January 4, 2017

Mr. Jeffrey Brem
Lifetime Green Homes
100 Long Ridge Road
Carlisle, MA 01741

Re: Additional Solute Mondeling
100 Long Ridge Road
Carlisle, Massachusetts

Dear Mr. Brem:

Northeast Geoscience, Inc (NGI) has conducted additional field work and solute modeling at the above site and offer the results to supplement alternative modeling results presented by Nobis.

## 1.0 Updated Groundwater Elevations and Flow Direction Near SAS #1

Recent Mass-Balance modeling results completed by Nobis were based on theoretical groundwater flow directions in the vicinity of proposed SAS #1 and SAS #2. In order to provide a better understanding of the flow direction in the southern portion of the site, water table elevations were attempted to be obtained from three two-inch diameter-monitoring wells installed by NGI during the original field investigation and from six four-inch diameter drain pipes installed during test pit activities prior to the hydrogeologic investigation. One of the three monitoring wells (MW-1A-15) appears to have moved since the original survey (the new elevation did not match the original) so the water level was not used in the analysis. In additional, three of the drainpipes were dry, indicating they are not communication with the aquifer, are obstructed or are not deep enough to intersect the water table. As a result, these wells were also not under in the analysis.

The location and elevation of the monitoring locations were surveyed by rod and level relative to the locations of monitoring wells MW-1A-15 and MW-1-15, and relative to the top of casing elevation of monitoring well MW-1-15, and are presented on Figure 1. As can be seen on Figure 1 the monitoring locations are relatively well distributed across the southern portion of the site. The water table elevations at each location were measured using an electronic water level probe from top of casing and are also presented on Figure 1 along with water table contours calculated by triangulation with linear interpolation. As can be seen on Figure 1 the groundwater flow direction along the southern portion of the site is generally toward the south–southeast at a hydraulic gradient of 0.079. While it is possible that some portion of the discharges from SAS #1 and SAS #2 might intersect the wells serving #68 and #200 Long Ridge Road, its is less likely, based on groundwater contours, that the wells are directly downgradient of the SAS's. As a result predicted nitrate concentrations in the overburden at the wells would be below the maximum concentrations predicted along the centerline of the discharge plumes.

## 2.0 Additional Solute Modeling Results

Nobis testimony and correspondence have noted that the mass-balance and dispersion modeling "..both are of potential value…". While Nobis initially presented dispersion modeling for the project, recent analysis has focused on the mass-balance approach. In order to supplement the information provided by the mass-balance results, we have conducted additional solute modeling analyses using the previously presented Domenico (1987) analytical model, a somewhat more advanced semi-analytical model using the "Analytical Transient One-, Two- and Three-Dimensional Application" known as AT123D (Yeh, 1981), and a combination dilution-dispersion modeling approach developed by the EPA known as the Dilution-Attenuation Factor (EPA, 1996). The goal of this additional modeling is to supplement the mass-balance modeling and to provide a check on the modeling results presented to date.

### 2.1 Domenico Dispersion Model

The Domenico dispersion model previously presented by Nobis and NGI was reconfigured to estimate nitrate concentrations in the overburden at the private wells serving #68 Long Ridge Road and #200 Long Ridge Road from wastewater discharged at SAS #1 and SAS #2. The model was run assuming groundwater flow directly toward each of the wells from both of the SAS's (Center Line Approach). In addition, the model was configured assuming groundwater flow as shown on Figure 1 in order to determine the concentration in the overburden at #68 Long Ridge Road, assuming the well was located off the center line of each plume (XY Position) and the results are presented on Table 1D. As can be seen on Table 1D the predicted nitrate concentrations in the overburden at the wells are individually below 5 mg/l and the combined values for each approach (are below 10 mg/l). A model with the well serving #200 Long Ridge Road off the centerline position for SAS #1 and SAS #2 was not developed as we believe, based on the groundwater flow direction observed on 12/30/2016, that that scenario was highly unlikely. NGI also conducted a sensitivity analysis of the Domenico model in order to show which specific parameters used in the model impacted the predicted results and the results are included on the graph in Appendix A. As can be seen on the graph source depth and source concentration were proportional to predicted concentration while transverse dispersivity was inversely proportional to predicted concentration. The model was not sensitive to changes in the other model parameters. Based on the sensitivity analysis and considering that the input parameters used were either field derived or based on sound literature estimates, it is reasonable to assume that the Domenico model provides useful estimates of nitrate concentrations at the site.

