

52120-24/6

MEMORANDUM OF UNDERSTANDING**MAMQUAM HYDROELECTRIC PROJECT****ENERGY PROJECT CERTIFICATE****22 November 1993****Condition**

During tunnel excavation, the proponent must monitor ARD potential and ensure that any pockets of acid generating rock are blended with neutralizing waste rock to achieve an NPR (ratio of neutralizing and acid generating potentials) of more than 3:1.

This requires the following operations:

- A professional present on the site full time should inspect the waste rock following each round to identify mineralized rock with elevated sulphide levels. Inspection should be the responsibility of a Site Geologist approved by the Ministry of Energy, Mines and Petroleum Resources (MEMPR). If the daily inspection duties are carried out by some other person, such as the Resident Engineer, this person must be trained to the satisfaction of the Site Geologist. The ongoing geological inspection should include a log of the geochemical characteristics, quantities removed and storage location of the waste (dump site, lift, etc.).
- Occurrences of significant volumes ($> 25 \text{ m}^3$) of "suspect" mineralized rock should be sampled and the acid generating (total sulphur content), neutralizing potential and paste pH determined according to the methods described in EPA-600/2-78-054.
- Waste rock samples should be taken from the less than 4 mm fraction.
- A minimum of once a week, the site should be visited by the Site Geologist to examine the monitoring record and samples and inspect the active part of the waste dump. The Site Geologist should also be available for unscheduled visits at the request of the Resident Engineer.
- Where the analyses show the rock has more than 0.25% sulphur and an NPR of less than 2:1, it must be blended with neutralizing material in shallow lifts ($< 2\text{m}$ deep) to achieve an NPR of more than 3:1.

The visual inspection and sampling of the excavated rock can be carried out on the rock face, on excavated rock or on the waste dump.

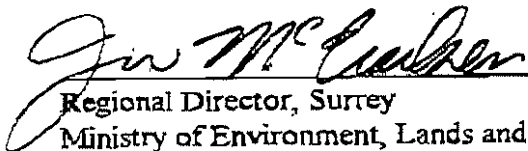
If the inspection is carried out on either the rock face or excavated rock, "suspect" mineralized rock should be stored separately until analytical results are available.


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As an alternative to carrying out the geological monitoring as the rock is excavated, it may be possible to monitor the rock in the dump. However, if the rock inspection is carried out on the dump, the dump must be constructed in shallow lifts (< 2m deep), which must remain uncovered until inspected, and until mineralized rock can be analysed.

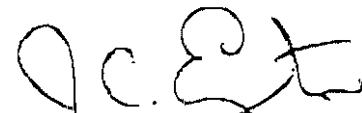
If any material is encountered with a total sulphur level exceeding 0.25%, the Supervising Engineer will inform the Regional Director, Environment Division, Ministry of Environment, Lands and Parks (MELP), Surrey, with a copy to the Manager, Reclamation and Permitting, MEMPR. If the samples are deemed to be acid generating, Northern Utilities Inc.'s (NUI) Environmental Supervisor will instruct NUI's construction company to blend the problem waste rock with neutralizing waste rocks.

The inventory and analysis information should be submitted to MELP on a monthly basis.


Regional Director, Surrey
Ministry of Environment, Lands and Parks


Comptroller of Water Rights
Ministry of Environment, Lands and Parks


Senior Habitat Biologist
Department of Fisheries and Oceans


Manager, Reclamation and Permitting
Mine Review and Permitting Branch
Ministry of Energy, Mines and Petroleum
Resources


President
Northern Utilities Inc.

NORTHERN UTILITIES INC. MINISTRY OF ENVIRONMENT,
LANDS AND PARKS
LANDS OPERATIONS

614-850 West Hastings Street
Vancouver, B.C. Canada V6C 1E1
Phone (604) 682-8700
Fax (604) 682-8780

18 July 1994

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#401 - 4603 KINGSWAY
BURNABY, B.C. V5H 4M4

The Honourable Moe Sihota
Minister of Environment, Lands and Parks
Room 346
Parliament Buildings
Victoria, BC
V8V 1X4

COPY

Dear Minister:

Northern Utilities Inc. (NUI) is a Canadian owned, B.C. incorporated Company. We have been involved with the feasibility studies and regulatory approvals of a 50 MW hydroelectric project near Squamish, BC for the past five years. The principals of our Company, including the writer, have previously completed construction of a 6 MW project on the Moresby Island of Haida Gwaii which has been operational since June 1991.

