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Report on contamination of Comox lake and the Puntledge
river by the effluent from No. 4 mine of
the Canadian Collieries, Ltd.

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Report on Contamination of Comox Lake and the Puntledge River
by the Effluent from No. 4 Mine of the Canadian Collieries, Ltd.

by

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Object of Visit

In response to a complaint by Fisheries Inspector H.H.M. Beadnell (of Comox) to the effect that the effluent from number 4 mine of the Canadian Collieries was causing undesirable symptoms in the waters of Comox lake and the Puntledge river, the writer was requested by Fisheries Supervisor J.F. Tait (of Nanaimo) to visit the locality and to ascertain in what way present conditions differ from those which prevailed on the occasion of the writer's former visit on November 25, 1930. A report covering the former visit is appended hereto.

Itinerary.

On Tuesday, April 25, the writer was met by Inspector Beadnell at Courtenay and the Comox lake road was followed to the boat landing on the lake. The mine dump, approximately one-half mile to the north-east, was reached by row-boat.

After landing at the dump, the four pipes discharging effluent onto the cump were visited, followed by an inspection of the system of trenches which have been dug in an effort to baffle the effluent in its course to the lake. The railway toward Cumberland was followed as far as its first crossing over Allen creek in order to obtain a general idea of the lay of the land.

Returning to the effluent pipes, samples of the water were obtained and on

rowing back to the boat landing, further water samples were obtained at the lake bottom in three feet of water close to the shore at the position shown in sketch map 2. A third water sample was taken at the bottom in three feet of water at the boat landing.

Where the Comox lake road crosses Allen creek, the creek water was sampled. On reaching the junction with the branch road leading back to number 4 mine, the latter was followed to the crest of the low ridge immediately above the mine, from which vantage a good general view of the baffling trenches in the dump flats was obtained, as well as a better conception of the somewhat complicated topography of the low ridges lying to the east and south-east of the mine.

On returning through Cumberland, the trend of the railway grade paralleling the road was carefully observed, also the height of land which exists between Allen creek and the slopes leading toward the Trent river valley. A side road leading north-west to Bevan was taken just out of Cumberland, and a stop made to examine the character of water flowing north-east through a culvert under the road (see sketch map number 1). This was stated by Inspector Beadnell to be effluent from number 5 mine. Turning south just before reaching Bevan, the upper (impounding) dam on the Puntledge river was visited and water samples were secured. The return to Courtenay was then made.

Observations

The ocher-yellow turbidity of the lake water, reported by Inspector Beadnell to have been very pronounced some weeks ago, had somewhat abated; bottom was visible at a depth of 3 to 3 1/2 feet along the shore of the eastern end of the lake, except near the mouth of Allen creek where the water was somewhat clearer.

The turbidity may in part be due to the glacial silt brought down by rivers farther up the lake, although the colour was quite different to any which the writer has observed in visiting many glacier-fed lakes. As the mine dump was approached, a yellowish to red deposit was noticeable on certain snags along the shore, and on some, but not all, beach logs. The submerged rocks along the shore-line were not particularly coated with any deposit, but the opacity of the water precluded observation of the rocks which would form the normal shore-line (the lake at this time being rather high).

On landing at the northern end of the dump, the writer immediately noticed considerable change in the lay-out of the trench system from that described in his former report. According to Inspector Beadnell, the Canadian Collieries had put forth every effort to satisfy the demands of the Fisheries Department. Deep trenches had been dug with electric shovels; two to provide troughs for the effluent and one to obtain material for throwing up a retaining barrier along the edge of the dump nearest the lake in order to prevent the recurrence of a direct overflow of effluent into the lake as once observed and reported by Inspector Beadnell. It should be pointed out, however, that this was an emergency overflow necessitated by a clogging of the settling basins with the result that effluent backed up toward the railway and was in danger of working back into the mine.

