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November 14, 2008

Walker Aggregates Inc.
P.O. Box 340
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Attention: Mr. Ken Lucyshyn
Vice President and General Manager

Dear Sirs:

Re: Duntroon Quarry Expansion Hydrogeological Peer Review Comments
Response to Supplementary Karst Review Comments from Daryl Cowell, P.Geo
File 04 930521.52

As requested, we are providing our response to the supplementary review comments raised by Daryl Cowell, P. Geo. in his email correspondence to Kathryn Pounder (Niagara Escarpment Commission), dated October 15, 2008. Mr. Cowell has requested additional information with respect to the following two issues.

1. Confirmation of the parameters and modelling associated with the filling of the expansion quarry (based on parameters in Table 5-14 of the Jagger Hims Limited 2007 addendum hydrogeological report.
2. The large anisotropic lineament to the north of the MAQ and expansion quarry extraction areas. This may be associated with high K-values identified for the NW corner of the latter which is affecting the outflow volumes noted in (1) above. The feature should be better-quantified and may require some further assessment of the MAQ quarry modelling and collaboration with the Jagger Hims modelling. Additional pumping tests/slug tests may be required?

Mr. Cowell had also expressed “some concern about the quantification of impacts due to “percolation” water at the springs in the karst report, although the Jagger Hims modelling

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results appear to suggest these will be minor". Mr. Cowell indicated that since the assessment of the modelling work is being undertaken by Chris Neville, P.Eng. (S.S. Papadopolous & Associates Ltd.), this aspect will be left with him. There is an additional question with regard to monitoring, but that is to be discussed at the Agency meeting on November 24th 2008 that is to include the Adaptive Management Plan.

We have prepared the appended response to the two main issues noted above. We trust that the information is satisfactory, and we are available to discuss our response with the peer reviewers upon request.

Yours truly
JAGGER HIMS LIMITED

Andrew G. Hims, P. Eng
Consulting Engineer

David J. Ruttan, P. Eng
Senior Hydrogeologist

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PROPOSED DUNTROON EXPANSION
LEVEL 2 HYDROGEOLOGICAL ASSESSMENT ADDENDUM REPORT
(October 2007)
RESPONSE TO SUPPLEMENTARY KARST PEER REVIEW QUESTIONS

FINAL LAKE LEVELS AND WATER BUDGETS

Table 5-12 of the Duntroon Quarry Expansion Cumulative Impact Assessment 2007 Report, on pg 127 shows the simulated steady-state water budget for the existing quarry final lake by itself, without either the proposed Duntroon expansion lake or the proposed MAQ Highland Quarry lake being present. Precipitation and evaporation were input into the Lak3 package for MODFLOW based on the previously-used 30-year climate normals for the Thornbury-Slama climate station of 966 mm per year for precipitation and estimated evaporation of 740 mm per year. The difference between the two values is the annual recharge that will help to fill the lake once quarrying has ceased. As well, there will be groundwater discharge into the quarry from the surrounding rock aquifer, similar to what occurs during the extraction process. As the lake fills and the water level rises, the quantity of groundwater discharge will progressively decrease until equilibrium, or steady-state, conditions are established.

Horizontal leakances into the lake for the Lak3 package were derived from the weighted average of hydraulic conductivity of the rock mass around the lake perimeter for each layer and then dividing that weighted average by the distance between cell centers in a horizontal direction.

Vertical leakances were derived by assuming that the rock layer below the lake is the lakebed and dividing the vertical hydraulic conductivity of the rock (taken to be one order of magnitude lower than the horizontal value) by the layer thickness. As the floor of the lakes will gradually accumulate sediment over time, fractures that “daylight” on the quarry floor will become filled with sediments and the leakances will decrease.

The values given in Table 5-12 for precipitation are based on 0.966 m/year multiplied by the area of the final lake and converted to m^3/day. The value for evaporation is taken as 0.740 m/year (evaporation from a free water surface) multiplied by the area of the final lake, and converted to m^3/day. Therefore, there is an annual surplus of precipitation over evaporation of 0.23 m/year, which reflects the annual average direct recharge to the lake, and is equivalent to 252 m^3/day.

