phosphorus, base cations, anions):** These data are needed to help interpret observed changes in benthic communities and the biofilm. Following a sensitivity analysis of existing data, sampling can probably be seasonal. Collecting data seasonally will allow for calculation of a rough estimate of the annual phosphorus loading.

7. **Merganser eggs (?):** The eggs of this species contain contaminants in higher concentrations, so they are a good indicator of contaminants in the food supply. Sampling only needs to be done once per year, each year.

Lakes

8. **Sediment cores and fish tissue:** Although not clearly a suitable topic for the FRBAP, workshop participants suggested that collecting sediment cores and fish tissues from lakes would permit development of a history of contaminant loads (e.g. lead, mercury, PCBs), land use impacts, and climate changes. Sampling once should be adequate.

3.5 General Issues

During sub-group discussions, a number of other issues arose. For example, participants suggested looking for opportunities to use common methods, procedures, and timing across programs. They also recommended periodic program reviews to both update sampling designs and the list of measured parameters. They advised tailoring monitoring approaches to the stressors present, and to the river reach and ambient conditions. It was assumed that there would be a strong QA/QC program, not just for the field portion of FRBAP, but also for the laboratory and data handling and analysis components as well. The issue of data access was raised, but there was no discussion of this topic. Finally, participants from several subgroups emphasized the need for strong communications and planning throughout the FRBAP. They also recommended that there be a strong link with the research component of FRAP, and that there be annual scientific workshops to share research and monitoring results, and to identify priorities for the coming year.

4.0 References Cited

Bernard, D., C. Perrin, M. Paine, T. Berry, J. Richardson, and D. Marmorek. 1992. Fraser River Basin Assessment Program: Discussion Paper. ESSA Ltd., Vancouver. Report Prepared for Environment Canada, Environmental Surveys Branch, North Vancouver. 83 pp.

Dorcey, A.H.J and J.R. Griggs. 1991. Water in sustainable development. Westwater. 288 pp.

MacDonald, L.H., A.W. Smart, and R.C. Wissmar. 1991. Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest. U.S. EPA 910/9-91-001. 166 pp.