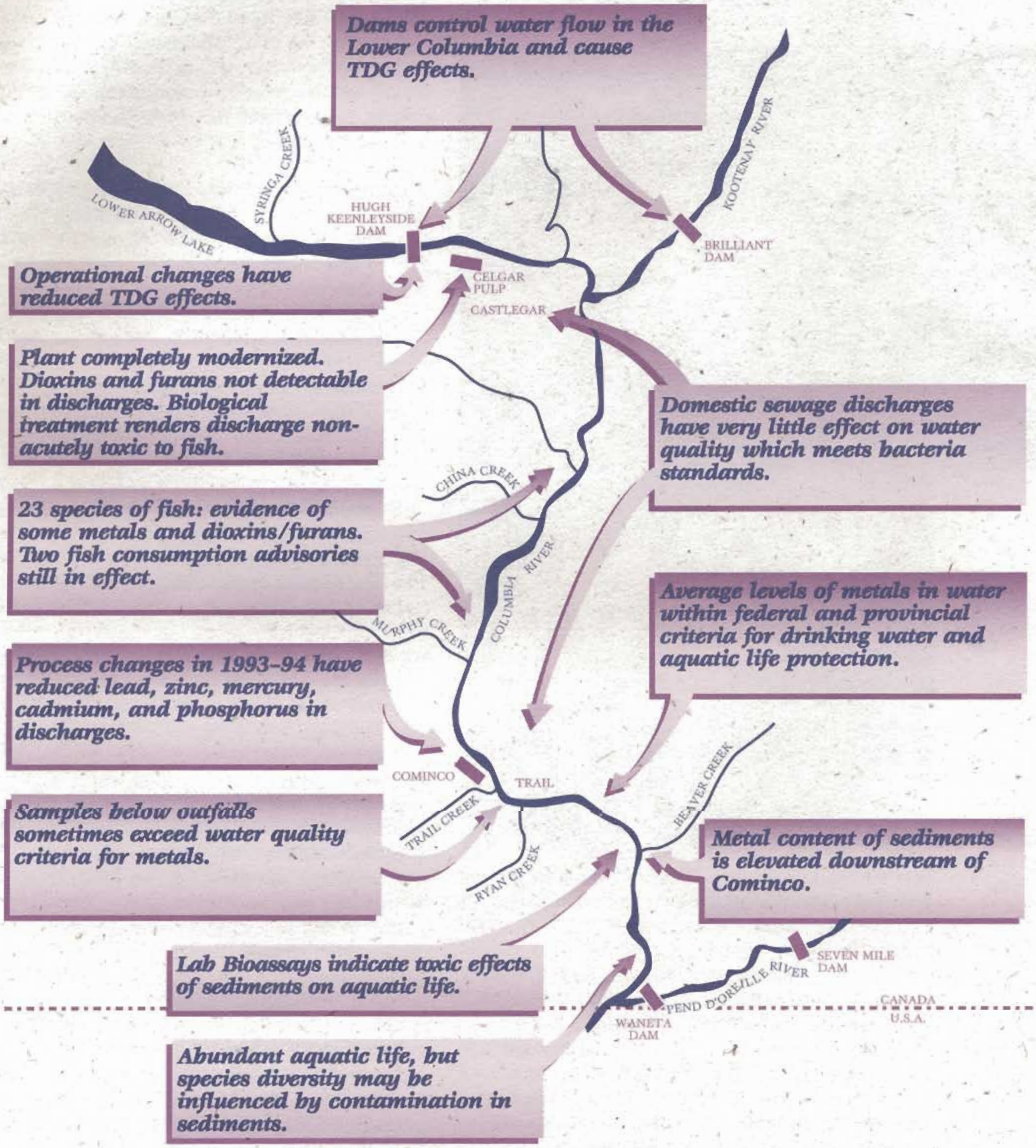
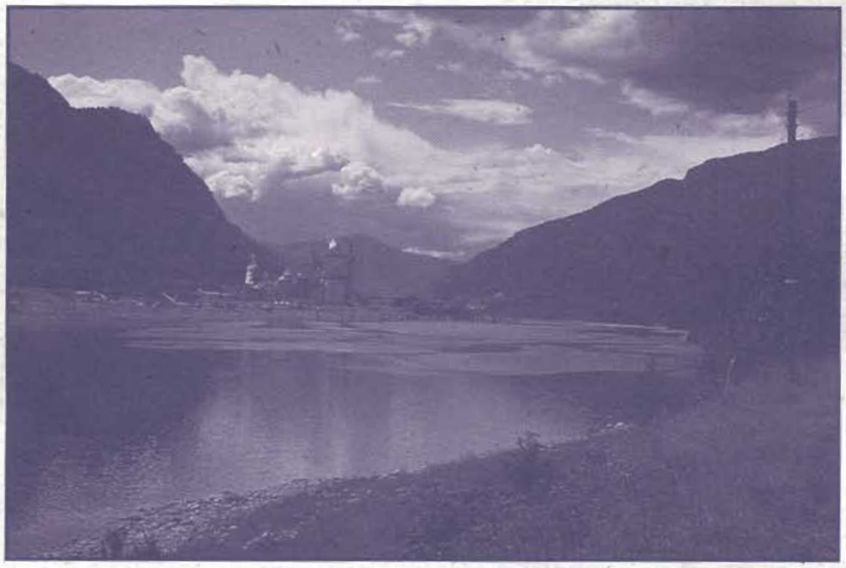
Columbia River 1991–93
Integrated Environmental Monitoring Program
PUBLIC REPORT



