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# WATER MANAGEMENT FOR MINES

Paper Presented
by

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# WATER MANAGEMENT FOR MINES

Last year my colleague Mr. Howie presented a paper on waste management for mines, and taking into account that the water act is presently under review and being rewritten, I think this year is an opportune time for a paper on water management.

The law of British Columbia with regard to water is based on the concept that water is property, and as such, under the British North America Act, comes under the jurisdiction of the Provinces. The jurisdiction of the federal government over water is therefore limited to special matters such as navigation, anadromous fish and international streams, while all use of water within the Province comes under the control of provincial statutes.

The most important single feature of British Columbia law with regard to water is the denial of "riparian rights" which are derived from England common law.

The riparian law still works well in countries where the supply of water is plentiful and where it is not used extensively for high-quantity use. However, the inadequacy of the riparian law under British Columbia conditions was recognized at a very early time by the hydraulic miners of the Cariboo gold rush days.

The first legislation with regard to water in British Columbia is contained in the Gold Fields Act of 1859, in which it was provided, in effect, that the Gold Commissioner could grant exclusive rights to the use of defined quantities of water, not necessarily for use by a riparian owner; that the water-user would pay a rental to the Crown; that neglect to use the water or wasting of the water would result in the cancellation of the privilege; and that the holder of the right could sell water, provided that he charged fair and non-discriminatory rates.

Under the Water Privileges Act of 1892, provision was made for the use of water for purposes not covered by the Gold Fields Act or the Land Act. The Act for the first time declared that all the water in the streams of the Province belonged to the Crown, and that no further riparian rights could be acquired. The Water Clauses Consolidation Act in 1897 consolidated the various laws dealing with water. The Water Act

was amended in 1939 and was cut down from 300 sections to about 80. In 1960 the Water Act was amended to provide that groundwater areas are to be proclaimed by Order-in-Council.

The Water Act is at present being rewritten. The new act is in keeping with the government policy of decentralization where the maximum amount of decision-making will be done regionally. This revised Act will be more of a water Management Act whereas the present Act is in the format of a Water Allocation Act.

Although we are very well endowed with water in this province, as the precipitation is so intense in many areas, there are vast areas where demand can exceed supply as here in the Okanagan Valley. Water uses and users are not always compatible even with adequate supply. Recently there has been a case where the licencee was shot by the riparian owner for trespassing. Supply is only one aspect of water management; drainage and flood control are other very important aspects, especially when there is danger to life and property which could possibly be triggered off by poor construction practices by an individual or group.

In the interest of safety, Section 22 of the Water Act holds an owner of land, mine or undertaking liable for damage after the abandonment, suspension, termination or cancellation of a water licence or approval resulting from a defect, insufficiency or failure of the works. Section 23 makes it illegal to flood Crown land without the appropriate permit.

Thus the Water Act has always been used to protect the environment, e.g. under Section 41, a person is guilty of an offence who puts into any stream any sawdust, timber, tailings, gravel, refuse, carcass, or other things or substance after having been ordered by the Engineer or Water Recorder not to do so. Also, approvals under the Water Act have included water quality stipulations requested by Federal Fisheries. Provincial Fisheries have also frequently requested conditions to be included in water licences.

Every mine will require one or more water licences. A Water Supply Licence would be required for such purposes as:

1. Domestic Purposes; Camp supply potable and sanitary water.

2. Hydraulicking Purposes: Using water head to move earth materials.

3. Industrial Purposes: Most mine site uses.

4. Mining Purposes: Recover mineral from ore or ground.

5. Storage purposes.

6. Power Purposes: If hydro power is feasible.

7. Land Improvement Purposes: For this licence a water management plan to cover diversions and drainage is required.

If a storage or diversion dam is required for water supply or power purposes, and the dam is more than 10 m high, then engineering design plans must be approved by the Dam Safety Engineer in Victoria; smaller dams must be submitted for approval to the Regional Water Manager.