The 50 MW Mamquam Hydroelectric Project has, in the past five years, been subject to intensive public scrutiny including Provincial and Federal Regulatory Agencies as well as the local Municipal Government and the First Nations People. As a result both your Ministry and the Ministry of Energy, Mines and Petroleum Resources issued a Disposition Order declaring the project to be in the public interest subject to the satisfaction of certain conditions. We now have the pleasure of relaying to you that the project has an environmentally sound design and management plan and all of the regulatory approvals required to proceed to construction are in place.

We are sure it would not surprise you to hear that the magnitude of the work involved in bringing this project to the actual construction stage has been quite arduous for everyone involved, but particularly for the Agencies of your Ministry who have carried the burden of some of the most difficult decisions. We, therefore, would like to seize this opportunity to thank you for your staff's hardwork and goodwill in evaluating NUI's applications objectively, fairly and diligently. Even though our gratitude extends to every employee of your Ministry who was involved in the approvals process, we have to make specific mention of three individuals who worked with us closely. These individuals are: Mr. Ross Douglas, Lands Officer, Lands Division who is not only very knowledgeable on all aspects of the approvals which he has jurisdiction over but, was kind enough to explain these procedures to NUI patiently, so that our applications can, at their delivery, be most efficiently processed and throughout, despite NUI's occasional anxiety, has always responded to NUI with the utmost professionalism and courtesy.

The Honourable Moe Sihota
18 July 19943
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Mr. Brian Clarke, Manager, Planning and Assessment, Lower Mainland Region who was the most practical, experienced and knowledgeable biologist that NUI worked with throughout this process. At no time did we feel that anything more than sufficient data and simple scientific reasoning would be required to solve any technical problem that we had encountered.

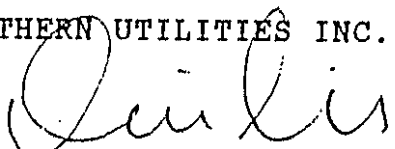
Finally, Ms. Pia Archibald, Senior Co-Ordinator for the Environmental Assessment Branch, who made us believe that public employees are as, if not more, conscientious as their private sector counterparts. We found Ms. Archibald to be very organized, responsive, punctual and determined to help. Most importantly, we felt she truly cared for what we were trying to accomplish.

We do sincerely hope that your Ministry will continue to employ public servants such as the ones we have had the pleasure of working with.

We also hope that, approximately, two years from now the Mamquam Hydroelectric Project will be successfully completed and that you, together with some of your staff, will give us the honour of attending the opening ceremonies.

Yours truly,

NORTHERN UTILITIES INC.



Alexander N. Eunall, Ph.D., P.Eng.
President

AE/sl

DELIVERED BY COURIER

cc Charles Liddledale, Senior Land Officer
James McCracken, Regional Director
Doug Dryden, Director



Province of
British Columbia

Ministry of
Energy, Mines and
Petroleum Resources

Parliament Buildings
Victoria
British Columbia
V8V 1X4

OFFICE OF THE
DEPUTY MINISTER

June 27, 1991

Mr. Alexander Eunall
President
Northern Utilities Inc.
614 - 850 West Hastings Street
Vancouver, British Columbia
V6E 1E1

B.C. ENVIRONMENT

JUL 0 21991

ENVIRONME.
ASSESSMENT BRANCH
VICTORIA, B.C.

Dear Mr. Eunall:

**RE: ENERGY PROJECT CERTIFICATE APPLICATION
MAMQUAM RIVER HYDROELECTRIC PROJECT:
SUMMARY OF AGENCY COMMENTS AND
REQUEST FOR ADDITIONAL INFORMATION**

Your Energy Project Certificate Application (EPCA) for the Mamquam River hydroelectric project at Squamish, British Columbia has been reviewed by federal, provincial and local government agencies.