### 2.1 AT123D Modeling

An additional solute transport model was developed using the AT123D (Yeh, 1981) application as part of the SEVIEW 7.1 software package (Environmental Software Consultants, Inc, LLC, 2014.). The AT123D model is a semi-analytical model, as it solves the solute transport equations by numerical integration, and can be used for estimating the transport of waste in groundwater for a variety of sources, aquifer configurations, and transport mechanisms at specific time-steps. The transport mechanisms simulated by AT123D include advection, dispersion, sorption, decay/biodegradation and heat losses to the atmosphere. The model assumes a uniform flow field like all analytical models, but uses different transport and decay functions than the Domenico model and has been shown to produce results similar to Modflow (Cecan and Schneiker, 2008).

The model was configured to simulate SAS #1 and SAS #2 as horizontal plane sources with dimensions and loads as proposed on the design plans with flows of 1,980 gpd each and nitrate concentrations of 19 mg/l. Other parameters such as hydraulic conductivity, porosity, etc were similar to those used in the Domenico dispersion models and were from field observations or literature values. The direction of groundwater flow was as shown on Figure 1 with the relative location of the private well serving #68 Long Ridge Road off the centerline of the plumes. The model was run for a total simulation time of 20 years and steady state conditions were achieved within less than one year. The results of the simulation are included in Appendix B. As can be seen in Appendix B the model predicts a total nitrate concentration of 3.91 mg/l in the overburden at the well serving #68 Long Ridge Road with the majority of nitrate (89%) from SAS #1.

### 2.2 EPA Dilution-Attenuation Factor

The US EPA (1996b) describes a method used for characterizing the risk associated with leachate derived from contaminated soils and their potential impact on down gradient sensitive receptors. The method combines the effects of dilution from recharge to the site with mixing of groundwater flowing beneath the solute source through dispersion. The resulting calculation returns a Dilution-Attenuation Factor (DAF) which is the ratio of the concentration at the source to the concentration at the downgradient sensitive receptor. The minimum DAF possible is 1 where there is no change in concentration from the source. The EPA assumes a default value of 20. If the resulting DAF value is greater than 20 the risk is considered acceptable. The EPA also describes a method for dilution of only with no dispersion known simply as the Dilution Factor (EPA, 1996a). The methods are similar but the dilution-only method is considered more conservative, as the mixing zone beneath the source area is not based on dispersion and the distance to a downgradient receptor and is used only as a first-order test of the site risk. The equations and results are included in Appendix C. As can be seen in Appendix C the Dilution Factor method returned a ratio of 24, which exceeds the EPA default value of 20, indicating low risk. The Dilution-Attenuation Factor method returned a DAF of 35, which also exceeds the EPA default DAF of 20. Using the DAF ratio it is possible to: 1) estimate the maximum concentration in a sensitive receptor down gradient of the source; or 2) back-calculate the maximum source concentration allowed in order to achieve compliance with a regulatory standard at the down gradient receptor. Based on the DAF calculation an estimated nitrate concentration of 0.54 mg/l was calculated for the overburden at the well serving #68 Long Ridge Road. It is interesting to note that this method of risk analysis is used by a number of State environmental agencies to estimate acceptable risk from solute sources. It is also interesting to note that the EPA approach includes dilution not only from annual recharge to the site but also from groundwater flow beneath the source area, which is not included in the MassDEP Mass-Balance modeling approach and provides a more realistic estimate of solute fate.

## 3.0 CONCLUSIONS

As a result of the field investigations by NGI and Nobis, solute modeling, private well water quality data and water level monitoring recorded at the site we reiterate the following conclusions:

- No direct impacts to private wells from existing land uses (both on and off site) have been shown.
- No water quality impacts to private wells are likely based on groundwater flow directions and a variety of solute transport modeling methods for groundwater in the overburden aquifer.
- No direct evidence of communication between the overburden and bedrock aquifers has been shown using both water quality and water level data.
- Groundwater mounding estimates have been shown to be within septic design parameters.
- The AOI method should not be used a predictive tool for non-credit land projects such as this, and that a three-dimensional model, such as the models presented above, should be used as required in the by-law.

If you have any questions or require additional information, please do not hesitate to contact me.