To date practically all water supply licences have been required for only surface water sources. But if a well is pumping water from an aquifer that is being directly recharged by a spring or stream, it may be necessary to take out a water licence on that particular spring or stream. As an example, the District of Sparwood has a water licence on MacKenzie Creek for their groundwater pumping station. While Section 4 of the Water Act gives the Lieutenant-Governor in Council the right by Proclamation to fix a day, or days, upon which the Water Act shall commence to apply to groundwater in any part or parts of the Province, this date has not so far been proclaimed.

Legal objectors to the issuing of a water licence are any licencee, riparian owner or applicant for a licence who considers that his rights would be prejudiced by the granting of such licence; also, the Deputy Attorney-General, the Deputy Minister of Agriculture and the Deputy Minister of Lands, Parks and Housing.

For the temporary use of water in mining operations, and particularly for Placer mines which occur in certain areas for only the summer months, a water approval under Section 7 of the Water Act rather than a licence can be issued. Section 7 of the Water Act allows approval for non-recurring uses of water for a period of six months without issuance

of a licence. The advantage of an approval over a licence is the shorter time required to obtain authorization. Whereas approval can be obtained in a very short time usually directly from the Regional Water Manager, a water licence normally takes over a year and often two years to process. However, an approval costs more, $100 per cfs compared to $20 per cfs for a licence. It is the policy of the Water Management Branch not to give a water approval as an interim measure to a proponent waiting for a water licence.

The function of Water Management includes all steps necessary to ensure the protection of watercourses throughout the development, construction, operation and abandonment phases of the project. Water management is necessary through the projected life to minimize disturbance, provide runoff control facilities, remove sediment from flowing water, stabilize banks and reclaim land as expeditiously as possible; also, in some circumstances, to control or mitigate deposition into natural waterways of heavy metals, acid drainage, total nitrogen and other toxic substances. The plan will have to be modified with time.

The principal tools employed within the water management plan are surface hydrology and groundwater. The environmental impact statements are reviewed by a hydrogeologist within the Water Management Branch.

SUGGESTED FRAMEWORK FOR A HYDROGEOLOGICAL STUDY

1. Topography, drainage and geology.

2. Groundwater

- occurrence and movement of groundwater
- depth to water table
- aquifer characteristics
- surficial deposits
- groundwater flow systems
- chemical quality of groundwaters, to include sampling prior to exploratory development
- quantity and quality of groundwaters to be disposed of
- groundwater - surface water relationships
- present use of groundwater
- possible effect of development on the groundwater regime

3. Monitoring Program.

Hydrology studies will be required to substantiate adequacy of water supply, for the design of drainage works, stream diversions and settling ponds. Usually water quantity monitoring stations should be set up both upstream and downstream of the disturbed area and at least one station should be continuously monitored. At least one year of recordings is usually required before proceeding to the construction stage. Water uses should be illustrated on water balance diagrams.

HYDROLOGICAL DATA REQUIREMENTS

Stage I

Based on existing data.

- mean annual runoff
- maximum and minimum annual runoff
- mean monthly distribution
- mean and return period annual maximum daily discharge
- mean and return period annual minimum daily, seven day monthly discharge

Some basic watershed characteristics must be compiled including:

- drainage area
- elevation range
- median elevation
- channel profile

A proposed monitoring program should be outlined giving:

- location
- instrumentation (water level recorder, staff gauge, type of current metre or weir)
- observation frequency and period of operation (all year, seasonal)

Stage II reports should also include the following after at least one year of project-related monitoring:

- annual and monthly runoff regime
- flood (peak) and low flows
- watershed physiographic characteristics
- floodplain zones
- quality (include suspended sediment)
- water use

From the monitoring, it should be possible to provide estimates of streamflow characteristics which relate to:

- water supply
- design of settling and tailings ponds
- design of culverts and stream crossings
- delineation of floodplain areas
- fisheries requirements
- project drainage plan
- impact assessments

Effects of development on:

- surface drainage modification
- groundwater flow modification
- ground and surface water quality
- other water uses and users

Some streams are already fully recorded, e.g. the Similkameen River system, the Elk River by B.C. Hydro for power, and some streams for fisheries. This does not mean that no development is possible in a watershed whose stream is fully recorded - one solution is to develop storage of higher flows to augment periods of low flow. The Similkameen River has been fully recorded since 1960 to honour the Agreement with the U.S.A. for a stipulated flow at Nighthawk.