Columbia River Integrated Environmental Monitoring Program:

CRIEMP

1991-93



Introduction[1]

THE Columbia River is one of the largest rivers in western North America. It is the main stem of a major river system encompassing eastern British Columbia, Washington, Idaho, Montana, Oregon, Nevada and Wyoming. It provides major social and economic benefits through irrigation, hydro-electricity, dependent industry, recreational amenities, and makes a contribution to the west coast salmon fishery. Dams through much of its length, and on major tributary rivers, have drastically altered the natural flow of the river system. Despite extensive changes to accommodate human use, the Columbia River remains a beautiful and productive environment that sustains a wide diversity of natural life.

Being at the headwaters, Canadians have a particular responsibility to protect the environmental integrity of the river. In earlier days the river was used without much thought for the consequences. However, since the 1970's environmental considerations have increased in importance, and this is reflected in the extensive reductions in discharges achieved by industrial operations on the river.

In 1990 the two major industries, Cominco and Celgar, together with B.C. Hydro, another major influence on the river, co-operated with the B.C. Ministry of Environment, Lands and Parks (BC Environment), Environment Canada, the federal Department of Fisheries and Oceans, and the cities of Trail and Castlegar to plan a comprehensive monitoring program. They wanted a joint program to evaluate the various components of the river's ecosystem: water quality, sediment quality and the biological communities living in the river, from the creatures living in the sediments, to the plants, and on up the food chain to fish. The object: to determine the overall environmental status of the Columbia River from the Hugh Keenleyside Dam to the international border.

A study of this kind, in a river as large and as complex as the Columbia, represented a tremendous challenge. Previous to 1991, Environment Canada and BC Environment conducted water quality and a few other fish related studies on the river. In addition, BC Hydro has done other studies of specific aspects of the river system. No previous attempt had been made to compare responses of different parts of the ecosystem to industrial and municipal discharges and dam operations in an integrated approach.

It is estimated that about 39% of the total annual Columbia River flow entering the U.S. passes through B. C. Hydro's Hugh Keenleyside Dam, 30% comes from the Kootenay River via Cominco's Brilliant Dam and 27% of the flow comes through Cominco's Waneta Dam on the Pend d'Oreille River where it enters the Columbia just above the international border. The remainder of the flow comes from many other small streams.

Operation of the upstream dams results in highly variable flow conditions. The discharges from the industrial operations on the river are also variable in terms of quantity and quality. Finding representative sampling sites on the Columbia River was a major difficulty, particularly for sediment and biological sampling. With the multitude of aquatic species living in the river, each adapted to its own particular habitat, choosing representative indicator species to assess the current health of the river system and to serve as baselines for future trend monitoring was recognized as a major problem. All of this had to be accomplished at a reasonable cost since government funding was limited, and the industry partners were already investing millions of dollars in plant upgrading.

