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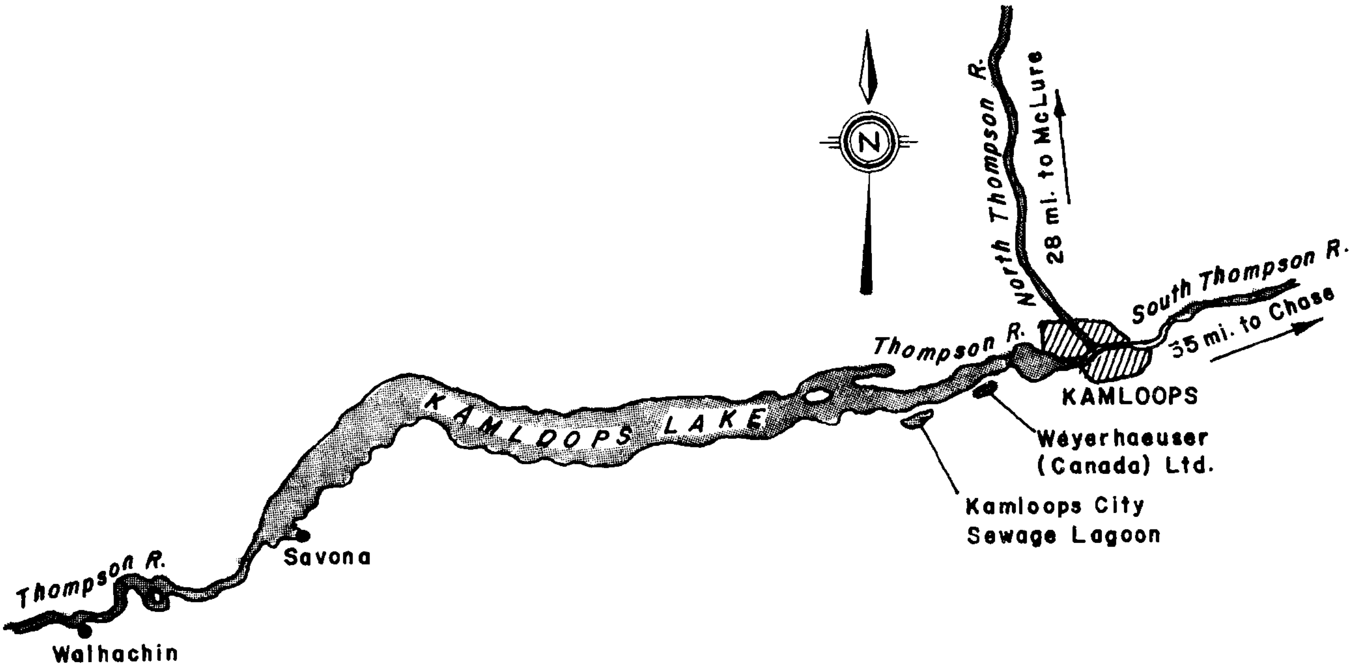
SUMMARY REPORT

ON

SOURCES AND EFFECTS OF ALGAL GROWTH, COLOUR, FOAMING AND FISH TAINTING IN THE THOMPSON RIVER SYSTEM



FEDERAL - PROVINCIAL

THOMPSON RIVER TASK FORCE

December 1975

December 1, 1975

LETTER OF TRANSMITTAL

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Sirs:

The Federal-Provincial Task Force is pleased to present the Summary Report on Sources and Effects of Algal Growth, Colour, Foaming, and Fish Tainting in the Thompson River System. Technical reports containing detailed data, interpretations, and recommendations will be published by the participating agencies. A list of agencies and their respective fields of study follows.

The report concerns itself primarily with data collected by Task Force members between the fall of 1973 and the spring of 1975. Some reference is made to earlier data and observations by non-Task Force members.

The findings and conclusions of the Summary Report reflect the overall view of all Task Force submissions and therefore may vary slightly from those expressed in the individual technical reports.

It is the collective judgement of the Task Force that the data indicates recent increases in algal biomass immediately downstream of Kamloops Lake are the result of increased nutrient discharges to the system by Weyerhaeuser of Canada Limited and the City of Kamloops. A major reduction of phosphorus from these pollution sources is the only option available to effect a reduction of algal biomass downstream of Kamloops Lake.