Sincerely,
**Northeast Geoscience, Inc.**

Joel Frisch
Hydrogeologist

## 4.0 REFERENCES


Cecan, Liliana and Schneiker, Robert A. 2008, "BIOSCREEN, AT123D, And MODFLOW/MT3D, A Comprehensive Review Of Model Results," Proceedings of the Annual International Conference on Soils, Sediments, Water and Energy: Vol. 13, Article 22.

Domenico, P.A., 1987. An analytical model for multidimensional transport of a decaying contaminant species. Journal of Hydrology, 91: 49-58.

Environmental Software Consultants, Inc, LLC, 2014. SEVIEW Groundwater and Vadose Transport with AT123D and SESOIL. Version 7.1.

U.S. EPA, 1996a. Soil Screening Guidance: Technical Background Document. Second Edition. Publication EPA/540/R95/128, Office of Solid Waste and Emergency Response, May 1996.

U.S. EPA, 1996b. Soil Screening Guidance: User's Manual. Second Edition. Publication 9355.4-23, Office of Solid Waste and Emergency Response, July 1996.

Yeh, G.T., 1981. AT123D: Analytical transient one-, two- and three-dimensional simulation of waste transport in an aquifer system. ORNAL-5602. Oak Ridge National Laboratory, Oak Ridge, Tennessee. 82 pp.

# TABLES

NORTHEAST GEOSCIENCE INC
Water Supply & Environmental Consulting

# TABLE 1A, 1B, 1C & 1D - NITRATE DISPERSION MODEL
## LIFETIME GREEN HOMES, LLC - THE BIRCHES
## CARLISLE, MASSACHUSETTS

***TABLE 1A - ORIGINAL NOBIS MODEL***

| Line No. | Source Description | End Point Description | Source Concentration *mg/L* | Source Width *ft* | Source Depth *ft* | Hydraulic Conductivity *ft/day* | Gradient *fraction* | Porosity *fraction* | Bulk Density | Organic Carbon Content *fraction* | Koc | 1st Order Decay Coeff* *1/yr* | Time *days* | Horizontal Dispersivity *ft* | Vertical Dispersivity *ft* | Transverse Dispersivity *ft* | POC Coords X *ft* | POC Coords Y *ft* | POC Coords Z *ft* | Predicted Concentration at the POC *mg/L* | Nobis Table 5 *mg/L* | *Difference* *mg/L* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Septic 1 | Property line southeast of A11 | 19.0 | 52.16 | 5.9 | 205.2 | 0.02 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 10.32 | 1.03 | 1.03 | 178.9 | 0.00 | 0.00 | 3.78 | 3.78 | 0.0 |
| 2 | Septic 1 | A11 | 19.0 | 52.16 | 5.9 | 205.2 | 0.03 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 9.16 | 0.92 | 0.92 | 147.5 | 0.00 | 0.00 | 4.73 | 4.73 | 0.0 |
| 3 | Septic 1 | 90 Long Ridge Road well | 19.0 | 52.16 | 5.9 | 205.2 | 0.03 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 13.87 | 1.39 | 1.39 | 301.3 | 0.00 | 0.00 | 1.94 | 1.95 | 0.0 |
| 4 | Septic 1 | SG-1 | 19.0 | 52.16 | 5.9 | 205.2 | 0.04 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 15.81 | 1.58 | 1.58 | 387.4 | 0.00 | 0.00 | 1.38 | 1.38 | 0.0 |
| 5 | Septic 1 | Ringheiser #68 well | 19.0 | 56.10 | 5.9 | 205.2 | 0.01 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 11.10 | 1.11 | 1.11 | 202.3 | 0.00 | 0.00 | 3.39 | 3.39 | 0.0 |
| 6 | Septic 1 | Hanauer #200 well | 19.0 | 56.10 | 5.9 | 205.2 | 0.02 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 12.95 | 1.29 | 1.29 | 265.3 | 0.00 | 0.00 | 2.42 | 2.42 | 0.0 |
| 7 | Septic 2/3 | Property line to east | 19.0 | 109.90 | 5.9 | 110.8 | 0.14 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 2.03 | 0.20 | 0.20 | 25.2 | 0.00 | 0.00 | 17.77 | 17.77 | 0.0 |
| 8 | Septic 2/3 | Well A4 | 19.0 | 50.52 | 5.9 | 93.1 | 0.09 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 12.00 | 1.20 | 1.20 | 231.5 | 0.00 | 0.00 | 2.69 | 2.69 | 0.0 |
| 9 | Septic 2/3 | Well A5 | 19.0 | 50.52 | 5.9 | 93.1 | 0.07 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 14.34 | 1.43 | 1.43 | 320.8 | 0.00 | 0.00 | 1.74 | 1.74 | 0.0 |
| 10 | Septic 2/3 | SG-2 | 19.0 | 50.52 | 5.9 | 101.7 | 0.04 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 19.19 | 1.92 | 1.92 | 577.0 | 0.00 | 0.00 | 0.77 | 0.78 | 0.0 |
| 11 | Septic 2/3 | Higgins #55 well | 19.0 | 109.90 | 5.9 | 110.8 | 0.04 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 19.56 | 1.96 | 1.96 | 601.2 | 0.00 | 0.00 | 1.37 | 1.37 | 0.0 |
| 12 | Septic 2/3 | south property line | 19.0 | 50.52 | 5.9 | 110.8 | 0.04 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 6.09 | 0.61 | 0.61 | 81.6 | 0.00 | 0.00 | 8.38 | 8.38 | 0.0 |