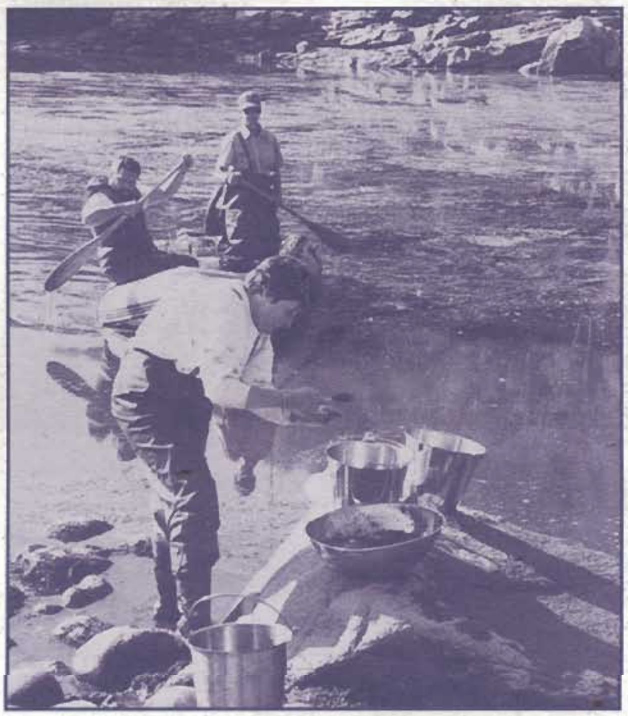
[1] This Public Report is a very brief summary of the full CRIEMP Interpretive Report intended for a more technical audience. Those interested in a more detailed evaluation of CRIEMP 1991-93 may obtain a copy of the full report from Bill Macpherson, Public Affairs Coordinator, Ministry of Environment, Lands and Parks, Kootenay Region, #401, 333 Victoria St., Nelson, B.C. V1L 4K3 (604)354-6346

In 1990, with the help of consultants, a steering committee made up of the contributing partners in the project put together CRIEMP: The Columbia River Integrated Environmental Monitoring Program. The program comprised regular water quality monitoring at sites from the Hugh Keenleyside Dam to the international boundary at Waneta; sediment sampling at accessible sites; a survey of aquatic life, again at accessible sites; sampling of freshwater mussels, and a unique analysis of river moths (caddisflies) as a measure of biological contamination from sediments. The Department of Fisheries and Oceans prepared separate reports on levels of contaminants in mountain whitefish, and fish health data. B.C. Hydro provided extensive data on fish populations and movement, collected in studies for their proposed Columbia Basin Development Program. They also provided monitoring data on 'total dissolved gases', an important and potentially harmful effect that results from dam operations under certain conditions.

Combining resources and sharing data and decisions has been a unique feature of the CRIEMP process. This partnership approach offers a constructive alternative to the adversarial 'command and control' relations too often evident between industry and regulatory agencies.

Consultants were retained to assist in the sampling design and to carry out the data collection. Analysis of the thousands of data points was completed in 1993 after 15 months of sampling and monitoring. A further contract was let with a consultant to statistically evaluate the data and attempt the difficult task of interpreting what it all means relative to the original objective of assessing the overall environmental status of the river. Not surprisingly perhaps, considering the dynamic complexity of the river ecosystem, the findings are tentative and qualified. Scientists are always cautious about stating unqualified conclusions unless supported by adequate and statistically valid data. That ideal is achievable, but certainly not easy, in a system as complex as the Columbia River.

River moths were sampled to see if they were bio-indicators of contaminants.



River sediments were sampled to test for contamination by metals or organics.

Results

This report summarizes the findings of the CRIEMP study, and the conclusions that can be put forward at this time. Further monitoring programs will follow CRIEMP 91-93, that over time will provide more information on the status and trends of environmental conditions in the river.