Groundwater flow out of the lake and into the surrounding rock aquifer is 3.5 m^3/day, while groundwater flow from the aquifer into the lake is 397 m^3/day. Groundwater flow from the aquifer into the lake can be confirmed by inspecting the groundwater potentiometric contours which show that the simulated heads in the aquifer are higher than the water level stage in the lake.

As part of this response, this water budget was compared to a new simulation model output in which the lake was represented as a Constant Head boundary that was set at elevation 512.0 m asl. In other words, two models were used; the original model with the Lak3 package representing the existing quarry lake, and a separate model with a group of constant head cells representing the existing quarry lake. Results are shown in Table 1 below, and are compared to Table 5-12 from the 2007 report.

TABLE 1
COMPARISON OF RESULTS FROM LAKE PACKAGE AND CONSTANT HEAD PACKAGE, EXISTING QUARRY LAKE ONLY

Method of Representing Lake	Groundwater Inflow m^3/day	Groundwater Outflow m^3/day	Precipitation minus Evaporation (Recharge) m^3/day
From Table 5-12 Lake Budget **Lak3 Method**	397	3.5	252
Constant Head Method	422	5	269

Note: Groundwater inflow is flow out of the aquifer into the lake
Groundwater outflow is flow out of the lake into the aquifer

Apart from small differences in quantities that occur because the areal extent of the budget zone for the constant head method is slightly greater than that for the lake package, there is good agreement between the two methods.

The Constant Head method does not require a leakance value that was derived from a weighted average of hydraulic conductivity of the rock, as does the Lak3 package, but instead relies on the inputting of a predetermined lake stage as the package name implies. This, in effect, provides a method of backward-checking the results. The good agreement between the two sets of results provides additional confidence in the applicability of the Lak3 modelling package and in the estimate of final lake stage. It also indicates that the method of calculation of leakances for the Lak3 package is representative.

In the October 2007 Addendum Report submission, the Duntroon expansion lake was simulated using the Lak3 package in Visual MODFLOW, with the water level in the existing quarry lake being represented by a constant head elevation of 512.0 m asl. It was recognized that representing the existing quarry lake as a constant head does not permit the model to show any effects which may be due to the presence of the expansion lake on the existing quarry lake. To explore this limitation, the model was transferred from Visual Modflow to Groundwater Vistas, which is an alternative graphical user interface for the Modflow code. In Groundwater Vistas, multiple lakes can be entered graphically whereas, in Visual Modflow, lakes have to be added using a text editor. This is discussed further below.

Table 5-14 of the 2007 report shows the water budget for the expansion quarry lake using the Lak3 method. Groundwater flow from the aquifer into the lake is 390 m^3/day, while groundwater flow from the lake into the aquifer is 782 m^3/day. Precipitation and evaporation are equivalent to 1688 m^3/day and 1298 m^3/day respectively, resulting in a surplus (recharge) of 390 m^3/day.

Simulating the lakes with the High Hydraulic Conductivity method (rather than by the Lak3 method) shows that small changes in the relative difference between the groundwater levels in the aquifer adjacent to the lake and the lake water level stage determines whether most of the water discharges to the lake or, alternatively, moves from the lake to the aquifer. With the Lak3 package method, water exits the lake and enters the aquifer to the north of the lake, and from there flows predominantly westward through the zone of higher hydraulic conductivity rock. As well, groundwater flow from the east end of the lake is towards the northeast and east to the Niagara Escarpment.

Modelling the expansion lake with either constant heads or with the river package could not be completed because the proposed two levels of quarrying complicate the simulation. The west, north and eastern sections are to be mined to elevation 500 m asl while the central-southern section is to be mined to elevation 490 m asl.

The expansion lake can, however, be modelled using the High Hydraulic Conductivity method (High k method). This method involves replacing the original hydraulic conductivity of the rock in the Modflow cells within the limits of the lake with significantly higher values which, when the model is run to steady-state, produces an almost flat hydraulic gradient across the lake representing the lake level. The existing quarry lake was simulated with a constant head at elevation 512.0 m asl.

Results of the water budgets for the two lakes using the High Hydraulic Conductivity method are shown in Table 2, below.