The following provincial Ministries and agencies have no comments: Municipal Affairs, Recreation and Culture (Programs); Development, Trade and Tourism; and Lands and Parks (Parks). The Ministry of Environment (MOE) identified additional information needs during the review of the draft EPCA. A copy of the attachment to the February 18, 1990, memorandum from the MOE is included as part of this summary and information request.

Comments have not been received from the Ministry of Native Affairs, the Ministry of Agriculture and Fisheries, the District of Squamish, the Regional District of Squamish-Lillooet, or the federal government, except for Transport Canada. A summary of this information will be sent to you as soon as it is received in this office.

Of the agencies that provided comments, there is concern with the lack of additional project evaluation that has occurred since the draft EPCA was submitted. In particular, there have been no additional environmental studies undertaken to define the impact on fisheries and archaeological resources. Therefore, a full review of and meaningful response to information contained in the EPCA cannot be completed at this time.

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Mr. Alexander Eunall
June 27, 1991
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Nevertheless, the attachment summarizes the responses from those agencies that have provided comments, in the form of:

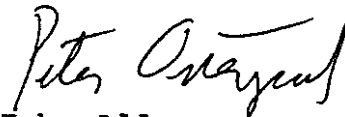
- . general comments and concerns; and
- . specific supplementary information that is required before a disposition recommendation to the Minister could be considered under section 19 of the Utilities Commission Act (the Act).

The supplementary information requested by the various agencies should be sent to:

Ms. Denise Mullen
Acting Director
Energy Project Analysis Branch
Ministry of Energy, Mines and Petroleum
Resources
Room 433
617 Government Street
Victoria, British Columbia
V8V 1X4

Please contact representatives from the various agencies noted in the attachment if you have any questions specific to their comments. You may also contact Ms. Mullen at 356-2161 if we can help you further.

Yours sincerely,

for 
John Allan
Deputy Minister

Attachments

cc: Mr. Peter Ostergaard
Assistant Deputy Minister
Energy Resources Division

✓ Mr. Doug Dryden
Director
Environmental Assessment Section
Policy and Planning Division
Ministry of Environment

Mr. Bill Grant
Executive Director
Regulatory Affairs and Planning
B.C. Utilities Commission

NORTHERN UTILITIES INC.
MAMQUAM RIVER HYDROELECTRIC PROJECT
ENERGY PROJECT CERTIFICATE APPLICATION (EPCA)
SUMMARY OF AGENCY COMMENTS AND
REQUESTS FOR ADDITIONAL INFORMATION

COMMENTS:

Public Consultation

The transmission interconnection is an integral part of the Application. Further public consultation is needed to determine the most appropriate transmission line route.

Contact: Mr. Neptune Smith, B.C. Utilities Commission at 660-4700.

Electricity Purchase Agreement

A copy of the agreement with B.C. Hydro must be filed with the B.C. Utilities Commission. Approval of this Agreement, under section 85.3 of the Utilities Commission Act, is needed before the sale of electricity can begin.

Contact: Mr. Philip Carter, Ministry of Energy, Mines and Petroleum Resources at 356-2142.

Emergency Response Plan

If approved, a dam safety plan that incorporates appropriate warning, notification and response actions will be required.

Contact: Mr. Ron Johnson, Provincial Emergency Program at 387-9900.

Crown Lands

(a) Powerhouse and tailrace

A portion of project is located within the Soo Provincial Forest. The Ministry of Forests permit is needed before Crown land tenure can be issued.

(b) Powerhouse and substation

There is a conflict with a right-of-way issued to B.C. Hydro. A written agreement between the proponent and B.C. Hydro is required before Crown land tenure can be issued.

Alienation of land through either lease or sale of fee simple rights is subject to survey. A License of Occupation can be issued pending the results of the survey.

(c) Transmission Line

There are a number of conflicts with existing rights-of-way and private land associated with the proposed "south route."