During the CRIEMP study, water quality was generally within established federal and provincial water quality criteria and objectives. These criteria and objectives are quality "goal posts" or "targets" for specific water uses such as drinking water and the protection of aquatic life. Sediments were found to contain elevated levels of metals downstream from Cominco, but no standards exist for this and it was difficult to determine the precise effect on life in the river. Communities of aquatic plants and insects were found to vary from place to place in the river. Differences in river bottom habitat, with highly variable flow rates and

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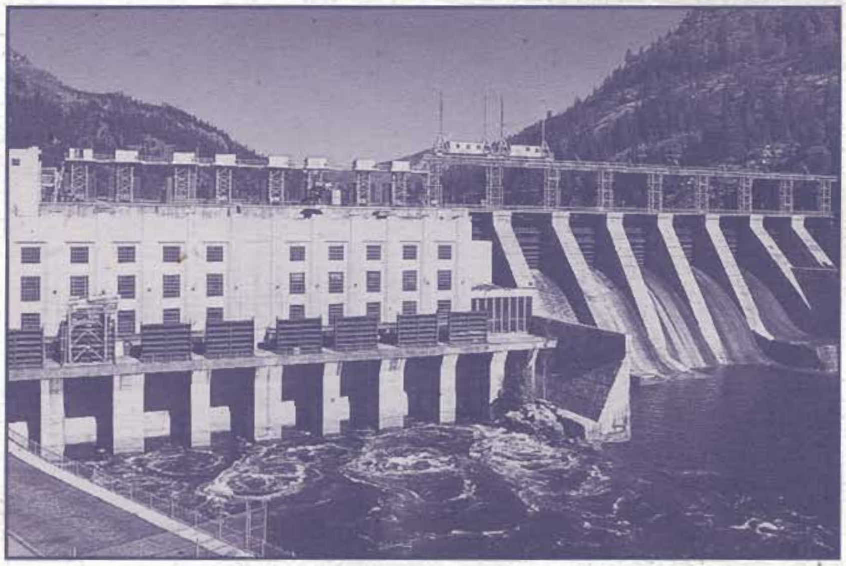


LARRY DOELL

Top: Cataloguing water samples.

Above: Cominco's Brilliant Dam.

water levels caused by the dams, can be expected to cause varying effects on their development and health.

This first CRIEMP study has helped identify better study methods, particularly for its biological component, as well as discovering important new information about the overall health of the river ecosystem.

Water Quality

The CRIEMP study found that many aspects of water quality were within established federal and provincial water quality criteria, however the following aspects sometimes exceeded the "acceptable limits" defined by provincial or federal objectives/criteria:

- dioxins and furans in sediment;
- total gas pressure levels;
- river bottom organic deposits;
- metals including cadmium, chromium, mercury, lead, zinc and copper;

Average concentrations of metals in the water were within government criteria except for chromium, which was high throughout the river. Maximum levels for some metals, such as chromium, zinc, copper and lead, occasionally exceed established limits and these limits are exceeded more frequently downstream of Cominco.

Dioxins and furans were not detected in the water. Low levels of resin and fatty acids (they are found in solid plants like trees) and other organics found immediately downstream of Celgar were within water quality criteria.

Municipal sewage discharges to the river at Castlegar and Trail were found to be very minor contributors to the river and not a cause for concern except in the area immediately next to the discharges. Drinking water quality was not impaired by these discharges.

Tests for total dissolved gases (TDG) below the dams indicated elevated levels. High TDG levels can be produced in nature, but the action of water plunging over a dam's spillway can raise those levels and the pressure of the gases dissolved in a river below a dam. TDG can cause an effect known as 'gas bubble trauma' in fish although only a low incidence was observed. This effect can be explained as follows: a fish in the river swims in equilibrium with its environment. If the gas pressure levels in the water increase, corresponding gas levels in a fish's body tissues and blood also increase. Fish can lose control over buoyancy as the gas comes out of solution because the swim bladder overinflates, or bubbles form under the skin and in the soft tissues of the mouth, gills and eyes. This affects fish in much the same way that a SCUBA diver coming up too fast can get the bends from bubbles of gas forming in the bloodstream. Fortunately, adult fish can compensate for these effects by swimming to deeper waters where natural pressures are higher and the TDG effects are reduced. This is likely the reason adverse symptoms have been so seldom observed in the study area.

