GEC
Guiton Environmental Consulting

Deep Bay Improvement District
5031 Mountainview Road
Bowser, BC V0R 1G0

September 11th, 2013

Attn: Ms. Leslie Carter, Administrator

Re: Third Party Review of Groundwater Feasibility Study
Kala Geosciences Ltd. June 30th, 2010
Deep Bay, BC

Dear Ms. Carter

This report represents a third party review of an existing groundwater feasibility study that was conducted in the Deep Bay Area. The study in question is presented in a report by Kala Geosciences Ltd. (Kala), dated June 30th, 2010. That report was prepared for Baynes Sound Investments Ltd. (Baynes), a land development company that is proposing a large residential development in the Deep Bay area.

Introduction

It is understood that the proposed residential development wishes to obtain a water supply from the Deep Bay Improvement District water system. In addition to groundwater extraction, it appears that the proposed development is also contemplating an in-ground wastewater (sewage effluent) disposal scheme. It is further understood that the Deep Bay Improvement District (the District) has concerns regarding the impact of the proposed development on the District's aquifer and the overall capacity of the aquifer to sustain the increased extraction contemplated for the proposed development. As a result of these concerns, the District has retained Guiton Environmental Consulting Ltd. (GEC) and specifically Mr. Rick Guiton, M.Sc., P.Geo, Senior Hydrogeologist, to conduct a review of the existing Kala feasibility study and to provide advice regarding the conclusions of that work.

GEC Scope of Work

The GEC scope of work consisted of three main tasks as follows:

1. Review of relevant reports and data
2. Site reconnaissance and inspections
3. Preparation of a letter report

Approval to proceed with the agreed work was received on Friday, August 9th, 2013. Relevant reports and data were then assembled and reviewed during the following two and a half weeks. A list of the reviewed reports is attached. A site reconnaissance inspection was conducted over the two day period of August 29th and 30th, 2013. Preparation of this report was conducted during the

first week of September. All work was conducted by Mr. Rick Guiton. No new or independent investigation work was conducted as part of the scope of work required of GEC.

Kala Feasibility Study – Objectives

Firstly, the Kala study is clearly identified as a feasibility study, not a detailed investigation or design level study. Therefore, as appropriate, Kala provides only "preliminary conclusions" and contemplates additional work requirements. The objectives of the Kala study are clearly identified as follows:

1. Verify the well yield of WIN 255
2. Provide recommended sites for new wells
3. Determine drawdown interference impacts on the existing District wells
4. Determine any potential impacts on the Gainsburg swamp
5. Estimate the sustainable yield of the site.

Kala Feasibility Study – Description of Aquifer and District Well Field

As reported by Kala and other authors, the site is underlain by provincial aquifer 416, Quadra Sand. The Quadra Sand aquifer is known to be large, but variable. The two key variables of this aquifer are its productivity and the intermittent presence of an overlying stratum of low permeability. Firstly, the variable productivity of the aquifer is evidenced by the numerous unsuccessful wells and the variable flow rates of the Districts successful water wells. Secondly, the aquifer is generally overlain by a low permeability stratum; however this low permeability stratum can be locally absent as seen in some of the well logs. Where it is present, the low permeability stratum will intercept and retain infiltrating precipitation, creating what is known as a "perched zone of saturation" or a "perched water table". Where the low permeability stratum is very near ground surface, due for example to a topographic depression, the perched zone of saturation can build up to and above ground surface and create an area of surface water such as the Gainsburg swamp. Otherwise, the perched zone of saturation remains below ground in the shallow subsurface, where it is seen as a very shallow water table in excavations, and where it is readily available to plant root zones and evapotranspiration processes.

The District has seven water supply wells identified as WIN13731 (Well 1-73), WIN13732 (Well 2-73), WIN13733 (Well 3-69), WIN 13734 (Well 4-77), WIN 13735 (Well 5-85), WIN13736 (Well 6-90), and WIN 13737 (Well 8-97). An eighth well, WIN255 (Well 7-96), also referred to as provincial observation well 331, is not in use. The productivity of the Districts seven wells increases to the east, with the two most eastern wells, #8-97 and #5-95, being the most productive and most utilized. Therefore, the majority of groundwater extraction originates from a relatively small area due primarily to the degree of aquifer variability.