Where the final route crosses private or otherwise occupied Crown land, the proponent must obtain consent from the existing user/owner.

Contact: Mr. Ross Douglas, Ministry of Lands and Parks at 660-5500.

Forests

- (a) The forest land impacted by the project is 18 hectares. A significant portion of this is on Woodlot License 28. The licensee, ^{s.22} should be contacted to discuss ways to minimize land use conflicts.
- (b) Construction and maintenance traffic could conflict with industrial operations on the Stawamus-Mamquam forest road. Safety considerations will have to be developed in cooperation/consultation with existing road users.
- (c) All merchantable timber should be pre-sold and cleared under timber sales. A penalty will be levied for the destruction of or damage to immature (non-merchantable) timber.
- (d) The proponent must comply with fire protection regulations.
- (e) The transmission line along the Stawamus-Mamquam forest road would have to ensure that large trucks and machinery have safe passage. The preferred transmission line route is on the downhill side of the road to minimize blowdown, harvesting and forest land impacts.

Contact: Mr. Oliver Thomae, Ministry of Forests at 878-9671, local 255.

ADDITIONAL INFORMATION:

Transportation and Highways

- (a) There is some concern about the potential impacts on existing public roads caused by construction traffic carrying over-sized and overweight vehicles, particularly regarding the safety of bridge structures. In addition, there is no mention of the need to obtain permits from the Solicitor General (Vehicle Load/Dimensions) or Highway Act (structure on rights-of-way or transmission line crossings).
- (b) If a public highway/road is constructed for access to the project site, the District Manager, South Coast Region, Ministry of Transportation and Highways must review construction specifications and standards.

Contact: Mr. Derek Parkes, South Coast Region, Ministry of Transportation and Highways at 660-8229.

Crown Lands

- (a) Powerhouse and Tailrace

Please provide a detailed plan describing the nature, dimensions and location of the proposed facilities. In addition, identify the type and quantity of material that will be removed from the tunnel, borrow pit or quarry, the amount of rock and gravel that will be used on-site, and where the surplus material will be disposed of.

A permit is required for any rock, gravel or fill used or removed during the construction of the project.

Issuance of Crown land tenure is subject to a Quit Claim from mineral claim holders and a survey of the land. A License of Occupation can be issued pending the results of the survey.

- (b) Powerhouse and substation

Provide a detailed sketch of the area drawn to scale and showing the following:

- (i) the nature of all improvements including the fill;
- (ii) the location of all improvements in terms of geography and existing roads; and
- (iii) the area occupied by improvements related to the total area of the project.

Any dwelling intended as a permanent caretaker residence will be subject to floodproofing standards as specified by the Ministry of Environment, Water Management Branch.

(c) Transmission Line

Applications for Crown land tenure for any of the alternate transmission line routes will require detailed plans describing the dimensions and location of the corridors. Specific reference should be made to cadastral maps showing legal surveys.

Contact: Mr. Ross Douglas, Ministry of Lands and Parks,
Lower Mainland Regional Office at 660-5500.

Archaeological Resources

Comments provided on the draft EPCA asked that an additional archaeological impact assessment be undertaken for several project facilities, and that results of this assessment be included in the final EPCA. The EPCA includes an overview assessment; however, recommendations contained in this overview have not been implemented. Furthermore, the statements made on page 3 (section A5.1) and page i (Appendix 4) of the EPCA regarding heritage resources are misleading given the need for further assessment.

A detailed archaeological impact assessment is required before a decision can be made on the extent of the impacts to archaeological resources.

Contact: Mr. Ray Kenny, Ministry of Municipal Affairs,
Recreation and Culture at 356-1438.

Health

- (a) Provide a description of an approved sewage disposal system that may be required for the powerhouse facility.
- (b) Describe the source, treatment and testing guidelines for any domestic drinking water available at the project site.
- (c) Describe the current status of the negotiations with the District of Squamish regarding access to the Mamquam River to augment water supplies.
- (d) If a work camp is planned, advise Mr. L. Clarkson, Environmental Health Officer, Coast Garibaldi Health Unit Sub-Office, Squamish, British Columbia at 892-3585.