Respectfully submitted,

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1 INTRODUCTION

In early 1971, complaints from the public about deteriorating water quality in the Thompson River system were received by several government agencies. These reports noted that the river water had become dark brown in appearance and that frequent foam patches appeared on Kamloops Lake and in quiet eddies of the Thompson River. Many people also observed the "dark brown growth" on the river bottom downstream of Kamloops Lake. Residents of the area and visitors complained that because of the algal growth the river bottom had become extremely slippery which made fishing and other recreational activities difficult. There was also concern that this growth could reduce or destroy the fish of the Thompson River through reduction in egg survival and destruction of fish food organisms. Fish caught from the Thompson River downstream of Kamloops Lake were reported to have objectionable flavour and odour. Many of the residents of this area were concerned about loss of revenue brought into the area by the tourist fishery.

In response to these observations and complaints, an immediate short-term study of the North and South Thompson rivers, Kamloops Lake, and the Thompson River was carried out in the spring of 1973 by an ad hoc Federal - Provincial committee. Data available from previous years and data on chemical and biological samples collected during the spring of 1973 were analyzed to determine the sources of colour, foaming agents, biological growth, and fish-tainting substances. Based on these data, a preliminary committee report was presented in May, 1973. Conclusions and recommendations of that report are summarized below:

(1) The increased colour in the Thompson River was due to the effluent discharged by Weyerhaeuser Canada Ltd. It was recommended that the Director of the Pollution Control Branch should give consideration to require colour reduction in the pulp mill effluent.

(2) Tainted fish were found in the Thompson River, but those substances which caused off-odour and off-flavour of fish were not positively identified.

(3) The source of the foam on the Thompson River was unknown.

(4) The increased algal growth was tentatively explained by the nutrients present in the water. Nutrient concentrations were not attributed to any one source.

(5) It was recommended that a joint Federal - Provincial Task Force determine the source and effects of nutrients, foaming agents, and fish tainting substances on the Thompson River system including Kamloops Lake.

In the fall of 1973, a Federal - Provincial Task Force was formed consisting of the following representatives:

British Columbia	Environment Canada
Pollution Control Branch	Environmental Protection Service
Fish and Wildlife Branch	Fisheries and Marine Service
Department of Agriculture	Environmental Management Service
Forestry Service	International Pacific Salmon /Fisheries Commission
Department of Health	

A data-collection program was initiated and continued to the spring of 1975. This report contains a summary of the study results concerning the water quality of the Thompson River and the limnology of Kamloops Lake. Individual submissions of data collected and detailed discussions and results will be presented in a technical report.

2 EUTROPHICATION

Nuisance algal growths in natural waters are almost invariably associated with an excessive supply of nitrogen or phosphorus.

A large nutrient supply (nitrogen and phosphorus) to Kamloops Lake and the Thompson River is discharged from two point sources, the City of Kamloops and Weyerhaeuser Canada Limited.

2.1 Kamloops Lake

Lakes can be classified as eutrophic, mesotrophic or oligotrophic. A eutrophic lake is nutrient enriched with high algal productivity, while an oligotrophic lake is nutrient poor with very low algal productivity. A mesotrophic lake has an intermediate level of algal productivity.

Algae

Results of quantitative algal determinations show that Kamloops Lake is an oligotrophic lake. The low biological productivity of Kamloops Lake in summer is strongly influenced by light limitation caused by natural river turbidity and by mixing of algae to depths many times greater than the depth of light penetration. In the winter, the low water temperatures inhibit production. The phytoplankton species composition is characteristic of oligotrophic conditions and no nuisance blooms occur at present. Natural peaks in algal biomass and primary productivity occur in late August and September when the bulk of the nutrients in the water are from diffuse sources throughout the watershed and are associated with declining flows. It follows that Kamloops Lake will show a slow response to increases in nutrients from pollution sources, and hence will continue to be relatively insensitive to increased nutrient inputs in the future.

Benthic algal production around the nearshore areas of Kamloops Lake is not high at present, but further growth may occur in some areas if nutrient inputs to the lake are increased. However, such production will be restricted primarily to a short period in the spring because of the fluctuations in water level that characterize the lake.