TABLE 2
COMPARISON OF RESULTS FROM LAK3 PACKAGE, CONSTANT HEAD PACKAGE AND HIGH HYDRAULIC CONDUCTIVITY METHOD, DUNTROON EXISTING QUARRY AND PROPOSED EXPANSION QUARRY LAKES

Method of Representing Lakes	Groundwater Inflow m^3/day	Groundwater Outflow m^3/day	Precipitation minus Evaporation (Recharge) m^3/day
From Table 5-14 Expansion Lake Budget Lak3 Method	390	782	390
Modflow Constant Head Method for Existing Quarry Lake	360	586	226
High K Method Expansion Lake	316	718	399

Note: Groundwater inflow is flow out of the aquifer into the lake.
Groundwater outflow is flow out of the lake into the aquifer.

The presence of the expansion lake significantly modifies the water budget of the existing lake in that more water flows out of the existing lake as groundwater. The water budget quantities for the expansion lake are relatively comparable for the Lak3 package and the high hydraulic conductivity method.

Figure 1 shows groundwater flow directions in Layer 3 of the model near the bottom of the existing quarry lake. Groundwater flows into the existing quarry lake from all sides except on the east side where there is flow eastward to the Niagara Escarpment. Groundwater flows into the expansion lake from the southwest and west with minor inward flow from the east side. Groundwater then flows northeast and north to exit the lake on the north side from where it flows westward. There is a minor component of groundwater flow from the lake northeast to the Niagara Escarpment.

As noted above, when modelling lakes with Visual Modflow using the Lak3 package, it is necessary to use a text editor to construct the input files for the lakes, and this makes it extremely time-consuming to input complex multiple lakes. In order to facilitate this current assessment, the existing 6-layer calibrated model was transferred from Visual Modflow to the Groundwater Vistas modelling software, which is a preprocessor that can accommodate multiple lakes using the Lak3 package.

Two scenarios were modelled. The first scenario includes modelling the existing and proposed Duntroon expansion quarry lakes using the Lak3 package. The second scenario included the existing quarry lake and the expansion lake, as well as the MAQ lake which were modelled using the Lak3 package.

Table 3 gives the computed lake stage and water budgets for the existing and proposed Duntroon expansion quarry lakes modelled in Groundwater Vistas.

TABLE 3
LAKE STAGE AND WATER BUDGETS FOR EXISTING AND PROPOSED DUNTROON EXPANSION, QUARRY LAKES
GROUNDWATER VISTAS LAK3 METHOD

Lake	Stage m asl	Groundwater Inflow m^3/day	Groundwater Outflow m^3/day	Recharge m^3/day
Existing Quarry Lake	516.18	46	282	233
Duntroon Expansion Quarry Lake	512.11	479	869	390

The predicted lake-stage results are long-term steady-state average values, but there will be seasonal fluctuations imposed on these averages. Since the existing quarry lake has its lowest brow elevation at 512.8 m asl, this will be the final lake stage average elevation unless perimeter containment berms were to be constructed at the lowest point to increase the average water level (which would be straightforward to do). There will be sufficient water seasonally to recharge the wetland to the west of the existing quarry. The water budget quantities for the expansion lake are 26% and 13% greater (groundwater inflow and outflow respectively) than in Table 5-14 of the 2007 report because in this assessment both lakes were simulated using the Lak3 package.

In addition, the simulated water level in the existing quarry lake rose to an elevation (516.18m) that is several metres higher than what physically is the minimum brow elevation at the quarry, because this model did not include any constraints such as a minimum brow elevation when computing the final lake level. In reality, the lake level will rise to the elevation of the lowest natural outlet feature, which in this case is the ground elevation at the west end of the existing quarry, and excess water will discharge from the lake to the adjacent wetland / surface water system.

As a further assessment tool, a sensitivity analysis was carried out on vertical leakance for the above model. All vertical leakances were doubled to simulate the lake-aquifer interactions before sedimentation occurs to reduce the hydraulic conductivity of the lake bed. Under these conditions, the simulated final lake level for the existing quarry lake was 516.14 m asl, a reduction of only 0.04 m. The simulated lake level for the expansion quarry lake was 512.20 m asl, indicating that vertical leakage at the bottom of the lake is less important than is horizontal leakage from the side of the lake.