Air Navigation

There are a number of certified airports and heliports in the Squamish area. The effect of the proposed transmission line on these facilities cannot be properly evaluated until a final transmission line route has been selected.

Once the final route has been chosen, provide a detailed map showing the transmission line and technical drawings of the profile of locations where the line crosses highways, valleys and water courses. The need for obstruction markings will be determined at this time.

Contact: Mr. D.G. Neil, Transport Canada at 666-5533.

Minerals

It does not appear that the proponent has contacted either the mineral claim holders in the project area, or identified mineral tenures. The map included in the EPCA, depicting transmission line routes, has no scale and is difficult to read. Provide an updated map that clearly identifies alternative transmission line routes related to landmarks such as rivers, creeks, existing transmission lines, etc.

Attached is a mineral claim map. The following claim holders should be contacted to discuss potential impacts of the project on these claims.

Dent 1-8 Claims:

Northern Ore Hunter Inc. (604) 688-4850
1030 - 800 West Pender Street
Vancouver, British Columbia
V6C 2V6

Ravin Claim:

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In addition, claim holders should be included on the invitation list, should more public consultation sessions be held.

Contact: Ms. Janet Fontaine, Ministry of Energy Mines and Petroleum Resources at 356-2288.

Capital Costs

The capital costs and financial project shown in the draft EPCA (1989) are out of date. An evaluation of this part of the final Application cannot be completed; therefore, provide current cost and financial information.

Other

In the draft EPCA, Highland Energy Ltd. undertook to carry out or complete a number of studies which are necessary to establish project feasibility. The results of the following studies should be submitted:

- (i) Section 2.4.2 Terrain. Specific issues that should be addressed are:
 - . erosion and possible bank stability generated by the tailrace discharge; and
 - . potential for downstream gravel recruitment.
- (ii) Section 2.4.6 Water Resources, specifically additional issues raised on page 2-11.
- (iii) Section 2.5.4 Economic Impact, specifically a cost-benefit study.

Contact: Mr. Neptune Smith, B.C. Utilities Commission at 660-4700.

DRAFT APPLICATION FOR AN ENERGY PROJECT CERTIFICATE MAMQUAM RIVER HYDROELECTRIC PROJECT

Applicant: Highland Energy Systems Ltd.

Location: On the Mamquam River approximately 7 km east of Squamish, British Columbia.

Project Description: An hydroelectric power project with a firm capacity of 40 MW generation. The project is a run-of-the-river operation with flows up to 20.7 m³/s and a head of 252 metres that will drive a single turbine. Project consists of a powerhouse, tailrace, tunnel and two weirs. A 69 Kv transmission line will be built. New road construction is limited to about 2 kilometres.

Ministry of Environment Comments

1.0 Issues - General

The Application for an Energy Project Certificate (E.P.C.) should include further details regarding: water quality, groundwater, waste rock disposal, seismic assessment, geotechnical assessment and river hydrology and morphology. Further assessment on fisheries will be required due to the low flows created by the proposed diversion weir resulting in almost total use of water for power generation. As well, further investigation on fish screen design is required to ensure effective blockage of migrant steelhead pre-smolts and resident rainbow trout from entering the tunnel intake. Details on these issues, and their information needs, are provided below.

2.0 Hydrology

Water survey of Canada has had a continuous recording gauge, station (number 08GA054) on the Mamquam River since 1966. This gauge is at Mashiter Creek (drainage area 334 km²) and provides sufficient data for the river flows. However, more hydrology information is required to design ancillary water structures. In particular, precipitation data should be used, with the rational method, to assess flows in drainage ditches and associated settling ponds.

The draft Application mentions that a 200 year return period flood-flow is specified for design of the tunnel intake structure. The diversion weirs, drainage ditches and settling ponds' hydraulic structures should also be designed for the 200 year return period instantaneous (or peak) flow. Road culverts should have a minimum diameter of 1/2 metre and be designed for the 100 year instantaneous flood with ponding level at the soffit. Road bridges should have 1 metre clearance above the 200 year, 24-hour flood event.