The accompanying sketch map (2) shows the approximate arrangement of "A", the trench dug to provide material for the retaining wall "F". "B" is a settling trench which, judging by the amount of sediment in its bottom, was in use for only a short period. The material composing the dump at the north end of trench "B" is very coarse and it appears that owing to the proximity of the northern end to the lake shore, the effluent seeped underground into the lake too rapidly to allow a proper settling action; moreover, it is reported that the effluent

overflowed in the direction of the railway track and there is at one place distinct evidence of this having happened. "C" is a third deep trench at present carrying the combined effluent from four pipes, roughly estimated to be one thousand gallons per minute. The water flows down the moderately steep gradient of the trench to a pool "E" which is approximately 30 feet long, quite narrow, and three feet deep. This pool was not increasing in depth, indicating underground seepage into the lake. The level of the water in "E" is approximately 9 feet above the lake, which is 45 feet distant at this point.

Inspection of the foreshore of the lake nearest the pool disclosed the presence of half-a-dozen small streams of water running out from under the dump and on testing each of these, there was no doubt of the fact that they were coming directly from the effluent water in either the pool "E" or the lower portion of the trench "C", which is approximately 12 feet above the lake and 40 feet distant. The streams running into the lake were clear, but their deleterious effect is pointed out later.

The areas indicated by "D" in sketch map 2 are ponds into which the effluent has been diverted in the past. Those to the north of trench "C" are now filled with an ochre-coloured mud to the same height as the railway grade; this mud is still in the process of drying out and was not sufficiently firm to enable its depth to be ascertained. It is probably three feet deep if not more, and renders the ponds unfit for further use until cleaned out, if this were feasible. The ponds "D" south of trench "C" are deeper, and although containing much mud, are capable of being used for short periods.

It should be emphasized that such ponds will never prove efficient for any length of time. When first put in use, a great amount of underground seepage deleterious to the lake takes place; gradually the deposit of mud blocks the seepage channels and prevents further contamination of the lake, but on the

other hand, the ponds then retain their water and soon overflow.

The trench "A" has apparently never received effluent water and was probably not intended for this purpose. Should it be used, it would be subject to the same criticism as trenches "B" and "C", namely, the material in which it is dug is so porous that a large percentage of the effluent would seep into the lake until sufficient mud had accumulated.

Chemical Composition and Deleterious Nature of Effluent

There is no reason to suppose the chemical composition of the mine effluent is noticeably different to that given in the previous report. It is decidedly acid, contains no appreciable amounts of toxic substances, but is highly charged with soluble iron salts in the unoxidized state. It is this latter property which is the source of the complaints made against its presence in the lake.

When a solution of unoxidized ("ferrous") iron salts is subjected to the action of the air or allowed to flow into fresh water which normally contains much dissolved air, oxidation of the iron salts takes place with the formation of hydrated ferric oxides and carbonates which are insoluble in fresh water, or even in cold, slightly acid water. In the process of forming these compounds, the acids in the effluent may conceivably be bound in the form of insoluble complex compounds combined with the precipitate.

It will thus be seen that exposure of the effluent water to the atmosphere for a sufficient length of time (as in suitable settling basins) will remove the iron salts and much of the acids. But if the raw or incompletely oxidized effluent reaches Comox lake or the Puntledge river, the completion of the oxidation takes place at the expense of the oxygen dissolved in the lake or river water. This action is deleterious in two ways:

(a) The percentage of dissolved oxygen in the lake or river, essential for the respiration of fishes, development of eggs and fry, and production of animal organisms which may constitute food for the fishes, is depleted to a point below its normal value.

(b) The concomitant deposition of the insoluble iron hydroxides and carbonates tends to smother bottom vegetation in the lake and river, and forms a slime over spawning beds. Fish eggs are very sensitive to the presence of chemicals, and are probably adversely influenced if laid in, or covered by, this deposit.

A third harmful factor may result from the access of the effluent to the lake or river. Any free acid which is not neutralized will tend to increase the hydrogen-ion concentration of the fresh water since the latter differs from sea water in not being capable of compensating such increases. Animal and vegetable life in fresh water establishes a delicate balance of hydrogen-ion concentration, and a disturbance of this balance will have an unfavourable result on the productivity of fish food and the development of eggs in the water. The waters at the western end of Comox lake and the Puntledge river had an abnormally high hydrogen-ion concentration (i.e., they were abnormally acid) at the time of this visit.

Summary Results of Water Analyses.

A full analysis of the water samples is not deemed necessary. A large sample of the effluent taken at the point marked "Sample 1" on sketch map 2 is being further investigated; other samples were analyzed for their dissolved oxygen content, hydrogen-ion concentration, and concentration of soluble iron salts.