Since the final lake level affects the groundwater inflows and outflows quite significantly, a drain was input in the model in the area of the wetland west of the existing quarry to simulate surface water flowing west from the lake. The water level stage of the drain was set at 512.8 m asl (i.e. at the minimum brow elevation at the quarry face), and the drain conductance was set as high as possible in order to maintain a balanced water budget in the area.

Table 4 provides the results. The final simulated lake stage for the existing quarry was 513.84 m asl using this approach. This exercise can be regarded as an example of mitigation measures that could be put in place to control water levels and discharges. The final water level in the existing lake does have an effect on the water level in the expansion lake, but the relationship is not linear as can be seen by comparing lake stages between Table 4 and 3.

TABLE 4
LAKE STAGE AND WATER BUDGETS FOR EXISTING AND PROPOSED DUNTROON EXPANSION, QUARRY LAKES, WITH HYDRAULIC CONTROL ON EXISTING LAKE LEVEL GROUNDWATER VISTAS LAK3 METHOD

Lake	Stage m asl	Groundwater Inflow m^3/day	Groundwater Outflow m^3/day	Recharge m^3/day
Existing Quarry Lake	513.84	103	337	233
Duntroon Expansion Quarry Lake	512.05	339	729	390

With hydraulic controls present in the model, the simulated water level for the existing quarry lake decreased by 2.34 m. The expansion lake level decreased by 0.06 m. The predicted lake stage in the 2007 report Table 5-14 (511.9 m asl), and the predicted expansion lake stage in Table 4 (512.05) show close agreement as do the water budget values (reproduced in Table 2 above). Under these conditions, the simulated expansion lake level is not particularly sensitive to the simulated existing quarry lake level. Excess water which is available in the existing quarry lake can drain to the wetland to the west without significantly affecting the expansion lake level or the groundwater inflows and outflow to and from the expansion quarry lake.

HIGH HYDRAULIC CONDUCTIVITY ZONES

The high hydraulic conductivity zones (high k zones) in the bedrock that are incorporated into the 2007 model north of the Duntroon Expansion Quarry and the MAQ quarry, assist in the calibration of the existing conditions model. The presence of such zones has been inferred based on site water level data, examination of topography and lineations observed using aerial photography and from the results of mapping the fracture set orientations. These high k zones have not been confirmed in the field through detailed drilling and testing.

In their current form in the 2007 calibrated model, and in the lake model scenarios discussed above, the high k zones may result in removal of significant quantity of groundwater from the lakes. It is recognized that the rock material may be less conductive than is represented in the 2007 calibrated model, and therefore a sensitivity analysis was conducted to explore the impacts of lower hydraulic conductivity in these zones. In the sensitivity analysis, the high k zones north of the quarries were removed from the model and were replaced with the (lower) hydraulic conductivities of the surrounding rock material. Table 5 shows the simulated steady state lake stages and water budgets for the existing and proposed Duntroon Expansion Quarry lakes, with the high k zones removed and no hydraulic controls in place at the existing quarry. These results should be compared to Table 3.

TABLE 5
LAKE STAGE AND WATER BUDGETS FOR EXISTING AND PROPOSED DUNTROON EXPANSION, QUARRY LAKES, NO HIGH HYDRAULIC CONDUCTIVITY ZONES, NO HYDRAULIC CONTROLS.
GROUNDWATER VISTAS LAK3 METHOD

Lake	Stage m asl	Groundwater Inflow m^3/day	Groundwater Outflow m^3/day	Recharge m^3/day
Existing Quarry Lake	516.85	27	306	233
Duntroon Expansion Quarry Lake	514.62	293	696	390

Under these simulated conditions, the water budget for the existing quarry lake is relatively similar to the values in Table 3. Whereas the groundwater inflow in Table 5 is about 40% less than in Table 3, the two values are relatively small such that the absolute difference is minor. Groundwater outflow in Table 5 is 9% more than in Table 3. For the expansion lake, groundwater inflow in Table 5 is about 40% lower than in Table 3, and groundwater outflow is 20% lower than in Table 3. These results indicate that 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 lake levels.