The present design appears to direct almost all the Mamquam River's flow, for most of each year, into the tunnel. Apart from the graphs shown in Figures 3.3 to 3.14 (pages A2-13 to 24), low flow analysis is lacking. Low flows are required for estimating residual flows in the Mamquam River between the tunnel's intake and its tailrace. The Ministry anticipates the proposed level of water use/diversion will have an impact on fisheries (see fisheries comments). Regulation procedures for residual flows should be included in the Application for an Energy Project Certificate. The design and operation of the project should include the installation of flow meters at the diversion weir and intake weir.

The Application should show the runoff regime for both residual flows directed over the diversion weir, as well as flows directed through the intake. This flow routine should be in terms of mean, 5 and 10 year return period for annual minimum daily, 7-day and monthly discharge.

3.0 Drainage and Water Quality

Drainage ditches and settling ponds should be built prior to clearing and grubbing for project construction in order to intercept contaminated runoff from disturbed areas. A drainage plan, with a diagram on a scale of about 1:5000 with a contour interval of 5 metres, should be presented in the final Application for an E.P.C. Cross-sections of these ditches with design velocities and flows should also be included.

Run-off from waste rock piles and discharges emanating from the tunnel portal during construction should be intercepted and collected in a settling pond(s). The design of settling ponds in order to meet discharge (effluent) quality objectives will be required as part of the application process for a Waste Management Permit. A monitoring program of discharges to the environment will also be required (contact Regional Waste Manager - Ministry of Environment's Surrey Office).

Steep topography could contribute to high water velocities in access road ditches (see Hydrology Comment above). The Application for the E.P.C. should include details of road drainage and erosion control from access road runoff areas.

4.0 Groundwater

It is unlikely that any producing wells are located within the project's area. Nevertheless, verification of well use and an assessment on groundwater impacts should be made in the final Application.

The geotechnical assessment mentions large heavy fractures in lava rock. The tunnel alignment may intersect a buried valley which may contain groundwater under artesian pressures. This would have significant ramifications on tunnel de-watering during construction and on the design a settling pond for sediment control. As such, a groundwater consultant's report should be included in the Application to include recharge and/or discharge regimes at the tunnel.

5.0 Waste Rock

Waste rock will require several hectares for disposal. Waste rock should be tested for acid generation potential prior to use in roads or any other construction. Waste rock that is stock piled should also be tested for acid generation potential. The waste rock dump should be designed to ensure slope stability and should be revegetated with self-sustaining plant species.

6.0 Seismic Assessment

A seismic load of 13% of structural weight does not seem sufficient for this area. Using the National Building Code of Canada, this site is located within a Zone 4 Hazard. Using a probability level of 10% in 50 year for this zone, a horizontal force of 20% appears to be a more appropriate seismic load.

7.0 Geotechnical Assessment

The level of the draft Application's geotechnical assessment does not seem adequate for the final feasibility cost estimate of the tunnel.

The basement rocks were subject to glacial actions prior to overlay lava flow. The lava rock may contain heavy fractures, especially near the basal contact. The proposed tunnel alignment may intersect the basal contact at several locations. The buried valley beneath the lava flow, situated on the same side of the river as the tunnel, may be filled with drift and contain groundwater under artesian pressures. Drift is also reported to be above the powerhouse location, but its thickness is uncertain (page A2-55 and 56). As such, it is recommended that a detailed geotechnical assessment be undertaken prior to any construction in order to minimize environmental impacts from unforeseen construction problems.

8.0 River Morphology

Large amounts of coarse sediments are carried down the Mamquam River from tributaries. On construction of a diversion weir, these sediments will be deposited and will build up in the river channel due to the smaller residual flows. This material would restrict passage of water flow and could also result in all the water being percolated through coarse materials. The latter would be a barrier to "downstream" migration of steelhead pre-smolts during low flow periods.

