Appendix A:
Groundwater Comments re. HRM Case 20929, and NSE Wetlands Application 2017-110980 for Proposed Development on Peggy's Cove Rd., Upper Tantallon

Final Submission on October 21, 2018 to: Shayne Vipond, Planner III, HRM Planning Applications
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Our comments below regard Englobe's ***Level 2 Groundwater Assessment****, Report P-0012667-0-00-200* and related review materials, for Phase 1 (only) of this proposed development, which represents a water demand estimated by Englobe to be 39,350 L/day for 46 dwelling units plus commercial space. Although an Application for Groundwater Withdrawal has not yet been submitted to Nova Scotia Environment (NSE), for this demand a permit will be required, unless demand is reduced to under 23,000 L/day, which is 32 - 33 dwelling unit equivalents.

Since an NSE Groundwater Withdrawal Approval will be needed, we have included in our comments references to the requirements in NSE's ***Guide to Groundwater Withdrawal Approvals*** (GGWA). Our comments primarily reference the guidelines in NSE's ***Guide to Groundwater Assessments for Subdivisions Serviced by Private Wells*** (GGA), which obtains for Level 2 applications. Compliance with this Guide for Level 2 Assessments is linked to Federal drinking water standards regarding groundwater *quality;* however, there is no legislation regulating Level 2 groundwater *quantity* issues, which are approved through municipalities. Halifax Regional Municipality (HRM) policy and NSE groundwater guidelines seek to protect adjacent properties and existing water users from harm (see cover letter), which is also our purpose.

➡ **Our main comment on the Level 2 Groundwater Assessment and materials is that policies and guiding principles of causing no harm to abutters were not adequately followed during Englobe's research and analysis.**

Not only is there not enough *sustainable* water supply for Phase 1 itself when safety factors and contingencies are considered; there is even less available when existing surrounding groundwater uses are considered, including reservation of 50% of available supply for baseflow maintenance of wetlands and streams. Englobe assumes that the proposed development can borrow groundwater from surrounding lots, but those surrounding properties, especially the commercial ones, are already borrowing from the subject site, especially during fall low water table season, which coincides with high seasonal demands of existing commercial wells in the vicinity. We seek to protect existing wells and wetlands from harm.

A summary of our comments explaining this is below, following the order of topics in the Guide to Groundwater Assessment (GGA), in blue font, with topics in the Guide to Groundwater Withdrawal Approval (GGWA) requirements also included. Based on these two guides, our comments are organized as follows:

1. Records Review and Reporting
2. Water Quantity Sustainability
3. Conclusions and Recommendations

1. Records Review and Reporting

1.1 Pumping Tests Review

There were a number of components of the well monitoring during the pumping tests which were very insufficient, as follows:

1) No abutting dug wells were monitored, since Englobe claims that they are not connected to the deep aquifer. We disagree, and cite as proof, the fact that there was some effect from pumping on the piezometer in the wetlands (P-1), which obviously is completed in the shallow groundwater.

2) Only 4 off-site wells were monitored during the pump test. The GGWA requires that all wells within 500 m be identified (which was not done), and that those for which there are potential interference effects should be monitored. As significant interference effects (greater than 1.0 m of drawdown, as indicated in GGWA, Section 2.4.2) were measured at distances between 62 m and 250 m from the pumping wells, at a minimum all wells, both drilled and dug, within 300 m of the pumping wells should be monitored.

3) The GGA requires that a well survey be conducted for a minimum of 10 adjacent properties. Although Englobe indicates in their report that an interview and questionnaire was carried out for homeowners and businesses within 500 m of the proposed development, there are no details provided, other than for the 4 wells that were included in the pump test (PW1, PW2, PW3 and PW4). There are a number of adjacent properties which had already experienced interference effects from previous commercial developments, and this should have been taken into account when determining the extent of the monitoring program during the pump test.

Pumping tests should be re-done in October, when water tables are lowest, and area water use highest.
Pump testing of the 2 drilled wells (Well 3 and Well 4) was done in early March when groundwater flow levels, and therefore availability, are typically at a bimodal seasonal high during first snow melt, and groundwater levels, which peak in May just before vegetation evapotranspiration starts, are at their second highest annual level. Merely recalibrating results would not take into account the high fall seasonal demand of Acadian Maple, which we understand can be up to 14,000 L/day.