***Note: POC = Point OF Compliance***

***TABLE 1B - NGI EDITED NOBIS MODEL WITH CORRECTED PARAMETERS***

| Line No. | Source Description | End Point Description | Source Concentration *mg/L* | Source Width *ft* | Source Depth *ft* | Hydraulic Conductivity *ft/day* | Gradient *fraction* | Porosity *fraction* | Bulk Density | Organic Carbon Content *fraction* | Koc | 1st Order Decay Coeff* *1/yr* | Time *days* | Long. Dispersivity *ft* | Vertical Dispersivity *ft* | Transverse Dispersivity *ft* | POC Coords X *ft* | POC Coords Y *ft* | POC Coords Z *ft* | Predicted Concentration at the POC *mg/L* | Nobis Table 5 *mg/L* | *Difference* *mg/L* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Septic 1 | Property line southeast of A11 | 19.0 | ***52.15*** | ***6.0*** | ***19.1*** | 0.02 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 10.32 | 1.03 | 1.03 | 178.9 | 0.00 | 0.00 | 3.84 | 3.78 | 0.06 |
| 2 | Septic 1 | A11 | 19.0 | ***52.15*** | ***6.0*** | ***19.1*** | 0.03 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 9.16 | 0.92 | 0.92 | 147.5 | 0.00 | 0.00 | 4.80 | 4.73 | 0.07 |
| 3 | Septic 1 | 90 Long Ridge Road well | 19.0 | ***52.15*** | ***6.0*** | ***19.1*** | 0.03 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 13.87 | 1.39 | 1.39 | 301.3 | 0.00 | 0.00 | 1.98 | 1.95 | 0.03 |
| 4 | Septic 1 | SG-1 | 19.0 | ***52.15*** | ***6.0*** | ***19.1*** | 0.04 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 15.81 | 1.58 | 1.58 | 387.4 | 0.00 | 0.00 | 1.41 | 1.38 | 0.02 |
| 5 | Septic 1 | Ringheiser #68 well | 19.0 | ***55.95*** | ***6.0*** | ***19.1*** | 0.01 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 11.10 | 1.11 | 1.11 | 202.3 | 0.00 | 0.00 | 3.44 | 3.39 | 0.05 |
| 6 | Septic 1 | Hanauer #200 well | 19.0 | ***55.95*** | ***6.0*** | ***19.1*** | 0.02 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 12.95 | 1.29 | 1.29 | 265.3 | 0.00 | 0.00 | 2.46 | 2.42 | 0.03 |
| 7 | Septic 2/3 | Property line to east | 19.0 | ***110.00*** | ***6.0*** | ***10.3*** | 0.14 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 2.03 | 0.20 | 0.20 | 25.2 | 0.00 | 0.00 | 17.85 | 17.77 | 0.08 |
| 8 | Septic 2/3 | Well A4 | 19.0 | ***50.60*** | ***6.0*** | ***8.7*** | 0.09 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 12.00 | 1.20 | 1.20 | 231.5 | 0.00 | 0.00 | 2.74 | 2.69 | 0.05 |
| 9 | Septic 2/3 | Well A5 | 19.0 | ***50.60*** | ***6.0*** | ***8.7*** | 0.07 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 14.34 | 1.43 | 1.43 | 320.8 | 0.00 | 0.00 | 1.77 | 1.74 | 0.03 |
| 10 | Septic 2/3 | SG-2 | 19.0 | ***50.60*** | ***6.0*** | ***9.5*** | 0.04 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 19.19 | 1.92 | 1.92 | 577.0 | 0.00 | 0.00 | 0.79 | 0.78 | 0.01 |
| 11 | Septic 2/3 | Higgins #55 well | 19.0 | ***110.00*** | ***6.0*** | ***10.3*** | 0.04 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 19.56 | 1.96 | 1.96 | 601.2 | 0.00 | 0.00 | 1.39 | 1.37 | 0.02 |
| 12 | Septic 2/3 | south property line | 19.0 | ***110.00*** | ***6.0*** | ***10.3*** | 0.04 | 0.35 | 1.59 | 0.02 | 0.00 | 0.00 | 10,950 | 6.09 | 0.61 | 0.61 | 81.6 | 0.00 | 0.00 | 8.60 | 8.38 | 0.22 |