Sediment Quality

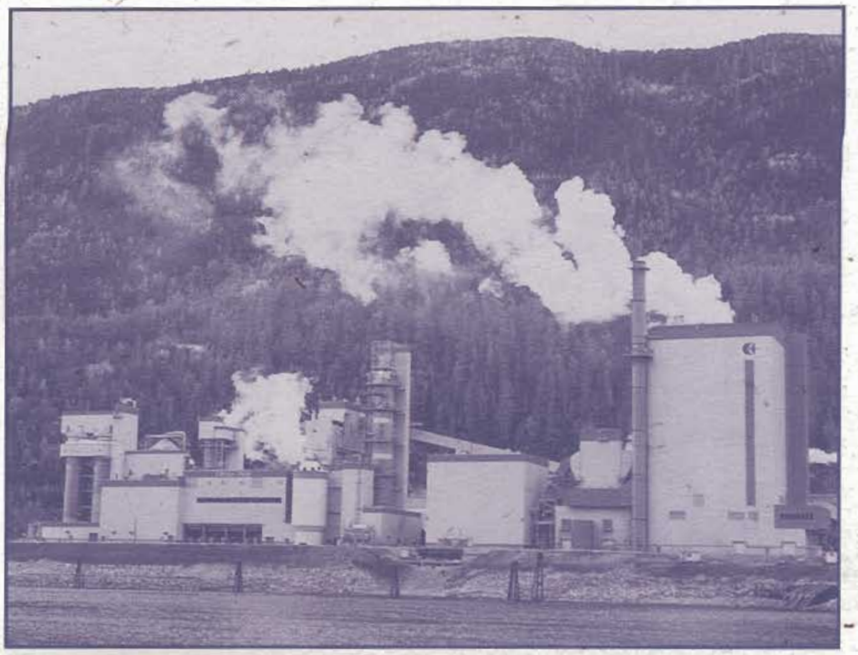
The CRIEMP study found that metals in sediments were significantly higher downstream of Cominco. Relating this chemical data with respect to its biological importance was difficult as criteria are still being developed for metals in sediments. As well, the sediment study was made more difficult since many factors influence how contaminants will deposit in the lower Columbia. Most of the metals in the sediments are bound up within slag deposits. There is little known about the toxicity or availability of metals in those sediments. However, laboratory tests have shown slag to have toxic effects on invertebrates and fish, although similar species are found living in slag sediments in the river.

The study of organic compounds such as resin and fatty acids, dioxins and furans in the sediments was also complicated by the variation in the nature of sediments deposited at each location. There are no criteria for resin and fatty acids in sediments, making it difficult to assess their significance. However, provincial criteria for dioxins and furans were exceeded in 1992 at all sites except the Kootenay Lake reference site.

River Biology

The biological impacts of water and sediment quality within the lower Columbia River were studied by trying to characterize the many communities of small aquatic plants and animals present throughout the study section of the river. The intent was to identify some biological indicators that could be used to regularly monitor the health of the river environment.

Algae and large aquatic plants were not found to be useful indicators for monitoring the condition of the river, because of other changes caused by varying water levels. However, large aquatic plants showed elevated metal concentrations downstream of Trail. Aquatic insects and benthic invertebrates (animals living in or on riverbed sediments) were found to be useful for monitoring environmental impacts on the river. Moss may also be useful in future studies as it occurred extensively and almost exclusively downstream of Cominco.