Pumping tests analysis did not account for the one in ten dry year as a safety margin.
Droughts will occur more frequently than in the past, due to climate change, increasing the importance of this safety margin. At a minimum, the GGWA requires an analysis of the interference effects during a 90 day drought, which has not been done.

An important pumping test protocol was not followed.
Although a 72-hour pump test is the typical requirement, the GGWA also requires that well interference effects on surrounding wells and sea water intrusion be evaluated, and in this case, 72 hours was not sufficient to adequately assess those potentials.

Well 4 should be located further than 62.4 m from PW1 as well as from 3 abutting lots with well quantity issues.
It is Englobe's stated intent that Test Wells 3 and 4 be used as the proposed development's future potable water source. However, as indicated above, there is significant interference at PW1, and therefore at a minimum, Well 4 should be re-located at least 200 m from abutting wells so that it will not create significant interference. Five other residential wells near Well 4 could also be interfered with, or even dried up, due to the location of Well 4. GGWA requires protection of existing groundwater uses through the "first come first serve" rule.

Pumping test impacts on PW2 (Acadian Maple) and PW1 (38 Danny's Lane) were not adequately addressed.
Englobe has discounted the effect of drawdown at the Pulsifer well (at 38 Danny's Lane) from pumping at the on-site wells. This conclusion is based on the available drawdown in that well (water level at 8 m and pump set at 153 m). However, significant interference is defined by NSE (GGWA) as greater than 1.0 m of drawdown, and therefore the more than 8 m of interference drawdown is not acceptable. Likewise, Englobe is suggesting a 1.04 m drop in "static" water level at the Acadian Maple well, and is suggesting that that is not significant. However, pumping at the on-site wells appears to have the effect of exasperating the amount of drawdown at the Acadian Maple well while it is pumping. The average elevation of the maximum water level in PW2 during operations prior to the pump test was about 7.5 metres above sea level (masl), while during the pump test it was about 5.0 masl. Although it would require knowledge about the Acadian Maple well pumping rates to confirm whether or not this is an actual effect of the pumping of Well 3 and Well 4, it is a potential interference that has not been adequately assessed.

The revised recommended pumping rate of Wells 3 and 4 combined has no factor of safety.
In Englobe's 6 December 2017 response to CBCL's comments, Englobe`s revised supply is *exactly* their stated demand for the Phase 1 density of 35,950 L/day, based on avoidance of dewatering of fractures. Setting aside the coincidence of that quantification, this supply meeting the demand exactly is not adequate for extended drought periods, high peak use on-site, or for avoidance of mutual interference from high season off-site water users (Acadian Maple and Red Barn Nursery), which coincide with fall low flow conditions.

1.2 Groundwater Reports
There is no mention of the Tantallon Watershed Servicing Study, 2013, which contains useful relevant information about the area.

1.3 Watershed Information
There is no evidence of watershed mapping by Englobe, or mention of the slight, but important tertiary watershed divide that bisects the property, influencing storm drainage.

1.4 Stormwater Management Plans
Although a stormwater plan is not yet available, general statements should have addressed, including:

1) strategies to keep the stormwater conduits under Acadian Maple's driveway and Peggy's Cove Road open;

2) strategies to retain added runoff from replacing wetland soils under the cattail marsh with rock; and

3) impervious surfaces impacting groundwater recharge, quantity, and runoff quality, to St. Margaret's Bay.

1.5 Describe wells and their use within at least 500 m of the site (GGA) and within 500 m (GGWA).

Research and description of this was very inadequate as follows:

1) Only 5 out of 29 commercial wells within 500 m of the site west of Little Indian Brook were mentioned.

2) There was no mention of already existing water shortages of three abutting residential lots and nearby Red Barn Nursery.

3) There was no mention of abutter Acadian Maple`s use of up to 14,000 L/day during peak days in the fall.

1.6 Discuss potential well interference effects.

Englobe's analysis of well interference effects is inadequate, for the following reasons:

1) Graph 101 is inconclusive, yet is the basis of Englobe`s 210 m radius of influence. Only 3 out of 8 test and private wells were graphed, seemingly to choose only wells that fell exactly on a best fit line. There were also data inconsistency problems.

2) Well interference predictions should include a 90 day drought condition (GGWA), and this was not considered.

