Comments on Jagger Hims Limited Response to Supplementary Karst Review Comments
(dated November 14, 2008)

In my original peer review of the karst issues (April 8, 2008) and subsequently in my follow-up to JHL's (Andrew Hims) response to the peer review (JHL response dated August 26, 2008 and my comments to this via e-mail October 15, 2008) I noted concerns pertaining to the large east-west high conductivity zone ("high k"), located immediately north of the MAQ and expansion quarries, and to the high groundwater outflows modelled by JHL from the expansion quarry final lake stage.

The first concern has numerous implications not just to lake levels but also to potential operational concerns in the MAQ quarry, however, I have not formally reviewed documentation pertaining to the MAQ quarry. My issue with regard to the final lake levels in the expansion quarry had to do with the ability (or not) of this lake to maintain an appropriate level to recharge the ANSI A, ANSI B and Rob Roy Wetland Complex #2 as predicted in the JHL hydrogeogological modelling (October 2007 Hydrogeological Assemssment Addendum Report - Duntroon Quarry) in light of the predicted high groundwater outflows and the reliance on precipitation over evaporation to fill this lake and maintain overflows to the wetland complexes.

In response to these concerns, JHL undertook further detailed modelling simulations and sensitivity analyses to determine likely final rehabilitation lake levels. A detailed and thorough response to my concerns was provided by Andy Hims on November 14, 2008. I would like to summarize the key findings of the additional modelling simulations and determine what follow-up is required. At the risk of over-simplifying the modelling analysis, I think it is important to try to look at the new modelling results in terms of my original concerns to recharge to wetlands and the role of the high k zone.

In the original modelling provided in the 2007 Addendum Report, the steady-state (i.e., lake filled stage) modelling showed that the final water level in the expansion quarry lake would be maintained by seasonal overflows to each of the wetlands and by high groundwater outflows. This modelling was undertaken using the Lak3 package in MODFLOW but did not fully account for groundwater flow interactions with the existing quarry lake or in the MAQ quarry lake. In the 2008 follow-up modelling the lake level/water budget was re-modelled using alternative pre-processors for MODFLOW (Groundwater Vistas) to more easily accommodate additional lakes. Further, the more recent modelling undertook sensitivity analyses including the incorporation of hydraulic controls (i.e., with and without a fixed outlet from the existing quarry lake to Rob Roy Complex #6) and changing the upper zone hydraulic gradients (i.e., varying the hydraulic conductivity in the "high k" zone).

The proposed post-closing mitigation for wetland surface water supply requires both the final existing quarry lake and the expansion lake to reach levels that will allow recharge (at least seasonally) to their respective wetland systems. The existing quarry lake will need to reach a level that allows westerly discharge to Rob Roy Unit #6. This does not seem to be an issue in any scenario as the west side of the quarry is the lowest point and overflow to this wetland can be achieved under most scenarios (generally achieving an elevation of 512.0 mASL). Higher elevations would be problematical as there is a low point along the east (escarpment brow) at 512.8 mASL; thus levels exceeding this would result in direct spillage over the escarpment face.

When modelling the expansion quarry lake levels and accounting more fully for interactions with proposed existing quarry lake levels, it appears that there would be sufficient groundwater exchange between the two lakes (using 512.0 mASL as the steady state condition in the existing quarry lake) to prevent the former from reaching the required elevation to supply surface water to Rob Roy Unit 2, ANSI A and ANSI B wetlands. The lake stage in the expansion quarry must reach a level of at least 511.81 mASL to permit recharge to one or more of these wetlands (required elevations are 510.0, 511.9 and 510.0 mASL, respectively). Hence, the original estimate of reaching a final water level of 512.0 mASL in the existing quarry lake will not allow recharge to wetlands from the expansion quarry lake.

The revised modelling indicates that in order to reach a sufficient water level in the expansion quarry lake to supply surface water to the wetlands, water levels in the existing quarry will need to be kept higher than previously calculated. Keeping in mind the ultimate elevational control on the escarpment brow (512.8 mASL), and the need to prevent complete flooding of Rob Roy Unit #6 (and downstream), JHL proposes using berms (i.e., dikes) at the escarpment low and along the west side of the lake to accommodate the necessary higher water levels. This scenario would also require a hydraulic control (i.e., drain) to feed Rob Roy Unit 6 with recharge and control final surface levels.

The modeling of final water levels adjusted between the presence of two versus three lakes and the presence and absence of the high k zone in the north/northwest. In all scenarios, final lake levels decrease from the existing quarry to the expansion quarry to the MAQ quarry. Hence, there is a groundwater exchange amongst the lakes that essentially results in an outlet/drainage to the north and west. The presence of the high k zone results in more efficient exchange with “flow” to the north/west which in turn would lower the final water level in the existing quarry (relative to no “high k” zone), however, either scenario results in an elevation of the lake above the escarpment low point. With high k (and allowing for a functioning drain to Rob Roy Unit 6, the final lake stage in the existing quarry would need to be set at 513.75 mASL and 514.15 mASL without the high k zone.

There are two major conclusions resulting from the revised JHL modelling:

1) " The higher the final lake level in the existing quarry, the higher the final lake level that will be achieved in the expansion quarry." (JHL, November 14, page 12). Hence - some form of containment (i.e., berms) will be required around parts of the existing quarry lake to allow sufficiently higher water levels that will in turn permit water levels in the expansion quarry to reach a level that will ensure adequate recharge to the wetlands; and

2) "…the presence of high hydraulic conductivity zones north of the proposed expansion and MAQ quarries does have a significant effect on the water budgets of the Duntroon Expansion lake , as well as on the simulated water levels." (JHL November 14, pages 7 and 8) + "These high k zones have not been confirmed in the field through detailed drilling and testing." (JHL November 14, page 7).

Recommendations:

As a result of these findings by JHL, I would offer three considerations:

A) With regard to finding 1) above, the final height of berms required for the existing quarry lake should be determined for both scenarios (high k and no high k) and compared to elevations of surrounding cultural and natural features (roads, residences, wetlands, etc.). Contingencies/considerations should be provided in the event of the eventual failure of all or portions of the berms);

B) The feasibility of undertaking some grouting between the existing quarry lake and the expansion quarry lake (and/or between the expansion and MAQ quarry) should be investigated to either remove the need for berms or reduce their elevation/extent; and

C) The presence and characteristics of the high k zone north of the quarries must be fully investigated.

Respectfully submitted,

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