

Jumbo Glacier Resort Master Plan

Appendix 5-F

Geotechnical and Hydrogeological Review and Summary
prepared by Golder Associates

December 10, 2003

031-411-166

Pheidias Project Management Corporation
1660 – 1188 West Georgia Street
Vancouver, B.C.
V6E 4A2

Attention: Mr. Oberto Oberti, MAIBC

**RE: GEOTECHNICAL AND HYDROGEOLOGICAL REVIEW AND SUMMARY
JUMBO GLACIER RESORT,
INVERMERE AREA, BRITISH COLUMBIA**

Dear Sir:

Golder Associates Ltd. (Golder) has previously carried out a series of geotechnical, glaciology, hydrogeology, and natural hazard studies over a period of several years from about 1993 onwards as input to development of the Master Plan Concept for the proposed Jumbo Glacier Resort. As requested, Golder has reviewed these previous reports and information in our files, together with relevant available reports prepared by other consultants. This review also included the current preliminary conceptual resort area plans, Volume 5, Infrastructure, of the Master Plan Concept document prepared by Pheidias Project Management Corporation (Pheidias), as well as colour stereo air photographs providing coverage of the proposed resort site, plus the upstream and downstream portions of the Jumbo Creek valley..

Based on our previous experience and this engineering review of the currently available information, this letter presents Golder's assessment and professional opinion related to the following items contained in the "Jumbo Glacier Resort, Environmental Assessment Application Checklist – Combined Agency Response (Dec. 3/03)":

- Water supply and impact on Jumbo Creek
- In-ground wastewater disposal
- Debris flow hazard potential

1.0 AVAILABLE INFORMATION

The following information was obtained from Golder's project files or made available for use in the preparation of this assessment and professional opinion:

1. Golder Associates Ltd. report P93-1305, titled "Preliminary Hydrogeological Assessment for In-Ground Wastewater Disposal, Proposed Jumbo Valley Ski Resort, Invermere Area, British Columbia", dated September 20, 1993.
2. Golder Associates Ltd. study titled "Glaciology for Jumbo Creek proposed ski resort, Invermere, BC", September 1993.
3. KPA Engineering Ltd. letter titled "Jumbo Valley Ski Resort, Sewage Collection, Treatment and Disposal", dated November 8, 1993.
4. EBA Engineering Consultants Ltd. draft report titled "Hydrogeological Assessment for In-Ground Disposal of Treated Wastewater, Jumbo Glacier Alpine Resort, Jumbo Valley, British Columbia", dated October 1995.
5. KPA Engineering letter titled "Water Supply and Sewage Treatment System for the Jumbo Creek Alpine Resort", dated October 25, 1995.
6. Golder Associates Ltd. study titled "Snow avalanche atlas and field investigation", July 1995.
7. Pheidias Master Plan Concept report titled "Volume 5: Infrastructure".
8. Pheidias report titled "Part H. Canadian Environmental Assessment Act Issues".
9. Colour stereo air photographs of Jumbo Creek Valley: 30BCC 853, Nos. 169 to 171 (Upper Jumbo Creek Valley), 30BCC 853 Nos. 24 and 25 (Resort Site), and 30BCC 853 Nos. 9 to 12, inclusive (lower Jumbo Creek Valley).
10. Topographic (1:25,000 scale) plan P0, titled "Preliminary Conceptual Mountain Area Map, Jumbo Glacier Resort".
11. Pheidias (1:12,500 scale) plan P2.1 titled "Preliminary Conceptual Area Map of Summer Lifts and Trails".
12. Pheidias (1:7,500 scale) plan P4 titled Preliminary Conceptual Resort Area Plan".

2.0 GEOTECHNICAL, HYDROGEOLOGICAL ASSESSMENT & OPINION

2.1 Water Supply

As described in Section 5.35 of the Master Concept Plan Volume 5: Infrastructure, groundwater from drilled wells is to supply all of the water needed for the resort, with the wells envisaged as being located at one or more locations approximately 1 km upstream from the resort site. Civil engineering studies have determined that the water supply requirements for all resort uses will be less than about 185,000 cubic metres/year, which can be achieved with a well water supply of 20 litres/second or less. There is no need or plan for use of surface water from Jumbo Creek or elsewhere in the Jumbo Valley to provide water supply.

Jumbo Creek is located within a “U” shaped valley. Previous air photograph interpretation, site reconnaissance, and on site investigations confirm that the lower portions of this valley where groundwater wells will be located are underlain by variable but typically coarse and permeable granular deposits. These deposits have been derived from the fans of localized tributary drainage channels, avalanches or rockfalls, as well as the alluvial deposits from sediment transport and reworking of the side valley deposits by Jumbo Creek. The granular deposits are expected to be of substantial thickness within the lower, more gently sloping terrain near the bottom of the valley.

Preliminary geotechnical and hydrogeological investigations have confirmed the variable but generally high permeability and the presence of groundwater levels at shallow to moderate depth. In addition, observations of disappearance of tributary streams into the fan deposits provide confirmation of the high permeability and continuing groundwater recharge conditions along the Jumbo Creek valley.

Based on the available information and our extensive experience with comparable deposits and conditions, it is Golder’s opinion that the water supply needs for the Glacier Resort development can be readily provided by groundwater well installations. The current indications of a suitable groundwater source location a relatively short distance upgradient (upstream) of the main resort site is also considered beneficial since the risk of an adverse change in the groundwater characteristics resulting from the resort development or other factors is considered very low.