3) Well interference is considered significant if it exceeds 1.0 m at a drilled well or 0.25 m at a dug well (GGWA). Two of the four drilled wells monitored exceeded this (PW1 and PW2). Dug wells were not tested.

4) Englobe did not account for surrounding commercial and residential groundwater water demands. This should be quantified and subtracted from groundwater supply that is available to the proposed development, as we did in our mass balancing analysis.

1.7 Discuss the potential effects on surface water and the environment. Wetlands:

In addition to underestimating the over 2.5 ha of surface connected wetlands on- and off-site, pumping impacts on wetlands were inadequately measured with a single piezometer and inadequately analysed as follows:

1) Englobe installed one piezometer test on the subject property, to 2.74 m. A local geotechnical engineer doing soft soil probes in this area, found that half the time the probe had to be moved less than 1 m to avoid boulders, and soft soils in some areas were greater than 3 m thick. Because of the variation in wetlands thicknesses, more than one piezometer should be installed, and there should be a longer period of monitoring outside of the pump test period, to establish ‘background’ groundwater level conditions in the wetlands.

2) Englobe's assumption that the shallow and deep water tables are not connected, thus over pumping deep wells will not affect wetlands or shallow dug wells, is unjustified. While fracture connectivity is quite

variable in Upper Tantallon, we disagree that the wetlands are not connected to the deep water table, i.e., are underlain by an *aquiclude* such as *continuous* clay. Rather, it is very likely that the bedrock under the wetlands and surrounding dug wells has cracks, just as the bedrock under the uplands of the site does. Thus, the wetlands on site and surrounding it are underlain by an *aquitard*, i.e., a depression in the bedrock which retards drainage as it communicates *through cracks* to the deep water table. Connection is further demonstrated by the history of abutting well quantity problems coinciding with commercial developments. Also, as indicated above, there was some response in the one piezometer (P-1) monitoring the wetlands (although Englobe considers the results to be anomalous), and the wetlands monitoring with a single piezometer is not adequate.

3) The wetlands piezometer monitoring should be redone in October when groundwater levels and flow rates are expected to be at their lowest, because when this testing was done in early March, annual groundwater flow *rates* are at a bimodal annual high peak, as explained above.

4) As explained above, Englobe should do lot water balance calculations to reserve 50% of available supply to maintain wetlands baseflow (GGWA 2.4.1). Calculate, as we did, through mass balancing, *including quantified abutting demands*, the maximum number of units that can be sustained on this site without groundwater demand exceeding supply, which would draw down the wetlands shallow water table as well as the deep water table. The wetlands on- and off-site act as aquifer recharge for the shallow and deep water tables, holding water in the spongy peat, and slowly releasing it to the groundwater. Disturbance to the ericaceous shrub and forested bogs by drying them out from over-pumping could change aquifer recharge dynamics, contributing to drawing down the water table of the surrounding dug wells, to which they are connected.

5) It is not enough to simply replicate elsewhere, the wetlands directly disturbed by infill for the proposed access road and commercial development. The cattail marsh and the drowned bog underneath it serve as *on-site* stormwater retention, and as stated above, more analysis needs to be done re. replicating their stormwater management functions.

1.8 Discuss the potential effects on surface water and the environment. Saltwater intrusion:

Saltwater intrusion, since the site abuts the ocean, is inadequately addressed, and could be a problem.

Wells within 500 m of sea water should not drawdown water levels below sea level, unless it can be demonstrated that a permanent hydraulic divide exists between the well and the sea water source. As indicated in Englobe's report, the water level at PW3, which is approximately 40 m from the ocean, was drawn down to a level which was below sea level during the pump test. This indicates that over an extended period of pumping, seawater intrusion is very likely to occur in wells that are close to the ocean, even if that seawater intrusion does not extend to the pumping wells for the development itself. It should also be noted that the water level in the pumping wells was also at sea level (Well 4) or significantly below sea level (Well 3, which was 20 m below sea level).

CBCL, in their 17 January 2018 response to Englobe, indicates that Englobe had still not provided adequate response with respect to the potential for seawater intrusion. Although CBCL provides suggested additional information that would be required, up to and including a contingency plan should saltwater intrusion be observed, it is our opinion that this is not adequate. Allowing a development to go ahead that could

produce that result, i.e., seawater intrusion that requires the implementation of a contingency plan, is not recognizing the rights of the existing water users. For an existing water user to be required to accept water from some other source than their own well is not reasonable.