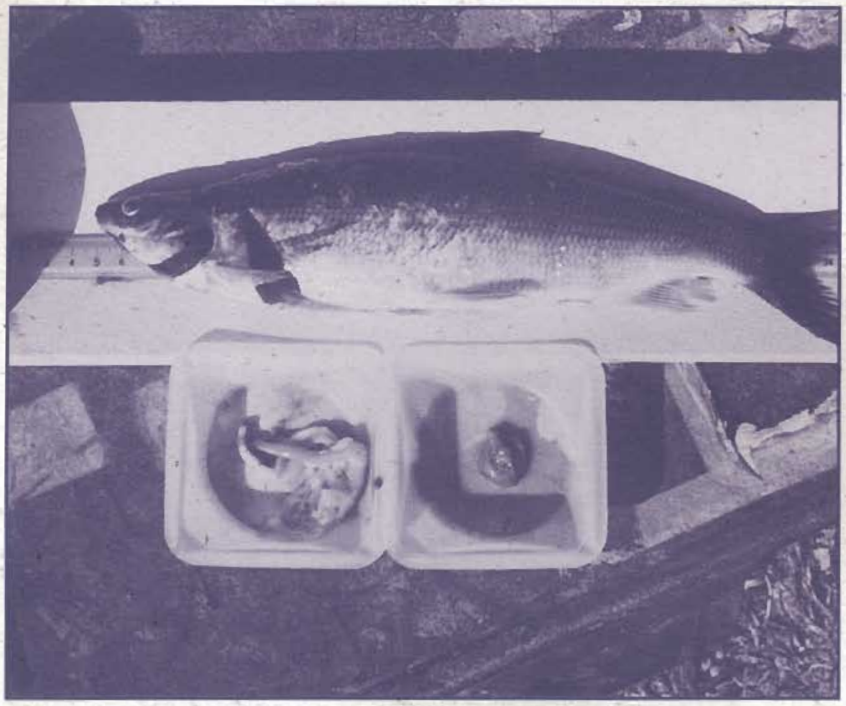
Modernized mill of Celgar.

The study found three distinct types of communities of aquatic insects in different parts of the river. Each was characterized by a variety of insects, but with different insect types and numbers at each site. Each was found in different sediment and water conditions, but bottom habitat differences, and the frequent changes of depth and flow rate due to the dams made it difficult to interpret the relationships. The community downstream of Cominco appeared to differ from those upstream. Several factors, including the presence of copper, lead and zinc in sediments, may be the reason for this.

Tests on Aquatic Life: Sediment Bioassays

A sediment bioassay is a test done in a laboratory with a tank of river water containing sediments from a specific test site and using aquatic creatures. Some of these tests showed that sediments immediately downstream of Cominco and Celgar had a toxic effect. Sediment bioassays are considered a useful method for categorizing sediment quality, but don't necessarily reflect actual conditions in the river.

Tissue analyses were done on river moths (caddisflies) and freshwater mussels to determine how much metal and organic contamination they accumulate in their bodies. Lead and copper levels in mussels were found to be higher below Cominco when compared with background levels. River moth tissues accumulated dioxins, lead and antimony.



Sampling of mountain whitefish.

The Cominco zinc-lead smelting complex at Trail.

Fish Studies

The CRIEMP program did not examine fish specifically, but a summary of studies by other organizations (Department of Fisheries and Oceans, B.C. Hydro, BC Environment) is included here for public interest. Studies of fish in the river downstream from the Hugh Keenleyside Dam found 23 species, including such sport fish as rainbow trout, walleye, white sturgeon and mountain whitefish. The populations of the principal sport fish seem to be relatively healthy and stable, although white sturgeon, burbot and bull trout have declined significantly in the last decade. Some other resident fish have also declined with changes in the make-up of the fish population, including the introduction of walleye and their subsequent rapid population growth.

The Columbia River Fish Health Study, conducted in 1992 by the Department of Fisheries and Oceans (DFO) in conjunction with the CRIEMP sampling program, showed some positive results in terms of decreasing dioxin and furan concentrations in mountain whitefish of the Columbia River. These contaminants are of concern because they can be extremely toxic and they tend to accumulate in fish.

The fish health component of this study showed the presence of abnormalities such as lesions, tumours, fin damage, fungal infections, parasites and bacteria in approximately 50% of all mountain whitefish tested. Fish abnormalities were further investigated in 1994, and preliminary results from field sampling indicate improvements in the external condition of mountain whitefish sampled in July 1994 from the Columbia River.

There are currently two fish consumption advisories in effect. One for dioxins and furans in mountain whitefish and lake whitefish is under review due to the lower levels of both chemicals now found in the river. The other existing advisory is for mercury in walleye and it too will be reviewed since recent tests have shown lower mercury levels in fish.

WHAT changes have taken place since the start of the monitoring program?