Nitrogen

The uptake of nitrate by Kamloops Lake phytoplankton during August and September does not reduce the nitrate concentration in the outflowing epilimnion water (warmer upper layer) significantly below that of the inflowing water. Thus the lake is ineffective in immobilizing the largely natural nitrate input of the summer months. The point source loadings of nitrate in the Kamloops area only increase the nitrate concentrations approximately 8% during the low-flow period (January - April). The concentrations of nitrate in the lake, however, increase beyond that of the inflowing river by about 17%. The increase is caused by the mixing of internally generated nitrate throughout the water column at fall overturn. This additional nitrate is produced in the late summer, both in the sediments and by the continued conversion of non-nitrate nitrogen forms to nitrate in the water column during winter. If the ultimate nitrogen source used by both these internal generation processes was the point source load and was eliminated, the concentrations of nitrate, which along with ammonia are important to algal growth, would only be reduced to concentrations between 90 and 100 $\mu g/\ell$. Such concentrations are most unlikely to limit algal production. It follows that controls on nitrogen in waste waters during winter will have an insignificant effect on concentrations of nitrates in the water leaving the lake.

Phosphorus

It has been estimated that 30% of the total phosphorus entering the lake is not sedimented and is exported by the lower Thompson River. The remaining 70% or approximately 1,000 metric tons of phosphorus are deposited annually in the basin of Kamloops Lake. Up to eighty percent (80%) of the 1,000 metric tons of sedimentary phosphorus occurs as apatite or similar mineral forms in particle sizes ranging from coarse to very fine and is biologically unavailable.

Most phosphorus released from sewage lagoons and pulp mills is apparently not sedimented in lakes and is biologically available in soluble and particulate form. Thus during low flows in Kamloops Lake the total biologically available phosphorus concentrations will be significantly increased by the phosphorus load from these sources. The minimum percentage of available phosphorus exported from the lake in winter that can be attributed to the pollution sources has been estimated to range from approximately 40% to 90%.

Oxygen

High dissolved oxygen levels were found at all locations in the river system and in Kamloops Lake. The consumption of dissolved oxygen in the hypolimnion of Kamloops Lake during summer was very low, which is typical of an oligotrophic lake. The only location where a higher consumption occurred was directly in front of the delta of the Thompson River at Tranquille. This increased consumption primarily results from oxidation of sedimented organic material at the delta but at present has not resulted in sufficient depletion of oxygen to endanger fish in the area.

2.2 Thompson River

Algae

The reported increase in benthic algal production in the lower Thompson River in recent years was not confirmed because of the absence of quantifiable data prior to 1973. During the winters of 1973-74 and 1974-75, comparisons were made of the quantity of algae in the Thompson River above and below Kamloops Lake and the North Thompson River at McLure and the South Thompson River at Chase. For both sampling years the algal biomass was greater at the two stations (Savona and Walhachin) on the lower Thompson River than at any of the stations above Kamloops Lake. This growth of algae degrades the aesthetic value of the river and may alter unfavorably certain biological interactions in the river downstream of Kamloops Lake.

Invertebrates

Like the algae, the exact historic abundance of benthic macroinvertebrate (e.g., aquatic insects) populations in the Thompson River is not known because of the lack of quantitative data. However, the public has reported seeing large populations of emergent stoneflies in the Thompson River downstream of Kamloops Lake prior to the mid 1960's.

Direct determinations of macroinvertebrate populations at Little Fort, Chase, Savona, and Walhachin were made in the spring of 1973, 1974, and 1975. Generally, insect diversity was greater at Little Fort and Chase than at Savona and Walhachin. The abundance of pollution-sensitive insects (mayflies and stoneflies) was considerably lower at Walhachin than at any other station. The number of certain pollution-tolerant organisms (e.g., oligochaete worms) collected at Savona and Walhachin far exceeded those collected at Little Fort and Chase. This suggests that a condition of organic enrichment exists downstream of Kamloops Lake.

In another study, using artificial substrates exposed for thirty days, macroinvertebrate populations in the Thompson River were sampled between Kamloops City and Walhachin in 1973, 1974, and 1975. Results were compared with similar collections made in 1964 and 1965. The number of sensitive species and total number of organisms were generally lower in spring of 1973 than measured previously, including control stations. On the other hand, the 1974-1975 samples were not unlike many of the collections made in 1964 and 1965.