Present government policy in the Similkameen is not to abandon any existing water licence to prevent the U.S.A. from increasing their share of the flow. To develop storage or drawdown flows on existing lakes is virtually impossible as most lakes are completely surrounded by private land with expensive dwellings.

For the water management plan, a preliminary design would be required for "approval-in-principle," and a detailed design for the "land

improvements" water licence. The plan could include detailed natural drainage, designed runoff diversions, interceptor ditches for natural runoff, contaminated drainage, settling ponds and treatment facilities for all disturbed areas, stabilization measures for watercourses and embankments, examination of the 200-year flood level encroachment into mine site facilities and the water supply distribution system.

Usually the design criterion for stream diversions, drainage of disturbed areas, and settling ponds is the 200 year, 24 hour flood event. A normally acceptable risk factor is a 10% chance of occurrence. A 200 year flood event has a 10% chance of occurrence in 20 years. Most mines have a life expectancy in excess of 20 years. Probability curves for various streams in this province have indicated 200 year storms which were about 1.5 times the 50 year storms that were already recorded. We do not consider a factor of safety of 1.5 over recorded storms and ones which will in all likelihood reoccur within the life of a mine as too conservative. Statistical reviews cannot allow for all possible events. Flood events occur in cycles, and in many areas there are no records during the early part of this century when high flooding events did occur. Present weather trends show extremes occurring more frequently i.e. within shorter time intervals than occurred during several previous decades. This trend would cause the 200 year flood event to occur within a shorter time period.

Storage dams over 10 m and all high-hazard or dams whose failure could cause loss of life are required to be designed for the probable maximum flood.

During construction of the W.A.C. Bennett Dam, the Peace River had to be diverted during 1963 and 1964. The maximum recorded flow measured at Hudson Hope to the date of design in 1961 was 270,000 cfs. For the duration of the four years of the diversion system, the diversion system was designed to contain an unprecedented flow of up to 320,000 cfs. However, in the spring of 1964, which was the most critical year of construction, the flow was 311,000 cfs - the highest recorded to date.

Stream diversions which mines require for many reasons (e.g. an ore body may lie below the streambed or the stream valley may be required for a waste dump or tailings pond), can no longer usually be solved by direct channelization. Loss of floodplain storage in the diverted section can cause flooding to riparian owners downstream. Also, channelization causes loss of fishery values, and increased velocities due to shorten-

ing of the original route and could cause erosion with downstream sediment problems. For this reason, a diverted section of stream could be required to duplicate floodplain areas, length, and fishery values of the original stream.

If a stream is diverted temporarily, as is often the case for valley waste dumps, then the reclamation plan must address the final drainage patterns that will sustain themselves naturally e.g. a stream cannot be left flowing along the side of a hill in a ledge-like manner. To let the stream run through the waste dump may not be permitted as this could have sediment problems downstream. Improper reclamation could be one reason for some barren streams in the northern part of this province.

Channelization with loss of floodplain storage and change in stream regime can be caused by other activities than diversion. A road embankment can also cause channelization. Location and alignment of culverts can make the difference in whether or not drainage patterns are self-sustaining.

The water management plan should include water quality monitoring stations situated both upstream and downstream of the minesite and other disturbed areas. A year's monitoring is generally a minimum requirement prior to the construction of the mine. This background information can benefit the proponent as water quality under pristine conditions sometimes do not meet the B.C. drinking water standards. Parameters for water quality and loading allowance are a Waste Management Branch jurisdiction, but there are Water Approvals where conditions include water quality parameters.