***Note: Highlighted values adjusted from original Nobis model.*** ←Adjusted Values→

***TABLE 1C - NGI UPDATED MODEL - SEPTIC MODIFICATIONS AND NEW PWS WELLS***

| Line No. | Source Description | End Point Description | Source Concentration *mg/L* | Source Width *ft* | Source Depth *ft* | Hydraulic Conductivity *ft/day* | Gradient *fraction* | Porosity *fraction* | Bulk Density *g/cm3* | Organic Carbon Content *fraction* | Koc *fraction* | 1st Order Decay Coeff* *1/yr* | Time *days* | Long. Dispersivity *ft* | Vertical Dispersivity *ft* | Transverse Dispersivity *ft* | POC Coords X *ft* | POC Coords Y *ft* | POC Coords Z *ft* | NGI Predicted Concentration at the POC *mg/L* | Nobis Predicted Concentration at the POC *mg/L* | Difference *mg/L* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Septic 1 | Property Line East of Disposal Area 1 | 19.0 | ***45.00*** | 6.0 | 19.1 | 0.02 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 10.53 | 1.05 | 1.05 | ***185.0*** | 0.0 | 0.0 | 3.38 | 3.84 | -0.46 |
| 3 | Septic 1 | 90 Long Ridge Road well | 19.0 | ***45.00*** | 6.0 | 19.1 | 0.03 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 13.87 | 1.39 | 1.39 | 301.3 | 0.0 | 0.0 | 1.76 | 1.98 | -0.22 |
| 4 | Septic 1 | SG-1 | 19.0 | ***45.00*** | 6.0 | 19.1 | 0.04 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 15.81 | 1.58 | 1.58 | 387.4 | 0.0 | 0.0 | 1.24 | 1.41 | -0.17 |
| 5 | Septic 1 | Ringheiser #68 well | 19.0 | ***45.00*** | 6.0 | 19.1 | 0.01 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 11.10 | 1.11 | 1.11 | 202.3 | 0.0 | 0.0 | 3.01 | 3.44 | -0.43 |
| 6 | Septic 1 | Hanauer #200 well | 19.0 | ***45.00*** | 6.0 | 19.1 | 0.02 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 12.95 | 1.29 | 1.29 | 265.3 | 0.0 | 0.0 | 2.10 | 2.46 | -0.36 |
| 7 | Septic 3 | Property Line East of Disposal Area 3 | 19.0 | ***53.00*** | 6.0 | 10.3 | 0.14 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 2.03 | 0.20 | 0.20 | 25.2 | 0.0 | 0.0 | 17.85 | 17.85 | 0.00 |
| 11 | Septic 3 | Higgins #55 well | 19.0 | ***53.00*** | 6.0 | 10.3 | 0.04 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 19.56 | 1.96 | 1.96 | 601.2 | 0.0 | 0.0 | 0.78 | 1.39 | -0.61 |
| 12 | Septic 3 | south property line | 19.0 | ***53.00*** | 6.0 | 10.3 | 0.04 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 6.09 | 0.61 | 0.61 | 81.6 | 0.0 | 0.0 | 8.53 | 8.60 | -0.07 |
| 13 | Septic 3 | PWS #1 | 19.0 | ***53.00*** | 6.0 | 8.23 | 0.03 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 21.03 | 2.10 | 2.10 | 705.3 | 0.0 | 0.0 | 0.62 | - | - |
| 14 | Septic 3 | PWS #2 | 19.0 | ***53.00*** | 6.0 | 8.23 | 0.04 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 20.72 | 2.07 | 2.07 | 682.1 | 0.0 | 0.0 | 0.65 | - | - |
| 15 | Septic 3 | PWS #3 | 19.0 | ***53.00*** | 6.0 | 8.23 | 0.04 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 21.05 | 2.10 | 2.10 | 706.1 | 0.0 | 0.0 | 0.62 | - | - |
| 16 | Septic 2 | Stream | 19.0 | ***46.00*** | 6.0 | 8.23 | 0.07 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 13.96 | 1.40 | 1.40 | 304.8 | 0.0 | 0.0 | 1.76 | - | - |
| 17 | Septic 3 | Stream | 19.0 | ***53.00*** | 6.0 | 8.23 | 0.04 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 15.56 | 1.56 | 1.56 | 375.5 | 0.0 | 0.0 | 1.49 | - | - |