Table 6 shows results for the same simulation as above, but with hydraulic controls in place to reduce the lake level in the existing quarry lake. These results should be compared to Table 4.

TABLE 6
LAKE STAGE AND WATER BUDGETS FOR EXISTING AND PROPOSED DUNTROON EXPANSION, QUARRY LAKES, NO HIGH HYDRAULIC CONDUCTIVITY ZONES, HYDRAULIC CONTROLS PRESENT ON EXISTING LAKE LEVEL
GROUNDWATER VISTAS LAK3 METHOD

Lake	Stage m asl	Groundwater Inflow m^3/day	Groundwater Outflow m^3/day	Recharge m^3/day
Existing Quarry Lake	514.15	133	392	233
Duntroon Expansion Quarry Lake	514.25	165	579	390

The removal of the high k zones results in higher final lake levels for both lakes, and changes to the groundwater inflow/outflow distribution. As in the above example, the effect on the water budget for the Duntroon Expansion Quarry lake is significantly greater than is the effect on the water budget for the existing quarry lake. In summary, although the high hydraulic conductivity zones provide the best calibration of the model, in the event that the local hydraulic conductivity of the rock is lower than was used in the calibrated model, the predicted final lake levels will be slightly higher than is currently predicted with the high k zones being present.

EXISTING QUARRY, EXPANSION QUARRY and MAQ QUARRY FINAL LAKE LEVELS and WATER BUDGETS

Table 7 gives the simulated final lake levels and water budgets for the three proposed quarry lakes modelled in Groundwater Vistas.

TABLE 7
LAKE STAGE AND WATER BUDGETS FOR EXISTING, PROPOSED DUNTROON EXPANSION, AND PROPOSED MAQ HIGHLAND QUARRY LAKES
GROUNDWATER VISTAS LAK3 METHOD

Lake	Stage m asl	Groundwater Inflow m^3/day	Groundwater Outflow m^3/day	Recharge m^3/day
Existing Quarry Lake	515.81	46	283	233
Duntroon Expansion Quarry Lake	511.81	477	867	390
MAQ Highland Quarry Lake	509.62	1002	1438	436

The presence of the proposed MAQ Highland Quarry lake has a relatively minor effect on the lake level in the Duntroon expansion quarry lake, lowering it by approximately 0.3 m (compare to Table 3). The water budgets for the existing and expansion quarry lakes in Table 7 are almost identical to the water budgets for the same lakes in Table 3. This indicates little impact from the proposed MAQ quarry lake as simulated using the Lak3 package.

With respect to achieving seasonal discharge to the wetlands to the northwest and northeast of the expansion quarry lake, the general ground elevations within the wetland areas are as follows:

- Rob Roy PSW Complex Unit # 2: 510 m asl or lower (perimeter ground approximately 510 m asl).
- ANSI A wetland area: 511.4 m asl (perimeter ground approximately 511.7 m to 511.9 m asl).
- ANSI B wetland area: 510 m asl (perimeter ground approximately 510.4 m asl).

For this simulation, the predicted annual average final lake level is 511.8 m asl, and this would be expected to rise by about 0.3 m to 512.1 m asl each spring. Therefore, discharge from the lake to the wetland areas in the spring would be expected.

Since the simulated lake level in the existing quarry (515.8 m asl) is higher than is required to achieve seasonal discharge to the Rob Roy PSW Unit #6 wetland area west of the quarry (512.8 m asl), the model was re-run with a hydraulic control drain in place designed to replicate the overflow from the lake and the resulting final water level in the existing quarry. Table 8 shows the simulated final lake levels and water balances for the three lakes (compare to Table 7).