Kala Feasibility Study – Key Findings

The Kala study provides numerous findings, observations, results, interpretations, conclusions and recommendations. However, with respect to the purpose of the GEC review, the key findings of the Kala study are:

1. The new development may require approximately 22 L/s
2. Kala indicates that the total capacity of the Districts seven wells is 47.28 L/s, excluding WIN 255.
3. The capacity or sustainable yield of WIN255 was determined by Kala to be 9.45 L/s.
4. Kala indicates that the Districts water demand averages 7.58 L/s on a yearly basis (2005 data), with peak usage of 10.94 L/s in summer (2006 data). This peak summer usage represents a 3.36 L/s or 44% increase of average flows
5. The total groundwater recharge to the Districts well field area is estimated by Kala to be 84 L/s. This rate of groundwater recharge was calculated by Kala to be a result of 21.4 L/s from infiltrating precipitation and 62.6 L/s from upland groundwater flow.
6. The sustainable yield of the Districts well field is estimated by Kala to be between 40.1 L/sec during drought years, and 55.9 during average years.
7. Kala concludes that the sustainable yield of the Districts well field is sufficient to meet the current District water requirements plus the demand of the proposed subdivision, which, using numbers provided by Kala, would be 7.58 L/s plus 22 L/s or 29.58 L/s. It should be pointed out that if the future average flow were to be 29.58 L/s, the peak summer flow would be 44% greater or 42.6 L/s, if current experience as indicated in item 4 above, were applicable.
8. Kala recommends that any new wells should be a minimum of 120 metres from existing wells, and that a properly sited and constructed 203 mm diameter well could yield between 9.45 and 12.6 L/s.
9. With respect to chemical composition, Kala determined that the groundwater is of high quality, but with an increasing trend of nitrate concentration, indicative of agricultural or sewage effluent based pollution near the Districts well field. The cause or source of this pollution is concluded by Kala to be unknown.
10. Kala provides recommendations regarding separation distance between any in-ground sewage effluent disposal fields associated with the proposed subdivision and the Districts well field area. Kala also recommends numerical simulation (computer simulation) analysis if the sewage disposal rate is greater than 3.47 L/s (300 m^3/d).

GEC Assessment of the Kala Study

The general approach and the various methods of analysis used by Kala for the feasibility study are considered appropriate. However, the proposed development will essentially quadruple the Districts current water demand, and will stress the aquifer well beyond any demand level experienced to date. Given this, along with the known degree of aquifer variability, the selection of input parameters and associated assumptions used by Kala to calculate aquifer recharge and sustainability could have been much more conservative at this initial feasibility stage; particularly in the absence of more detailed investigations and field verification. Although Kala does indicate some conservative assumptions in their work, the key parameters that have the biggest impact on groundwater recharge and aquifer sustainability calculations, were not selected conservatively. Some examples of this are provided in the following paragraphs.

Recharge to the aquifer from infiltrating precipitation was calculated to be 21.4 L/s using an assumed precipitation value of 1705 mm/yr and an assumed infiltration rate of 35 percent of

annual precipitation. The precipitation amount used by Kala is from the Mud Bay station, which is the closest to Deep Bay. However, three other stations in the nearby area, one in Comox to the north-west and two in the Qualicum Bay area to the south-east, have significantly lower total precipitation amounts (1098 to 1314 mm/yr). Given this high degree of variability, it would have been more appropriate to average these differing amounts, rather than select the highest amount. Similarly, the infiltration rate was selected at 35 percent (actually stated in the Kala report as: *..."could be in the order of 0.35."*). The selection of this value appears to be based primarily on the existence of a shallow water table. This value is significantly higher than generally accepted groundwater infiltration rates of 5 to 15 percent. Inspection of the site does suggest higher than normal infiltration rates, based on the lack of surface drainage features (as also pointed out by Kala) and the presence of sandy soils at surface. However, what is not apparently taken into account is the low permeability stratum, which where present, will intercept and perch the infiltrating precipitation and thus potentially reduce the amount which actually recharges the aquifer below this stratum. While it is agreed that the infiltration rate is likely greater than the normally expected range, it would have been more appropriate at this feasibility stage to be conservative and use a smaller increase, rather than the high value of 35 percent that was used.

If one were to average the precipitation amounts from the four weather stations, resulting in a value of 1324 versus 1705 mm/yr; and then were to use an infiltration rate of say 20 percent instead of 35 percent, the resulting calculation of groundwater recharge from infiltrating precipitation would be approximately 9.63 versus the 21.4 L/sec value determined by Kala using assumed higher input values.