2. Water Quantity Sustainability (Appendix B of GGA, as well as GGWA requirements)

The GGA provides guidelines for assessing water quantity sustainability at three different scales: 1) the individual well scale (safe well yield calculation), 2) the individual lot scale (lot water balance calculation), and 3) the subdivision scale (well interference calculation) and says, "All 3 types of calculations *should* be completed" (Section B.1, Appendix B). The GGWA *requires* these assessments and adds a requirement for assessment of total allocation for all groundwater users, i.e., the calculated *demands for surrounding wells*. We found Englobes's assessment of these three water quantity sustainability measures inadequate as follows.

2.1 Safe Well Yield Calculation

Englobe has used the appropriate calculations (as accepted by NSE) for the 20 year safe yield pumping rate. However, as discussed above, they do not take into account the GGWA requirement to consider the effect of a 90 day drought on interference drawdown. They also do not consider climatic conditions, either existing (i.e., the pump test should have been undertaken in October at a point of low groundwater level and high adjacent commercial property use), or those that might occur in the future because of climate change. Also, there is insufficient evaluation of potential seawater intrusion, either through modelling, or an extended pump testing period.

2.2 Lot Water Balance Calculation $Qlot = I A lot Euse/ 365 days$

This equation was not used in Englobe's Level 2 Groundwater Assessment, although it could have been used in the *text* of Englobe's Level 1 Groundwater Assessment, which we have not seen, as just the *table* was included in materials available to us. It is for the supply side only of a mass balancing analysis, without demands being subtracted. To our knowledge, Englobe did not do this, nor did CBCL ask for it. This calculation is critical to assessing regional supply. However, it is important that existing demands be subtracted and 50% of available supply be allocated to maintenance of wetlands and streams baseflow (GGWA 2.4.1), as we did in our groundwater mass balancing analysis, to adequately assess impacts on surrounding wells and wetlands. The GGWA adds a requirement for this regarding assessment of total allocation for all groundwater users, i.e., the calculated *demands for surrounding wells*.

The site's carrying capacity in isolation will be exceeded. In our mass balancing analysis, we calculated the carrying capacity for the site in isolation to be 10,365 L/day, or 15 dwelling unit equivalents at 2.3 people per dwelling unit. The developer proposes to exceed this by 25,585 L/day; thus, this extra demand must be met by groundwater from surrounding lands. As CBCL has pointed out in their 23 October 2017 letter to Englobe, "this approach has not been accepted for subdivision developments reviewed from 2007 to present".

2.3 Well Interference Calculation

Simply based on measurements during pump testing, well interference is considered significant if it exceeds 1.0 m at a drilled well or 0.25 m at a dug well (GGWA). Two of the four drilled wells monitored exceeded

this (PW1 and PW2). Dug wells were not tested, which we consider to be a serious oversight. As indicated above, well interference predictions should also include a 90 day drought condition (GGWA), and this was not considered.

High transmissivity calculated by Englobe is based on well intersection of two large cracks which should not both be dewatered. An average of three methods of calculating transmissivity was used, resulting in T = 1.4 x 10^{-5} m^2/second for the subject site test wells, which translates to T = 1.2 m^2/day. This is relatively high compared to pumping test transmissivities for wells in the Tantallon area, which range from 0.1 to 0.7 m^2/day, as stated in section 3.3.4 of the *Tantallon Watershed Servicing Study.* However, dewatering both cracks would not only be unsafe for on-site wells, as CBCL pointed out, but would also affect water volume available to surrounding off-site wells and wetlands.

2.4 Contingency Plans (GGWA)

On-site contingencies: Even just Phase 1 of the proposed development could have inadequate water supply since there is no safety plan to allow for peak demands, drought, and competing abutting commercial wells, as CBCL has pointed out. Englobe`s response to this comment was inadequate, as discussed above. Drilling deeper wells if shortages occur, could induce saltwater intrusion and impact surrounding wells. Englobe's suggestion of smoothing peak demands with holding tanks reduces rate, but not volume, and Provincial policy allows cisterns only for water quality or low well yield problems. It is worth considering what water conservation methods could be used that do not impact water quality, are effective, permanent, and quantifiable with respect to water saved. The use of recycled treated water from the proposed on-site sewage treatment plant for non-drinking water uses is a Provincial wastewater issue, so we have not commented. However, it would not add significantly to the number of units sustainable since most water demand is for drinking.