It must be emphasized that the above two invertebrate studies employed different sampling techniques. The number of certain types of organisms collected is closely related to the method used. The artificial substrate study suggested a moderate degree of organic enrichment. Direct collection of benthic communities from the natural river bottom reflected a condition of high organic enrichment downstream of Kamloops Lake.

Nutrients

The lower Thompson River is most sensitive to environmental degradation in late winter when flows and turbidity are lowest, immediately prior to the spring freshet. Because of the low flows, nutrients discharged to the upper river in waste waters are diluted less than at other times of the year. As a result, the lake receives higher concentrations of nutrients discharged from point sources at a constant rate throughout the year. During winter, this nutrient-enriched river water tends to remain mainly in the surface layers of the lake because of the existing thermal structure. Consequently, nutrient concentrations in the outflow rise throughout the winter. Thus, an abundant supply of nutrients is present in late winter and early spring when light intensity and water transparency are high, and the river level low and constant. The annual peak in algal biomass occurs at this time.

The major nutrient sources (the Kamloops City sewage lagoons and the Weyerhaeuser Canada Ltd. pulp mill) approximately double the concentration of dissolved phosphorus in the upper Thompson River during winter. Increases in the concentration of dissolved phosphorus entering the lake at Tranquille in winter produce increases in the output concentrations at Savona within a month.

The nitrate concentration also increases during this period, because of the export of water containing internally-generated nitrate from the lake. In fact, evidence from the study indicates that ample natural nitrate is present in the Thompson system in winter and it is considered highly probable that this has been the case in the past. An increase in phosphorus-loading to the river is thus the only factor that could have induced the reported recent increases in algal biomass.

The Task Force has concluded that reduction of nitrogen in these main pollution sources would not have any significant effect on the concentration of nitrate in the water at Savona during the winter since there is a large natural reserve of nitrogen supplied to the lake. A major reduction of phosphorus is the only practicable option available to reduce the nuisance growth of benthic algae in the lower Thompson River.

3 FISH TAINTING

In the spring of 1973, Rocky Mountain whitefish from the Thompson River downstream of Kamloops Lake were found to be significantly poorer in taste and odour than whitefish from the North and South Thompson rivers. In two-thirds of the fish from the lower Thompson River, the tasters detected a flavour like that of previously examined fish exposed to known dilutions of kraft pulp mill effluent.

In further tainting experiments, rainbow trout were exposed to various concentrations (0.5%, 2%, and 4%) of Weyerhaeuser effluent in the laboratory. Odour and flavour scores for the control fish were consistently high. Odour and taste were progressively worse on exposure to increasing effluent concentrations and/or with increasing exposure times.

In situ fish-tainting experiments were also conducted using rainbow trout placed in the Thompson River at Savona, in the vicinity of the pulp mill diffuser and sewage lagoons, and in the North and South Thompson rivers. Control samples were rated consistently and significantly superior to trout from all experimental sites on both odour and taste. Samples of fish located immediately downstream of the pulp mill diffuser and adjacent to one of the sewage lagoons were significantly poorer in odour and taste quality than samples from other stations.

4 COLOUR

During the study period it was observed that the Thompson River at the entrance to Kamloops Lake was stained a dark brown colour by the discharge of effluent from Weyerhaeuser Canada Ltd. During most of the year, when the flow of the Thompson River was less than 20,000 CFS, the discharge increased the water colour from background values of less than 6 units to more than 20 units downstream of the discharge. Maximum colour increases occurred during extremely low river flows.

Kamloops Lake has a pronounced seasonal change in colour. In summer, the lake's appearance is primarily a consequence of the turbid condition brought about by the Thompson River freshet. In winter, lake colour is most strongly affected by the effluent from the Weyerhaeuser Canada Ltd.'s pulp mill. This winter effect is accentuated by the low river flow and by the fact that much of this highly coloured water tends to remain in the surface layers of the lake. Throughout the winter, this coloured water exits the lake into the lower Thompson. There are no accurate historical winter values for the colour of the water exiting from the lake prior to the start-up of the pulp mill.

To the observer, the lower Thompson River appeared much darker that either the North or South Thompson rivers. The Thompson River below Kamloops appeared brown to black. The water was discoloured, and brown coloured algae covered the river bottom. Green coloured algae were predominant in the North and South Thompson rivers. This change in benthic algal colour accentuates the colour difference of the rivers above and below the lake.