A second example involves the calculation of recharge quantities from upland groundwater flow. Kala calculated this amount to be 62.6 L/s. Their calculation was based partly on the aquifer parameter hydraulic conductivity, that itself was calculated based on drawdown observed during the pumping test of well WIN255 (Well 7-96) in February 2010. The pumping test should have been conducted during the late Summer/early Fall period when groundwater levels are at their lowest due to an extended dry period, with high demand and limited groundwater recharge. Stressing the aquifer at this time, which is the time of year when maximum demand and groundwater pumping occurs, would have produced more realistic and conservative values of, not only aquifer parameters but also well interference effects and the potential impacts on the Gainsburg swamp. Kala points out that previous work by Hodge in 1999 indicated very little well interference from well pumping during summer. It should be pointed out that Hodge did not do any previous work at the site; his memorandum was a review of work done by Pacific Hydrology in 1997. The Pacific Hydrology report, dated November 25th, 1997 advises caution regarding interpretation of the observed minimal well interferences, because that particular summer was relatively wet, with a higher than normal water table.

The calculation of recharge from the upland was based on the hydraulic gradient observed by Kala within the small area of the well field. The hydraulic gradient in this small area is relatively steep at 0.027, as pointed out by Kala. However, previous work (Pacific Hydrology, November 25th, 1997), which also confirmed steeper gradients within the well field, demonstrated a much flatter gradient of about 0.13 immediately south of the well field, in the upland recharge area, the area in question when calculating quantities of flow from upland groundwater recharge.

Inspection of the site confirms that the upland recharge area is quite flat, and much flatter than the area in the vicinity of the well field. The change in hydraulic gradient is likely related to, and somewhat mirrors this change in topography, and must also be taken into account when evaluating upland recharge amounts. If one were to employ a hydraulic conductivity value that is lower by only a factor of 2 or 3 and a hydraulic gradient value that also recognizes the flatter gradient in the upland recharge area, then the calculated amount of upland groundwater recharge could be reduced to 50 percent of the 62.6 L/s calculated by Kala.

Using the above two examples it has been shown how easily the total estimated amount of groundwater recharge to the Districts well field area can be reduced to 41 L/s from the value of 84 L/s that was estimated by Kala. What is important in this exercise is to demonstrate the significance of assumed and unverified values of input parameters to various calculations. While one can create arguments to support or defend various assumptions and the selection of various parameter values, it would be more appropriate to take a very conservative approach at this stage, in the absence of proven and verified assumptions, given the magnitude of the proposed increase in groundwater extraction and the lack of any experience at these much higher extraction rates.

Some additional comments regarding the Kala study are presented in the following paragraphs.

The Kala study concluded that there was no observed impact on the Gainsburg swamp during the pumping test of well WIN255. Further, Kala concludes that since the swamp represents a perched condition, there will be no impact on the swamp due to the pumping of existing District wells or any new wells. Firstly, since the pumping test was conducted during February when the swamp was flooded, it would be extremely difficult to detect any pumping impacts since potential responses would have been masked by the large quantities of surface water in the swamp. If the test were to have been conducted during late Summer/early Fall when the swamp has dried (as was observed during the GEC site inspection), it would be possible to observe impacts if any were actually occurring. Secondly, the low permeability stratum that has created the perched swamp will also create perched zones of saturated groundwater in areas where the stratum exists. These areas may not be visible at surface like the swamp, due to higher ground surface elevations, but will exist nonetheless in the subsurface. Perched zones are not just limited to the Gainsburg swamp. All of these perched zones represent infiltrating water that has been intercepted and remains trapped and stored at or near surface. In this state these stored quantities of water will remain highly susceptible to evapotranspiration losses and will reduce the amount of water that could recharge the underlying aquifer. Therefore, the reduction in evapotranspiration losses due to the lowering of the water table during pumping, which was assumed by Kala in their calculation of well field sustainable yields, is quite likely overstated, particularly in the areas where perched conditions exist. As a consequence, increased evapotranspiration losses would result in a reduction in the calculated sustainable yield.

Given that a decision to approve the significant increase in groundwater extraction associated with the proposed subdivision would be a permanent and irreversible commitment, it is necessary to not only account for the current District water requirement, but also increases due to long term natural growth of the District. A conservative allowance for natural long term

increases should be included when concluding that the aquifer system has sufficient capacity. Similarly, the likely long term expansion of the Bowser well field to the south-east of the District well field may eventually impact aquifer capacity and should be considered in the evaluation. Also, some conservative allowance for future potential reduction in groundwater recharge associated with long term climate change effects, as well as a factor of safety allowance for unknowns and parameter variability, have both now become more common and appropriate components for projects of such significant magnitude and undertaking.