AT CELGAR

In May, 1993, Celgar completed a $700 million modernization of its pulp mill, including process changes to eliminate dioxin and furan compounds and greatly reduce the discharge of other chlorinated organics. A new $75 million effluent treatment plant has reduced contaminated discharges to the Columbia River by over 90%. 100% survival of rainbow trout in 100% effluent is now the consistent outcome of standard regulatory testing. The following list summarizes the progress at Celgar:

1989
- Stopped use of defoamers which contained the non chlorinated dioxins and furans. This caused a reduction in dioxin/furan-related compounds in the waste water from the mill.
- Process changes in the bleach plant improved the effective use of chlorine and chlorine dioxide so that less chemical was required.

1991
- Removed a water source from the bleach plant which contained the non chlorinated furan compound. This led to a reduction in the chlorinated furan content in the effluent
- Increased chlorine dioxide substitution for chlorine in the bleaching process.
- Began using hydrogen peroxide in the delignification process.

1993
- Old bleach plant off line in May 93; new bleach plant on line mid-1993. This reduced dioxin and furan levels below detection in the effluent.
- Moved to 100% substitution of chlorine dioxide for chlorine to reduce the amount of chlorinated organic compounds in the effluent.
- Began secondary treatment of mill effluent. This removed the acute toxic effect on test fish.

AT COMINCO

Contaminants in wastewater discharges from Cominco have also been significantly reduced since the start of the study. In a project completed during the fall of 1993, mercury, lead and cadmium discharges were cut in half. A 1994 process change in the fertilizer plant at Trail has virtually eliminated mercury, phosphate and gypsum discharges from that source. Cominco will stop slag discharges to the river in 1995 and begin to stockpile it on land. A new $145 million lead smelter, now being designed, will go into operation in late 1996, bringing about still further improvements in environmental performance at Trail. The following list summarizes the changes at Cominco and their effects:

1989
- Electrolyte stripping discharge eliminated, reducing dissolved zinc going into the river.

1993
- Contaminants going to the river via outfall 07 eliminated. Resulted in major reductions in lead, zinc, copper, arsenic and mercury reaching the river.

1994
- Phosphate plant shut down, resulting in elimination of phosphates, gypsum and all metals, except trace zinc, from the fertilizer plant.
- Installation of a 42,000 cubic metre pond at effluent treatment plant reducing surface run-off to the river and improving control of effluents.

1995
- Slag discharge to the river will be eliminated.

LARRY DOELL

B.C. Hydro's Hugh Keenleyside Dam.

AT B.C.HYDRO

B.C.Hydro is studying ways of reducing the high TDG levels at the Hugh Keenleyside Dam. Studies have shown that by selectively using deep water gates near the base of the dam instead of the spillways to release water, the TDG levels can be reduced. The studies are examining the effect such a change may have on dam safety and integrity. B.C.Hydro is using computer simulations in an attempt to predict which combinations of operating methods will produce the lowest TDG levels while meeting dam safety requirements.

B.C.Hydro meets regularly with DFO and BC Environment to discuss effects from the Hugh Keenleyside Dam on the fish. These discussions combined with public input have contributed to agreements with the U.S. power authority designed to address fisheries needs. In Canada flow modifications in the spring meet the needs of spawning trout and summer releases of stored water are delayed to maintain recreational water levels on Arrow Reservoir as long as possible. B.C.Hydro has recently completed an evaluation of operating impacts and alternatives (The Electric System Operating Review) and is discussing these issues with the provincial government.

Conclusion

The 1991-93 CRIEMP survey has provided useful information about where contaminants may have affected the river environment and the study field-tested each of the monitoring components for possible future use in monitoring the river. The initial survey has also confirmed the usefulness of CRIEMP's unique integrated approach to evaluating environmental conditions in the river. Future monitoring will track environmental changes in response to changes in industrial operations and other influences.

For more information about the Columbia River Integrated Environmental Monitoring Program contact a program member or to receive the full technical report contact Bill Macpherson, Public Affairs Coordinator, Ministry of Environment, Lands & Parks, 401-333 Victoria St., Nelson, B.C. V1L 4K3 (604)354-6346

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