Off-site contingencies: There is no plan stated to reduce impacts on off-site abutting wells and wetlands. This is a serious omission in Englobe`s analysis.

Contingencies are discussed further under Conclusions and Recommendations below.

3. Conclusions and Recommendations

3.1 Pumping tests were incorrectly conducted and analysed. We recommend:

Drilling Recommendations:

- As there was significant drawdown measured in the observation well PW1 (38 Danny's Lane), i.e. 8.36 m which is greater than the 1.0 m considered by NSE (GGWA, Section 2.4.2), the use of Well 4 as a production well should not be considered. Well 4 is only 62 m from PW1. Therefore, re-drill Well 4 at least 200 m from the nearest abutter's well, to minimize future well interference.

- Install a second piezometer in the wetland, to adequately characterize the response of the shallow groundwater to pumping the test wells.

Pumping Test Recommendations

- If well survey information (surrounding properties) is not detailed enough, re-do the survey, so that it is clear which wells have issues. Include at least 15 surrounding wells *including all abutters,* a mixture of drilled and dug wells, and the additional piezometer, as indicated above.

- Re-do the pumping test in October, to coincide with lowest annual groundwater levels, and highest adjacent commercial groundwater use.

- Run pumping test for 7 days, not 72 hours (GGWA), since we consider this to be a sensitive area due to nearby ocean and wells.

- During pump test supply private residents with water if necessary, and ask businesses to note water meter readings.

- If anomalies are encountered, e.g., carburetor problems, determine problem and redo for meaningful results.

Analysis Recommendations

- Properly analyze pumping test quantity results.

- Calculate results in order to determine drawdown interference for a 90 day drought (GGWA).

- Properly analyze off-site well interference for a less conservative, more accurate, zone of influence. This includes, considering all wells, not just 3, and properly interpreting for a range of influence when there is no clear distance intersection number.

- Properly describe the significance of off-site well interference, which 2 of 4 wells tested showed. Well interference is considered significant if it exceeds 1.0 m at a drilled well or 0.25 m at a dug well (GGA).

- To have good data for off-site well interference, do a *sufficient* gathering and analysis of well data within 500 m of the site (GGA and GGWA). This includes numbers and uses of wells within 500 m, as well as data on water quantity and quality issues, water levels, etc. It is especially important to describe the numbers and uses of abutting wells, and wells within 250 m of the site. For commercial wells within 500 m, assess water use, especially permits, and interview the owners re. problems.

3.2 Stormwater management issues were not considered. (GGA says should be.) We recommend:

- Propose strategies to keep the stormwater conduits under Acadian Maple's driveway and Peggy's Cove Road open, not silt clogged.

- Propose strategies to retain added runoff that will occur from replacing wetland peat soils under the cattail marsh with rock.

- Propose strategies to recharge groundwater with runoff from proposed impervious surfaces, and remove pollutants from runoff entering St. Margaret's Bay and surrounding storm drain system.

3.3 Wetlands were inadequately assessed and evaluated for disturbance potential. We recommend:

- Delineate, not just estimate, the extent of off-site wetlands with obvious surface water connections.

- Install more than one piezometer, to adequately assess effects on the wetlands from pumping (recognizing wetlands variability).

- Re-do pumping test in October when groundwater table is at annual lowest and, coincidentally, abutting commercial syrup bottling business is at annual highest groundwater use.

- Re-examine invalid assumptions that shallow and deep groundwater tables are not connected by cracks.

- Do lot water balance calculations to reserve 50% of available supply to maintain wetlands baseflow. Calculate, through mass balancing, *including quantified abutting demands*, the maximum number of dwelling units that can be sustained on this site without demand exceeding supply, which could dry out (kill) wetland peat, affecting aquifer recharge and nutrient retention functions of on- and off-site bogs.

3.4 Salt water intrusion could occur from over-pumping. We recommend:

- The pump test should be re-done, for a longer time period (7 days) in order to be able to better evaluate potential salt water intrusion.