During the prolonged pulp mill shut-down from early July to mid October, 1975, there was a marked change in the appearance of the lower Thompson River. As one resident who has lived in the valley for 66 years noted, "The Thompson River .... has regained its pleasant, fresh green appearance in contrast to the dark amber, unhealthy condition which has existed in recent years."

It is evident from the letters received from the public that for many persons their enjoyment of the recreational aspects of water usage has decreased owing to colour increase of the Thompson River in recent years.

The Task Force has not attempted to evaluate the effects of this colour on the biota in Kamloops Lake or the Thompson River. The main conclusion of the Task Force regarding colour was based on the only known harm caused—the aesthetic deterioration of the water of the Thompson River.

5 FISHERY

Pulp mill and municipal effluents contain constituents which cannot be identified by routine analytical procedures. Other studies with pulp mill and municipal effluents have detected such substances. These pollutants may cause injury and stress to fish, tainting of fish, reduction in fish food, or reduction in egg survival.

A decline of the sport fishery in the lower Thompson River and of the associated tourist industry has been reported. Data indicates a decline in angler use and total catch of steelhead over a ten year period. Observations by management and enforcement agencies indicate a parallel decline in resident rainbow trout fishery downstream from Savona over a similar time period.

An examination of pink salmon egg to fry survival in 1973-74 indicated above average survival when compared to other natural spawning grounds in the Fraser River system. It is improbable that such survival has been reduced from previous years in this river.

6 FOAM

During high flows, foam appears to be a natural phenomenon in the North Thompson River. The exact nature of the foam in the lower Thompson River during the low flows of 1972-73 was not ascertained. However, incidents of foam in the lower Thompson River coincided with start-up problems of the expanded Weyerhaeuser pulp mill. Foam has not occurred during the low flows since 1972-73. Foam can be caused by resin and fatty acids which are common chemical components of kraft pulping effluent.

7 CONCLUSIONS

(1) Discharge of phosphorus from Weyerhaeuser Canada Ltd. and the City of Kamloops should be reduced significantly. A treatment system should be adopted which will reduce as much phosphorus addition to the river as is technologically possible during most of the year. Phosphorus releases from settlements, feed-lots, etc., should also be minimized. The option of a variable schedule for wastewater phosphorus release that is related to the physical dynamics of Kamloops Lake is recommended for consideration in the Canada Centre for Inland Waters Technical Report

(2) Colour in the Weyerhaeuser Canada Ltd. pulp mill effluent should be reduced to cause publically acceptable aesthetic improvement.

(3) Studies should be initiated to identify and remove fish-tainting agents from the major point source discharges (Weyerhaeuser Canada Ltd. and City of Kamloops) to the Thompson River system.

(4) The Thompson River system should be monitored chemically and biologically on a continuing basis. Monitoring programs should include requirements established by the Task Force in order to detect changes in water quality leading to shifts in species composition and biomass in algal and invertebrate populations.

Monitoring results by permittees and regulatory agencies should be evaluated and reported by a federal-provincial committee after a five-year period.

(5) New developments that result in nutrient discharges into the Thompson River basin (e.g., industry, logging, feedlots, urbanization) should be controlled to ensure that individual and cumulative effects of such discharges does not impair water quality in the system.

(6) A social, economic, and technical study should be initiated to determine the feasibility of elimination of discharges detrimental to the Thompson River system. This could include total recycle, land disposal, joint effluent treatment.

(7) The following research should be encouraged:

(i) A research program should be undertaken on the physiology and nutrient energetics of benthic algal communities typical to British Columbia rivers.

Because of insufficient knowledge in this area, accurate predictions of the changes in algal biomass to be expected in the lower Thompson River as a result of phosphorus control are not possible. There is no interpretable record of the algal communities that existed prior to recent reported changes. Hence it is impossible to deduce objectively the condition of the lower Thompson prior to recent reported degradation.

(ii) An investigation of the effluent of the Weyerhaeuser Canada mill should be undertaken to isolate and identify toxic substances which may adversely affect the biota of Kamloops Lake or the lower Thompson River. Any such substances should subsequently be removed from the effluent.

(iii) The effect of altered algal and invertebrate community structures on the feeding ecology of salmonids should be investigated.