While unlikely, the proposed significant increase in groundwater extraction may possibly be considered a "Reviewable Project" under the BC Environmental Assessment Act. If so, a potentially lengthy and expensive environmental assessment may be required. Such an assessment may result in the identification of impacts, some of which could require mitigation. A commitment by the District to provide water to the proposed subdivision may end up being difficult to meet, should unacceptable impacts be identified, without any mitigation possibilities. At this point it is unknown if an environmental assessment could or would be triggered or if such an assessment would result in any onerous obligations. However, it is absolutely imperative that this possibility be clearly determined and confirmed or ruled out, with all obligations, costs and potential liabilities clearly identified and allocated, before any decisions or commitments are made.

Recommendations

While the Kala feasibility study is an important first step in the process of determining available groundwater resources at Deep Bay, it is not, nor does it appear that it was intended to be, the final step. In order for the District to determine what quantity of sustainable groundwater flow it can confidently allocate to the proposed Baynes development, a significant amount of further investigation is necessary and recommended prior to making any commitment regarding groundwater availability.

It is recommended that a detailed level of investigation be conducted to address the uncertainties and known variabilities associated with the aquifer. Such an investigation would address aquifer characteristics and variability over a larger area and would be conducted with an objective and conservative approach, and would include a sensitivity analysis of significant input variables. Well pumping and assessments of aquifer responses and impacts would be conducted at the time of lowest water table levels.

It is recommended that potential future well sites be investigated beyond the existing well field in both easterly and westerly directions, in order to avoid concentrating increased pumping within the same small well field area. Expanding the area of pumping perpendicular to the direction of natural groundwater flow, would laterally spread the zone of pumping influence and would intercept additional amounts of groundwater recharge without significantly increasing drawdown in one local area.

It is recommended that accurate details of the water requirements of the proposed development be provided by Baynes. At this point *"...may require approximately 22 L/sec."* does not provide the level of certainty necessary to evaluate capacity with confidence. Similarly, sufficient details

on the design of the in-ground sewage disposal system must be provided to accurately assess potential impacts on the groundwater flow system. Details of location of disposal areas, quality of treated effluent, and rates of effluent disposal are necessary, along with sufficient supporting subsurface investigations that demonstrate acceptability of the disposal design.

It is recommended that a large scale multi-well pumping test be conducted using existing District wells and new wells installed as part of the detailed investigation recommended above. This test would be done at the time of lowest water table levels (i.e. late Summer/early Fall). The total flow rate from this test should approximate future anticipated demand scenarios. As identified in the Kala Key Findings section of this report, the yearly average future demand requirement is indicated by Kala to be 29.58 L/s. If current experience applies, the summer peak demand would then be 42.6 L/s.

It is recommended that once all of the above recommendations are achieved, a three dimensional numerical simulation of the ultimately proposed pumping and effluent disposal schemes should be conducted to predict the long term performance and impacts of both systems.

We trust the information presented here is sufficient for your present purposes. Should you have any questions or wish to discuss the information and recommendations presented in this report, please do not hesitate to contact the undersigned.

Sincerely

Guiton Environmental Consulting Ltd.

PROFESSIONAL
PROVINCE OF
R. S. GUITON
BRITISH COLUMBIA
GEOSCIENTIST

Rick Guiton, M.Sc., P.Geo.
Senior Hydrogeologist – Principal

Attach: List of Reports Reviewed

List of Reports Reviewed

Kala Geosciences Ltd., a report titled: *"Baynes Sound Investments Ltd. – Deep Bay, BC – Proposed Residential Subdivision – Groundwater Feasibility Study (GFS)"*, and dated: June 30, 2010.

Pacific Hydrology Consultants Ltd., a report titled: *"Completion Report – Installation and Testing of Well 8-97 and Re-Evaluation of Groundwater Supply Potential of Quadra Sand Aquifer at Deep Bay"*, and dated: November 25, 1997.

Pacific Hydrology Consultants Ltd., a report titled: *"Completion Report – Groundwater Study at Deep Bay Waterworks District"*, and dated: March 29, 2007.

Pacific Hydrology Consultants Ltd., a report titled: *"Evaluation of Maximum Groundwater Potential from Wells in the Southwest Corner of D.L. 28 – West of the Island Highway at Deep Bay"*, and dated: August 15, 1995

Hodge, W.S., a Memorandum dated February 23, 1999, describing a review of the November 25, 1997 Pacific Hydrology Report titled: *"Completion Report – Installation and Testing of Well 8-97 and Re-Evaluation of Groundwater Supply Potential of Quadra Sand Aquifer at Deep Bay"*.

Hodge, W.S., a Memorandum dated February 6, 1996, describing a review of the August 15, 1995 Pacific Hydrology Report titled: *"Evaluation of Maximum Groundwater Potential from Wells in the Southwest Corner of D.L. 28 – West of the Island Highway at Deep Bay"*