Sample 2 taken from at the lake bottom close to the seepage from trench "C" (map 2) was deficient in oxygen, decidedly acid, and contained much iron as was expected for reasons stated later.

Sample 3 from the lake bottom at the boat landing contained more dissolved oxygen and was only slightly acid, but contained considerable amounts of unoxidized iron salts.

Sample 4 from where the road crossed Allen creek showed that Allen creek was unpolluted.

Sample 5 from the impounding dam on the Puntledge river contained an almost normal amount of dissolved oxygen, but was still unduly acid and gave a decided reaction for unoxidized soluble iron salts.

A slight deposit of iron compounds was observable on the visible bottom of the lake at the boat landing, and a similar appearance on the submerged rocks in the vicinity of the dam gave evidence that considerable unoxidized effluent has reached the lake at some time in the past. That this contamination is still taking place is evident from the yellowish tint of the water going through the spillway of the dam. It should be pointed out that the above-mentioned process of oxidation of soluble iron salts by the dissolved oxygen in the lake and river water is very slow; the deposition of the insoluble iron compounds may take place over a considerable length of time with the result that drainage currents cause some of this deposition to take place in the river. However, since the insoluble compounds are formed in an exceedingly dilute solution, they exist in almost colloidal suspension (particularly true in the case of iron compounds) and probably a much greater percentage of the insoluble iron compounds is carried out to sea than that which settles on the bottom of the Puntledge river.

There appears to be misconception on the part of Inspector Beadnell as to the nature of the yellowish deposit and yellowish tinge of the river water. The writer's previous report mentioned the presence of sulphuric acid in the effluent and it has been erroneously assumed by several people that the yellowish colour of the deposits and water is in some way caused by the sulphur in this sulphuric

acid. This is not so, and no such statement was made in the report. Although it must be admitted that a slight "sulphur" smell was noticed in the settling pond "E" (map 2), the yellowish colour noted is entirely due to the colloiddally suspended insoluble iron compounds. A field test was made to convince Inspector Beadnell that the yellow mud in the basins "D" contained no appreciable free sulphur.

Disposal of other Mine Effluents

Besides number 4 mine, another entry to this mine, known as "Scott's slope", is situated on the shore of Comox lake. This mine has one pipe discharging effluent indirectly into the lake but Inspector Beadnell stated the character of the effluent is quite dissimilar to that from number 4 mine; it shows no sign of deposition of iron compounds and is used for drinking purposes by the miners.

Number 5 mine is situated above and to the east (north-east?) of number 4 mine, and is the only other mine now operating. It was not visited. The effluent drains eastward into Maple (?) lake which, according to Inspector Beadnell, has more the nature of a swamp. This effluent was seen running through a culvert under the Cumberland-Bevan road (see sketch map 1) and has all the characteristics of the effluent from number 4 mine, including a heavy deposit of reddish sediment on the sides and bottom of the ditch leading to and from the culvert. The forested condition of the surrounding country did not allow conclusions regarding the ultimate disposition of this effluent to be drawn. If underground seepage is taking place, it is almost inconceivable that same could reach Comox lake or Allen creek and equally unlikely that it would reach the Puntledge river system since a small, unnamed creek flows between a southern branch of the Puntledge river and Maple lake (see map 1). Inspector Beadnell promised to investigate the drainage of this area.

Number 6 mine at Cumberland is not working at present, and its effluent is stated to have run eastward into a slough in the direction of the Trent river valley.

Number 7 mine (location?) is not working, and the ultimate disposition of the effluent is uncertain, although it was stated that the gravelly nature of the surrounding surface soil facilitated its disposal.

Number 8 mine (Bevan?) is also not working, but the effluent used to find its way into the Puntledge river.

Inadequacy of Present Effluent Disposal.

The effluent from number 4 mine is the principal source of complaint. The present system of disposal is not satisfactory and apparently never will be for more than a short period. The mine dump between the mine and the lake shore is limited in area and has been utilized for settling basins so long that the digging of new trenches is greatly hindered by existing deposits of sludge. Even if these deposits were thoroughly dry and new trench systems were instituted, the sludge when again moistened would form a semi-impervious layer along the sides and bottom and cause flooding either back toward the mine or into the lake.