TABLE 8
LAKE STAGE AND WATER BUDGETS FOR EXISTING, PROPOSED DUNTROON EXPANSION, AND PROPOSED MAQ HIGHLAND QUARRY LAKES, HYDRAULIC CONTROL PRESENT ON EXISTING QUARRY LAKE.
GROUNDWATER VISTAS LAK3 METHOD

Lake	Stage m asl	Groundwater Inflow m^3/day	Groundwater Outflow m^3/day	Recharge m^3/day
Existing Quarry Lake	513.75	99	333	233
Duntroon Expansion Quarry Lake	510.97	360	750	390
MAQ Highland Quarry Lake	509.54	950	1386	436

Lowering the existing lake level does result in a lowering of the expansion lake level, and to a minor extent, the MAQ lake level. With an annual average lake level in the expansion quarry of approximately 511 m asl, and a corresponding spring lake level of 511.3 m asl, spring discharge would be achieved for Rob Roy PSW Unit #2 and for ANSI B wetland area. The predicted spring lake level would be about 0.1 m lower than the ground level in ANSI A wetland area, such that seasonal surface discharge into that wetland would not occur. These results indicate that it would be beneficial to have the final lake level in the existing quarry remain as high as possible to help maintain higher water levels in the expansion lake and thereby facilitate seasonal discharge to the wetland areas.

This can be accomplished simply by raising the grade around the short, lowest, central section of the western perimeter of the existing quarry extraction area, and keying that into the existing berm to facilitate a higher final lake level. Stantec has reviewed such possible future grade changes with respect to potential impacts on natural heritage features, and in particular the nearest Rob Roy wetland unit #6 that is found to the west. The increased grade will not encroach on this wetland unit as it will be located within the existing licensed area, it will not negatively affect the catchment and associated surface water contribution to the wetland, or the seasonal groundwater contributions that supports the wetland function. The area will be naturalized with native plantings and offers an additional buffer to the wetland unit. In summary, raising the grade through this small section of the existing quarry has no potential to negatively affect the natural heritage features in the local landscape.

For the existing quarry lake, groundwater inflow to the lake is doubled while groundwater outflow from the lake to the aquifer increased by 18% compared to values in Table 7. The inflows doubled because the lake level was lowered compared to the surrounding groundwater levels. The outflows increased because of the lowering of the expansion lake by nearly 1m and minor change to the MAQ lake level.

Water budget values for the expansion lake decreased by approximately 100 m^3/day between Table 8 and 7. Water budget values for the MAQ lake between Table 8 and 7. are relatively similar.

As a sensitivity assessment, the model was re-run with the three lakes represented using the Lak3 package, but without the high hydraulic conductivity zones present to the north of the Duntroon Expansion and MAQ property. Table 9 shows the results and should be compared to Table 7.

TABLE 9
LAKE STAGE AND WATER BUDGETS FOR EXISTING, PROPOSED DUNTROON EXPANSION, AND PROPOSED MAQ HIGHLAND QUARRY LAKES, WITH HIGH HYDRAULIC CONDUCTIVITY ZONES REMOVED, NO HYDRAULIC CONTROLS ON EXISTING LAKE GROUNDWATER VISTAS LAK3 METHOD

Lake	Stage m asl	Groundwater Inflow m^3/day	Groundwater Outflow m^3/day	Recharge m^3/day
Existing Quarry Lake	517.72	19	524	233
Duntroon Expansion Quarry Lake	513.83	296	762	390
MAQ Highland Quarry Lake	513.07	446	942	436

Removal of the high hydraulic conductivity zones in the model results in higher simulated lake levels, and changes in the groundwater inflow/outflow distributions. Less groundwater inflow into the lakes occurs. With the exception of the existing lake, less groundwater outflow from the lake to the aquifer also occurs. These results are to be expected because the overall average hydraulic conductivity of the surrounding rock is less than the calibrated model case.

Table 10 shows the results with the high hydraulic conductivity zones removed, and hydraulic drain controls present on the existing lake level. These results should be compared against Table 8.

TABLE 10
LAKE STAGE AND WATER BUDGETS FOR EXISTING, PROPOSED DUNTROON EXPANSION, AND PROPOSED MAQ HIGHLAND QUARRY LAKES, WITH HIGH HYDRAULIC CONDUCTIVITY ZONES REMOVED, HYDRAULIC CONTROLS ON EXISTING QUARRY LAKE GROUNDWATER VISTAS LAK3 METHOD

Lake	Stage m asl	Groundwater Inflow m^3/day	Groundwater Outflow m^3/day	Recharge m^3/day
Existing Quarry Lake	514.23	150	390	233
Duntroon Expansion Quarry Lake	513.52	156	553	390
MAQ Highland Quarry Lake	512.90	425	867	436

The removal of the high hydraulic conductivity zones results in higher simulated final lake levels, and changes to the groundwater inflow/outflow distributions. Groundwater inflows and outflows to the existing quarry lake are increased moderately between Table 10 and Table 8. For the expansion and MAQ lakes, both groundwater inflows and outflows from the lakes are decreased and reflect the decrease in overall average hydraulic conductivity distribution as detailed above.