9.0 Water Licensing

Highlands Energy System Ltd. have already applied for a Water Licence under power purposes for diversion of 800 c.f.s. from Mamquam River. A further Water Licence application under *industrial* (i) purpose will be required for potable water used at the work camp. Any water required for a non-recurrent use for a term not exceeding a period of 6 months may be authorized by a Water Approval under Section 7 of the Water Act (such as for exploration work). For Water Approvals, contact the Regional Water Manager in the Ministry of Environment's Surrey office. Matters pertaining to Water Licensing under the Water Act should be directed to the Comptroller-of-Water-Rights in Victoria.

10.0 Fisheries Impacts

10.1 Zero water flows (Weir Construction)

The draft Application states:

"The diversion weir would be positioned across the Mamquam River, and would be designed to divert all low flows and a portion of high flows into the settling basin".

The fisheries concern, as well as an overall ecological concern, is that over 2.5 kilometres of the river may be entirely de-watered during low flow periods. This would cause the riverine ecology of this section to die. Although the majority of this section is composed of high gradient falls and rapids, there still exist resident fish populations, invertebrate food production for downstream fish populations and potential recreational attractions. There is the additional risk that during the April to June out-migration period for steelhead pre-smolts, the water level may fall below the weir elevation causing the river to be de-watered, hence block fish migration. Regarding ecological changes, it has been noted on river systems immediately downstream of flow interruptions that an increase downstream periphyton

growth occurs. This increased periphyton growth (biomass) results from reduced upstream macroinvertebrate colonization and grazing that keeps such growth in balance. An increase periphyton growth could have both aesthetic and fisheries impacts within the Mamquam river.

The Ministry of Environment requests that there be a regulated, minimum water flow throughout the year. This minimum water flow level will need to be determined by the proponent during subsequent hydrological investigations and discussions with the Regional Water and Fisheries Managers.

10.2 Fish Screen & Bypass (Intake Works)

There may be some problems with the large screen opening of 15mm, as well as the methodology for steering fish off into the 600mm culvert at the last stage before the water enters the tunnel's intake. The Regional Fisheries Manager would like to explore with the proponent some alternate designs that may provide greater protection for the fish resources.

The screen opening of 15 mm may have to be reduced in size in order to prevent the loss of smaller steelhead pre-smolts or resident rainbow trout, that are less than 200 mm in length. Presently, the Ministry does not know the actual size range of the out-migrating pre-smolts, nor the exact time period of migration. The Ministry estimates the pre-smolt size range is 200 to 300 mm and conjectures that the migration period is April to June. In order to ensure that the steelhead resource is adequately protected, the Ministry requests that the proponent conduct biological studies to determine more accurate size ranges and the migration periods.

A fixed vertical screen such as the one proposed in the Mamquam Project is conceptually workable, as are a number of other systems including fixed horizontal and inclined screens, rotating drums screens, and various behavioural diverters. However, the successful design of a diversion screen is not a simple matter. All engineering works are based on assumptions, and this one is no different.

The assumptions for effective fish screening on the Mamquam Project will involve fish behaviour, debris loading, and the hydraulic conditions existing at the screen face and in the bypass works. While the problem of fish behaviour at the face of screens has been thoroughly researched by fisheries biologists, the debris loading and hydraulics associated with each new screen is site specific. To minimize fish mortalities associated with the operation of a screening system the proponent should address the following factors:

- potential loss of migrating (displaced) pre-smolt and resident fish during periods of the year when the screen is out-of-service, thereby resulting in fish going down the tunnel's intake.
- fish mortalities on the screen or fish losses through the screen due to inadequate
- fish predation at the screen face and at the bypass outlet.

To minimize fish losses resulting from the installation of the fish screen, those variable which must be considered include:

- the fish swimming speed/screen approach velocity. The acceptable velocity is dictated by the sustained swimming speed of the smallest fish approaching the screen. The distance of this higher velocity from the face of the screen should be no more than 3 times the fish length (criteria for a clean screen). If the screen is to be cleaned only intermittently, then "hot spots" will occur as a result of non-uniform flow across the partially blocked screen face. Consequently, the approach velocity must be reduced accordingly such as by increasing the surface area of the screen.