There is still room for some new trenches in certain areas, but as already pointed out, when these are freshly dug, the porosity of the dump material at first allows seepage back into the mine if too close to the mine side of the dump, or into the lake if too close to the lake shore. Hence the practical area for trenching is somewhat limited.

The Canadian Collieries has tried to comply with suggestions made by the Fisheries Department with respect to trenching and erection of levees, etc., but in the writer's opinion, these suggestions do not seem to have been along the proper lines. The trenches have been too short and have led too directly to a

single pond or pool in which oxidation and precipitation of the iron compounds was expected to take place. The system of ponds seen on the occasion of the writer's last visit (December, 1930) was preferable to the present system, and it would appear that recommendations 2, 3 and 4 of the report submitted at that time have not been followed of late.

Recommendations.

(1) The possibility of obviating the nuisance of this mine effluent for once and all by diversion of same into the Trent river would be well worth investigating. The writer is not competent to judge the economic aspects of this plan, but on looking over the ground, it would seem that a wooden stove pipe following the mine railway for a distance of two and one-half miles into Cumberland would deliver the effluent onto a slope which would allow natural drainage into the Trent river valley in such a way that by the time the effluent reached the river, it would be innocuous. Upon inspection of a contoured map of this region, if such is available, a better grade than that followed by the railway might be secured. In any event, a rise will be encountered from Comox lake (439 feet above sea level), but as stated previously, the height of land appears to lie below the business section of Cumberland itself (elevation unascertained). In the event of contamination of the Trent river, Inspector Beadnell states that if any choice is to be made between the preservation of the Comox lake-Puntledge river system and the Trent river, the former is by far the more valuable from the standpoint of the fishery.

(2) Two peculiar, crater-like depressions of considerable area lie just to the north of the road leading toward number 4 mine. These are on higher ground than the mine and are indicated by the dotted areas on sketch map number 1. If it were feasible to pump the effluent into the nearer of these, the excavation

of a trench would easily connect the two into a reservoir of considerable capacity. With no knowledge of the direction of the underground mine workings, the writer cannot say what objections might be raised on the point of seepage back into the mine. In any event, should seepage take place too rapidly, some might reach Allen creek and thus be returned to Comox lake. Should seepage be less than inflow, overflow of this natural reservoir would tend to first occur toward Allen creek in the small sector north of the railway.

(3) Should both of the two above suggestions involving pumping prove impracticable, the solution of the problem must be found in a more efficient handling of the effluent on the present mine dump. Recommendations 2 and 3 of the writer's 1930 report stress the need of spreading the effluent over as large an area as possible in order to promote the oxidizing action of the atmosphere. It would appear that a serpentine arrangement of alternate shallow ponds and ditches, with the latter baffled or riffled to secure aeration, would prove effective. If this system were in duplicate, or better still, if the whole system were designed to allow the cutting out of any one pond, the system or pond cut out could be allowed to dry out sufficiently to enable removal of accumulated sludge.

Such a duplicate system was being used in 1930, but the serpentine and cascading effect was not properly designed. Instead of the effluent running through one pool into the next, the distributing stream ran past the mouths of several basins. Each basin received its quota of water, but the effluent reaching the basin nearest the lake was practically as raw as that in the pool farthest from the lake. The system should be so designed that the water reaches the pools or ponds nearest the lake only after the water has slowly transversed the whole of the series.

(4) Rapid seepage, even from pools remote from the lake is not desirable.

It has been explained that the free access of air is essential for removing the undesirable iron compounds. The air cannot freely act on the effluent while seeping underground. Hence a certain amount of muddy deposit in the pools and ditches is desirable in order to prevent excess seepage, and when the ponds are being cleaned, only the superficial mud should be removed. The ponds should be very shallow and separated from one another by narrow walls so as to utilize as much of the mine dump area as possible. The gradient from the effluent pipes throughout the whole system should be only sufficiently steep to ensure a proper flow and prevent backing up as the first ponds become shallower by reason of accumulated deposit.

(5) The use of crushed, crude limestone to effect neutralization of free acid in the effluent and thus accelerate oxidation was suggested in the 1930 report. Nothing was done about this, and the writer still believes that its use is to be recommended in the first two or three ponds of the system. Possibly the use of limestone is economically impossible.