Total nitrogen loading may pose a problem. Nitrogen can enter a stream from pit water due to blasting, particularly wet blasting; residual explosives in waste dumps can leach nitrogen and also from storage of explosives. The maximum limit for nitrite/nitrate nitrogen has been set as 10 mg/L combined for drinking water based on the susceptibility of infants to methemoglobinemia. Nitrite/nitrate concentrations have been recorded in the Fording River as high as 10.8 mg/L.

A Water Management Plan has now become an integral part of mine development just as a mining plan and a reclamation plan has for some time, although it is only relatively recent that mine development planning has progressed to the degree that it is possible to address the question of water management.

DISCUSSION RELATING TO YENON FELLMAN'S PAPER

Terry Martin, MEMPR; Yes Yenon I was wondering if you could explain the term "fully recorded."

Answer; The term "fully recorded" does not have an absolute definition; the comptroller and the regional water manager could have different definitions. A stream could be stipulated as "fully recorded" as, for instance, in the Elk River case where B.C. Hydro is saying they are licencing the entire flow for power purposes. The Similkameen River is "fully recorded" because of the stipulated flow at Nighthawk, and if you work out the minimum flow, and the number of water licences that make it up, there wouldn't be enough left. A stream could become fully recorded if the minimum recorded flow equals the requirements from a number of water licences while considering that so much is also required to be left for fisheries use. There is, therefore, no fixed definition.

Bill Fothergill, B.C. Hydro; Is there any new legislation on Water Rights on the amount of ground water control, that is on how much water you can take out of the ground?

Answer; The new Water Act is not yet published. I cannot say a thing about what will happen in the new Water Act until it's been seen by people much higher than myself.

B. Fothergill, B.C. Hydro; Yes, but you must have some ideas on how you would withdraw and measure amounts of water. Would it be like measuring air emissions?

Answer; Well I don't think that the new Water Act will be any more comprehensive than the present Act is. It will just have a stipulated day when it comes into effect. The Lieutenant-Governor will stipulate that.

Brendon Gordon, MEMPR; You mentioned that your permit system has been regionalized. What is your estimated time frame for issuing a water permit; the present system it takes about eight months?

Answer; Well water approvals can *be* done very quickly even at present.

Brendon Gordon/ MEMPR; What is the time frame - weeks, months?

Answer; I would say it could go as low as weeks, the thing that takes the time is the referral system. The application is referred to fisheries and the other ministries and we have to wait to get a reply back from them. So that is probably the only hold-up in that approval.

Brendon Gordon: What exactly is the definition of a stream?

Answer; It is in the Water Act and is any natural body of flowing water.

Ben Asare-Quansah, Crowsnest Resources; Do you look at groundwater from the aspect of mine design, pit design or just from its use?

Answer; We look at the effect of mine water and what the effect of the pit will be on the groundwater, the quality and the quantity.

Ben Asare-Quansah, Crowsnest Resources; But don't you look at how the groundwater will affect the safety of the pit?

Answer; That is up to the Mines Inspection Branch.

Jack Thirgood, University of British Columbia; If I heard you correctly you said there were some streams in B.C. that have been rendered barren by past mining practices, could you give us some examples?

Answer; I didn't say that they were proven to be rendered barren but that it was possible that they were rendered barren. There are a lot of barren streams up near Alice Arm and that area. It is possible that in previous mining or in hydraulic mining, that heavy sediment loading being put into a stream has rendered them barren,

Neil Duncan, Energy Resources Conservation Board; Isn't regional groundwater being studied by government departments? A mine is *a* pretty small part of an overall groundwater regime and obviously you would need some advice on what exists there right now.

Answer; There is work being done by the water board all over the province. There are wells being monitored and any proponent should check with our groundwater staff to see what work has been done so there won't be duplication.