- the creation of uniform approach velocity and guidance flows across the screen face toward and into the bypass collector. Average velocities will not do; at no time anywhere are velocities to exceed those given in the above item.
- the type of screening material to be used on the screen face. Stainless steel woven-wire (slotted or square opening) or wedge wire is recommended. The size of the mesh opening is determined by the size of fish to be excluded and should not be greater than 8 mm for 150 mm long fish. Maximum percent open area must also be maintained in order to minimize debris loading and head losses.
- the operating scheme for the screen. The operation of the screen will be dictated by the accumulation of debris on its face, which in turn will be influenced by the gross screen area, the screen type, the size of the screen openings, the screen profile, the nature and quantity of organic material suspended in the water column and the period of operation.

The Ministry recommends, as a minimum information requirements for the successful design of a fish screen for the Mamquam Project, that the proponent:

- determines the target species, size, and migration timing for the fish to be diverted and stipulate an appropriate screen size and operating period.
- determines the minimum bypass flow required to maintain acceptable bypass, rearing, and transportation flows between the intake and the trashrack.
- undertakes scaled hydraulic-model testing of the proposed screen configuration and type, its support structures, the bypass and channel geometry in order to ensure adequate and uniform screen approach velocities under different diversion flows. These flow conditions and the proposed screen installation must be verified by model testing in a suitable hydraulics laboratory.
- prepare a maintenance program of daily screen attendance for the first two years, and as required thereafter, to ensure debris build up is not a problem.
- develop a monitoring program to determine the efficiency of the installation for the first two years, as well as a commitment from the proponent to modify the screen if unacceptable fish losses occur.

10.3 Fisheries Habitat Protection (Tailrace Design)

The Ministry requests that the tunnel outlet (tailrace) location be as close to the canyon entrance as possible and that erosional influences are minimized. If any adult steelhead habitat is alienated above the tailrace, then the river flow there must never be less than 20% of the mean annual discharge.

The proponent should conduct periodic tests following the completion of the project to ensure that total dissolved gas supersaturation effects on fish arising from the water returned at the tailrace is not occurring. If these tests are positive, then the proponent will be responsible for correcting the situation.

The sensitive timing period for steelhead trout begins in May during their spawning phases and ends in August when the alevins emerge from the gravel. Any instream work must ensure that siltation effects are minimized. All cement work must be done totally in the dry.

10.4 Habitat Protection (Transmission Line)

During construction of the transmission line, the proponent must ensure that the Mamquam and Stawamus Rivers, and their tributary streams, are fully protected against water quality disturbances and that only a minimal amount of streamside vegetation is removed.

11.0 Fisheries Assessment

Fisheries assessment for the project was lacking in the draft application. The proponent should be aware that every autumn since 1987, steelhead trout fry have been transported by helicopter from the Federal Fisheries Tenderfoot Fish Hatchery in Squamish into the upper Mamquam River between Skookum and Crawford Creeks. The total number of fish stocked each season has averaged 16,500 fry with an average weight of 1.45 gm. The reason for this stocking program is to ensure that adequate numbers of adult steelhead will return to spawn and provide increased recreational angling opportunities within the Squamish River system. These headwater areas provide excellent fish rearing areas that allow the steelhead fry to mature over a two to three-year period before they are ready to begin their seaward migration. Research has indicated that approximately 50% of these headwater stocked steelhead population remain in the system as resident rainbow trout. This fish stocking provided additional emphasis on the need for impact mitigation such as by regulated low flows and adequately researched and designed fish screening.

12.0 On-site Environmental Management of Project

Though a small project, the proponent should consider an environmental program to manage construction impacts from all aspects of the project: road, tunnels, transmission line. This program would entail the hiring of a qualified environmental supervisor. Such programs have worked well for other hydroelectric projects in British Columbia. It is in the best interest of the proponent to establish an environmental program, in that the program ensures environmental specifications are being applied, facilitates communication with government, and expedites resolution of unforeseeable environmental problems. The Ministry will assist in the design of such a program and the T-of-R of a environmental supervisor.