CONCLUSIONS

The scenarios that were modelled with the Lak3 package using multiple lakes, are considered to be more representative of final conditions relative to the 2007 model since, in the 2007 model, simplifications had to be made to the input data (only one leakance per layer). By using the automated input from Groundwater Vistas, more-representative leakances could be used representing both horizontal and vertical aquifer-lake interactions.

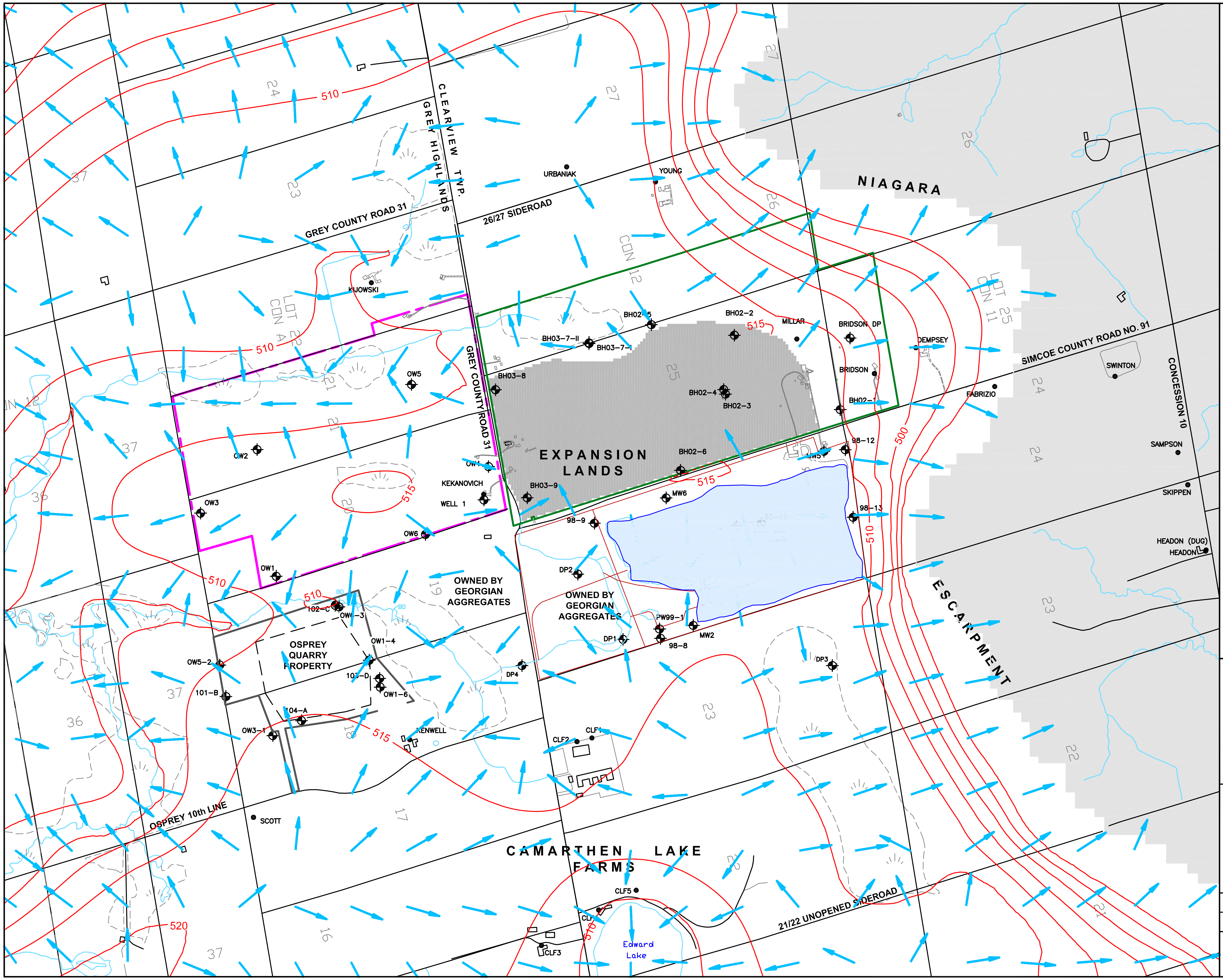
The simulations show that groundwater inflow and outflow from the lakes are dependent on the final lake levels that can be achieved. Also, the final lake level that is achieved in the existing quarry factors into the final lake level that can be achieved in the expansion quarry. The higher the final lake level in the existing quarry, the higher the final lake level that will be achieved in the expansion quarry.