The specific locations and type of the well installation(s), and the desirability or need for one or multiple wells to accommodate the inherent variations in subsurface conditions, control groundwater drawdown, and provide redundancy of supply should be determined as part of more detailed study once the master plan concept has been finalized and accepted.

2.2 In-Ground Wastewater Disposal

The Master Plan Concept and the 1995 report by KPA confirm that all sanitary and greywater discharge will be collected and directed to a treatment plant located downstream from the resort site. The effluent will be treated to tertiary standards before being carried by gravity flow in water-tight piping to one or more in-ground disposal sites located adjacent to the upgraded access road to the resort, which is roughly parallel to but offset north of Jumbo Creek.

As described above, current assessment and review of the previous reports indicates that suitable, permeable granular soils are present along and at least locally upslope of the proposed access road. It is Golder's opinion that in-ground disposal of the tertiary treated wastewater can be achieved using either or a combination of conventional tile fields or deeper "rock pit" infiltration chambers, with the selection of the disposal method depending upon local subsoil and groundwater conditions, as well as topography.

Since there is a generally consistent downslope gradient along the Jumbo Valley below the proposed resort and treatment plant, it is considered feasible and practical, if desired or needed, to spread the in-ground disposal sites over a significant distance to the south and east along the valley. Further, the location of the discharge line and disposal sites along or parallel to the road will provide ready access for inspection and maintenance, if required.

The use of in-ground disposal of the sewage discharge from the resort after tertiary treatment will also result in return to the groundwater regime of an equivalent volume to that obtained from the water supply wells, which are to be located a short distance upstream of the resort site. As such, it is Golder's opinion that there will be no significant or detrimental impact on the groundwater conditions within the Jumbo Valley. Equally, there will be no impact on the surface water conditions.

2.3 Debris Flow Hazard Potential

In addition to a general review of the available information, Mr. Mark Goldbach, P. Eng., Associate, one of Golder's senior natural hazard specialists, has reviewed the colour stereo air photographs covering the Jumbo Creek valley in the area of the proposed resort, as well as the topographic mapping shown in plan P2.1 titled "Preliminary Conceptual Area Map of Summer Lifts and Trails". Based on this review, Golder's assessment and professional opinion with respect to potential debris flow hazard is as follows:

- The gradient along Jumbo Creek extending some 2,000 metres or more upstream of the proposed resort site is generally less than 2 percent. There is no evidence of debris flow activity within Jumbo Creek shown on the air photos. It should be noted that debris flow initiation and transmission requires a slope gradient generally in excess of 20 to 25 percent, some 10 times steeper than that of Jumbo Creek. Consequently, it is Golder's opinion that the risk of either debris flow initiation or transmission along Jumbo Creek and the adjacent floodplain of the creek is very low to minimal.
- Although there is evidence of debris flow/flood activity on a number of the tributary streams located further up the valley and in the valley downstream from the proposed resort site, the tributary creeks adjacent to the proposed resort site appear to be relatively benign with respect to debris flow. No evident debris flow activity was observed at resort level. The largest tributary channel passing through the north east perimeter of the resort site is contained within a hanging valley further upslope. Any debris slide/debris flow/snow avalanche activity would likely be deposited within the gentler channel reaches of the hanging valley, located above the logged area. As such, it is our opinion that the risk to the proposed resort site due to debris flow activity is low. Further, the proposed resort is considered to be located in the best and lowest risk site with respect to debris flow risk compared to other areas either upstream or downstream within the Jumbo Creek valley
- Creeks on the west side of the proposed resort appear to have some snow avalanche potential and the small drainage channels adjacent to the resort site have some potential for flooding or debris flood. If additional risk reduction against both flooding and debris flow/flood events is considered desirable, use of containment berms along the perimeter of the floodplain setback zone could be considered.
- There is no indication of past or imminent large scale landslides in the vicinity of the proposed resort and no evidence of small to moderate slide activity resulting from the logging of this area. As such, it is Golder's opinion that the risk of significant landslide activity resulting from development of the proposed resort is very low.

During more detailed design phases, it is recommended that site specific channel assessments and measurements be carried out to better define the alignments and channel conditions as input to determination of floodplain setbacks, hazard potential and the desirability or need for additional mitigative measures.

3.0 OTHER CONSIDERATIONS

It is understood that the Ktunaxa Kiubasket Tribal office – TUS report indicates that the upper Jumbo Valley was not subject to complete glaciation during the Little Ice Age event due to its south aspect, although glaciation is stated to have occurred in the upper Toby Creek valley. As such, it is suggested that the upper Jumbo Valley could have had potential as a refuge for species affected by the adjacent glaciations.

It is noted that the Little Ice Age, which occurred during the middle ages, is considered to have been the result of a period of global cooling. However, expansions of the various glaciers in the Jumbo Valley and elsewhere did not result in the formation of a continental ice sheet, which could result in serious loss of habitat and species. It is Golder's opinion that species would have simply migrated down along Jumbo Valley and other valleys in this and other regions to nearby areas, possibly within a few kilometers, where the temperatures and habitat conditions remained suitable. In this respect, the migrations or movements of species during the Little Ice Age are not considered to be significantly different than the current seasonal patterns, where some species migrate annually to and from the higher terrain.

We trust that this information is sufficient for your immediate requirements. If you have any questions concerning this letter or require further assistance, please do not hesitate to contact the undersigned.

Yours very truly,

GOLDER ASSOCIATES LTD.

Richard C. Butler, P.Eng.
Principal

RCB/
031-411-1166