- The long term radius of influence calculated from the new pump test results should not approach the ocean, i.e., the production well locations and recommended long term pumping rates should not produce potential salt water intrusion.

- Monitoring wells should be placed on the proposed development property at a distance from the ocean which reflects well locations on adjacent properties, i.e. 40 m from the ocean. These wells should be constructed to be similar to the adjacent wells, i.e., they may have to include wells that monitor the deeper groundwater which is intercepted by the adjacent drilled wells, and wells that monitor the shallow groundwater such as is used in dug wells. These wells should be sampled for general chemistry and metals on at least a yearly basis, with results compared to those existing before the development begins operating any production wells.

- Although these steps should prevent salt water intrusion from occurring, there should be a contingency plan in place to address salt water intrusion if it happens. The contingency plan should begin with

changes to the pumping conditions in the development wells to stop the intrusion from happening, with secondary contingency steps to describe how adjacent property wells will be protected / replaced.

3.5 Safe Well Yield calculations show that there is no safety factor built into the proposed pumping rates.

We recommend:

- The GGWA requirement to consider the effect of a 90 day drought on interference drawdown should be addressed, in order to determine safe yields.

- The safe yield calculations should take into account climatic conditions, and therefore should be based on the conservative condition, i.e., on results from a pump test undertaken in October when groundwater levels, and therefore potential flows, are at an annual low. This time frame also corresponds with the maximum groundwater use from two nearby commercial businesses, Acadian Maple and Red Barn Nursery, which will have an effect on safe yield of proposed development wells.

- As indicated above, safe yields must take into account the prevention of salt water intrusion.

3.6 Lot Water Balance calculations show site must borrow heavily from surrounding lands.

Note: This calculation is not in Level 2 report. It may be in Level 1 text which we do not have, since CBCL says in 23 Oct. 2018 comments: "The Level 1 Report indicated that to meet projected water demands, source water for the development would need to be allocated from other, up gradient properties. As mentioned in our August 10, 2017 review, however, this approach has not been accepted for subdivision developments reviewed from 2007 to present."

We recommend:

- Re-do lot water balance calculations to include reservation of 50% of available supply to maintain wetlands baseflow (GGWA).

- Re-do lot water balance calculations, including 50% baseflow reservation mentioned above, to find L/day that can be removed from site *without* allocating water from up gradient properties (site in isolation).

- Re-do lot water balance calculations to included quantification and subtraction of demands of all abutting properties, especially including Acadian Maple's peak season use of up to 14,000 L/day.

- Given above, calculate how many dwelling units can be sustainably supported on the site, before water conservation measures are considered. Check this against the results of our mass balancing report.

3.7 Well Interference Calculations are not adequate.

We recommend:

- Consider all observation well results when calculating radius of influence, and therefore potential interference effects on off-site wells.

- Well interference should also consider existing conditions, i.e., pre-existing interference in some off-site wells.

- As indicated above, well interference potential should be calculated on the basis of a 90 day drought condition.

- The NSE definitions should be honoured, i.e., that a 1.0 m interference drawdown in a drilled well, or a 0.25 m drawdown in a dug well is significant. Safe yields should be adjusted (reduced) in order to prevent this condition.

3.8 Contingency Plans are inadequate. We recommend:

- A Contingency Plan should include measures to stop the spread inland of salt water intrusion, if it is determined to be occurring (through an appropriate monitoring program). Changes to operations of the pumping system for the development should be considered first, before changing conditions on adjacent properties (such as installing new wells).

- A Contingency Plan should also include measures to address changes in general hydrogeological conditions, such as the one in ten year dry year and a future lowering of the water table because of climate change-induced conditions. This could affect the site production wells themselves, as well as surrounding groundwater users and wetlands.

- A Contingency Plan should include measures to address unacceptable well interference, if it occurs in the future.

- A Contingency Plan should include an analysis of methods to cope with peak daily and seasonal demands, especially when occurring during lowest seasonal supply in October. NSE should be consulted regarding the use of cisterns to smooth out peak demand, considering the provincial policy of permitting cisterns only for low well capacity or poor water quality.

- Water conservation measures should be explored with HRM and NSE to increase the sustainability of the proposed development. If such measures are permanent, effective, and safe, they should be considered regarding creation of extra supply for contingencies.