In order to achieve a final lake level in the expansion quarry lake that will provide seasonal gravity discharge during the spring melt to all three of the adjacent wetlands, the modelling indicates that it may be beneficial to raise the water level of the lake in the existing quarry by means of perimeter berms around the west side of that quarry. It should also be noted, however, that these models which incorporate the Lak3 method and the high hydraulic conductivity method, do not include any annual surface water runoff component to the final lakes from within the quarry properties. Such runoff will act to increase the annual recharge to the lakes, resulting in slightly higher water levels than is simulated.

In the event that the rock in the high hydraulic conductivity zones (likely fracture zones) north of the expansion lands and MAQ lands is not as conductive as is used in the model, then the modelling indicates that final lake levels will be higher. However, it is likely that such higher k zones are present in some form, based on the predominance of the dominant east-west fracture set and the relative distribution of groundwater levels that are observed north of the Duntroon expansion property and the MAQ property. On this basis, the predicted lake levels with and without the high hydraulic conductivity zones are interpreted to reflect possible minimum and maximum annual average final lake levels, respectively.

It is anticipated that, as a result of long term monitoring through the quarrying operations, a final optimum average lake level for the existing quarry lake will be determined. The modelling indicates that it may be beneficial to raise the elevation of the ground surface around a short section along the west side of the existing quarry, and thereby allow a higher final lake level to be established. The progressive filling of the lake in the existing quarry will be subject to on-going monitoring throughout the operation of the expansion quarry, and the final grade elevations around the western perimeter can be adjusted as appropriate, with no resulting negative impacts on the adjacent wetland area

The simulated lake levels are annual average predicted levels, and seasonal fluctuations will occur. A typical range of seasonal fluctuations is expected to be 0.3 m above and below the average predicted levels. The modelling indicates that the final lake levels that will be achieved will be sufficient to provide seasonal discharge to the wetland areas around the existing quarry and the expansion quarry properties.



Legend

▭	EXISTING DUNTROON QUARRY PROPERTY
▭	PROPOSED DUNTROON QUARRY EXPANSION LANDS
▭	MAQ PROPERTY
⌖ BH02–6	BOREHOLE/WELL LOCATION AND DESIGNATION
— 500 —	GROUNDWATER FLOW CONTOURS (mASL)
→	INFERRED GROUNDWATER FLOW DIRECTION
▭	EXISTING LAKE
▨	PROPOSED EXPANSION LAKE

150 0 300 metres

N

NOTES:

1. MAP SOURCES OBM SHEETS 10 17 5600 49150, 10 17 5550 49100, 10 17 5550 49150 AND 10 17 5600 49100, NAD 27 DATUM AND McNAUGHTON HERMSEN CLARKSON PLANNING LIMITED, EXISTING FEATURES 2003.

GROUNDWATER FLOW DIRECTIONS WITH PROPOSED EXPANSION AND EXISTING QUARRY LAKES

DUNTROON QUARRY EXPANSION
CUMULATIVE IMPACT ASSESSMENT
GROUNDWATER MODELLING ADDENDUM
AND RESPONSE TO AGENCY COMMENTS
For Walker Aggregates Inc.

DATE: NOVEMBER 2008	SCALE: 1:15000
PROJECT: 4–930521.52	FILE NO.: 4–93052152–GW

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Figure