***Note: Highlighted values changed to reflect system design changes.***

***TABLE 1D - NGI UPDATED MODEL - SAS#1 and SAS#2 to #68 Long Ridge Road***

| Line No. | Source Description | End Point Description | Source Concentration *mg/L* | Source Width *ft* | Source Depth *ft* | Hydraulic Conductivity *ft/day* | Gradient *fraction* | Porosity *fraction* | Bulk Density *g/cm3* | Organic Carbon Content *fraction* | Koc *fraction* | 1st Order Decay Coeff* *1/yr* | Time *days* | Long. Dispersivity *ft* | Vertical Dispersivity *ft* | Transverse Dispersivity *ft* | POC Coords X *ft* | POC Coords Y *ft* | POC Coords Z *ft* | NGI Predicted Concentration at the POC *mg/L* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | Septic 1 | Well At #68 Long Ridge Road (Center Line) | 19.0 | ***75.10*** | 6.0 | 10.90 | 0.079 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 9.88 | 0.10 | 0.99 | 166.6 | 0.0 | 0.0 | 4.92 |
| 19 | Septic 1 | Well At #68 Long Ridge Road (XY Position) | 19.0 | ***75.10*** | 6.0 | 10.90 | 0.079 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 9.88 | 0.10 | 0.99 | 166.6 | 37.5 | 0.0 | 2.48 |
| 20 | Septic 2 | Well At #68 Long Ridge Road (Center Line) | 19.0 | ***67.60*** | 6.0 | 10.90 | 0.079 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 15.81 | 0.16 | 1.58 | 387.3 | 0.0 | 0.0 | 2.58 |
| 21 | Septic 2 | Well At #68 Long Ridge Road (XY Position) | 19.0 | ***67.60*** | 6.0 | 10.90 | 0.079 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 15.81 | 0.16 | 1.58 | 387.3 | 74.5 | 0.0 | 0.0003 |
| 22 | Septic 1 | Well At #200 Long Ridge Road (Center Line) | 19.0 | ***65.00*** | 6.0 | 10.90 | 0.079 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 9.94 | 0.10 | 0.99 | 168.2 | 0.0 | 0.0 | 4.89 |
| 23 | Septic 2 | Well At #200 Long Ridge Road (Center Line) | 19.0 | ***55.80*** | 6.0 | 10.90 | 0.079 | 0.35 | 1.59 | 0.02 | 0 | 0 | 10,950 | 13.72 | 0.14 | 1.37 | 295.2 | 0.0 | 0.0 | 3.17 |

| | |
|---|---|
| ***Combined Center Line Total at #68 Well:*** | **7.50** |
| ***Cobined XY Position Total #68 Well:*** | **2.48** |
| ***Combined Center Line Total at #200 Well:*** | **8.05** |

# FIGURES

NORTHEAST GEOSCIENCE INC
Water Supply & Environmental Consulting


Monitoring Well
Private Domestic Well
Approximate Stream Location
Assessors Parcels
SAS
Proposed Public Water Supply
Groundwater Contour (ft) (12/30/2016)
Groundwater Flow Direction

0 10 20 40
Feet

NGI
Northeast Geoscience Inc
Water Supply and Environmental Consulting
97 Walnut Street
Clinton, Massachusetts
978.365.9045
www.northeastgeoscience.com

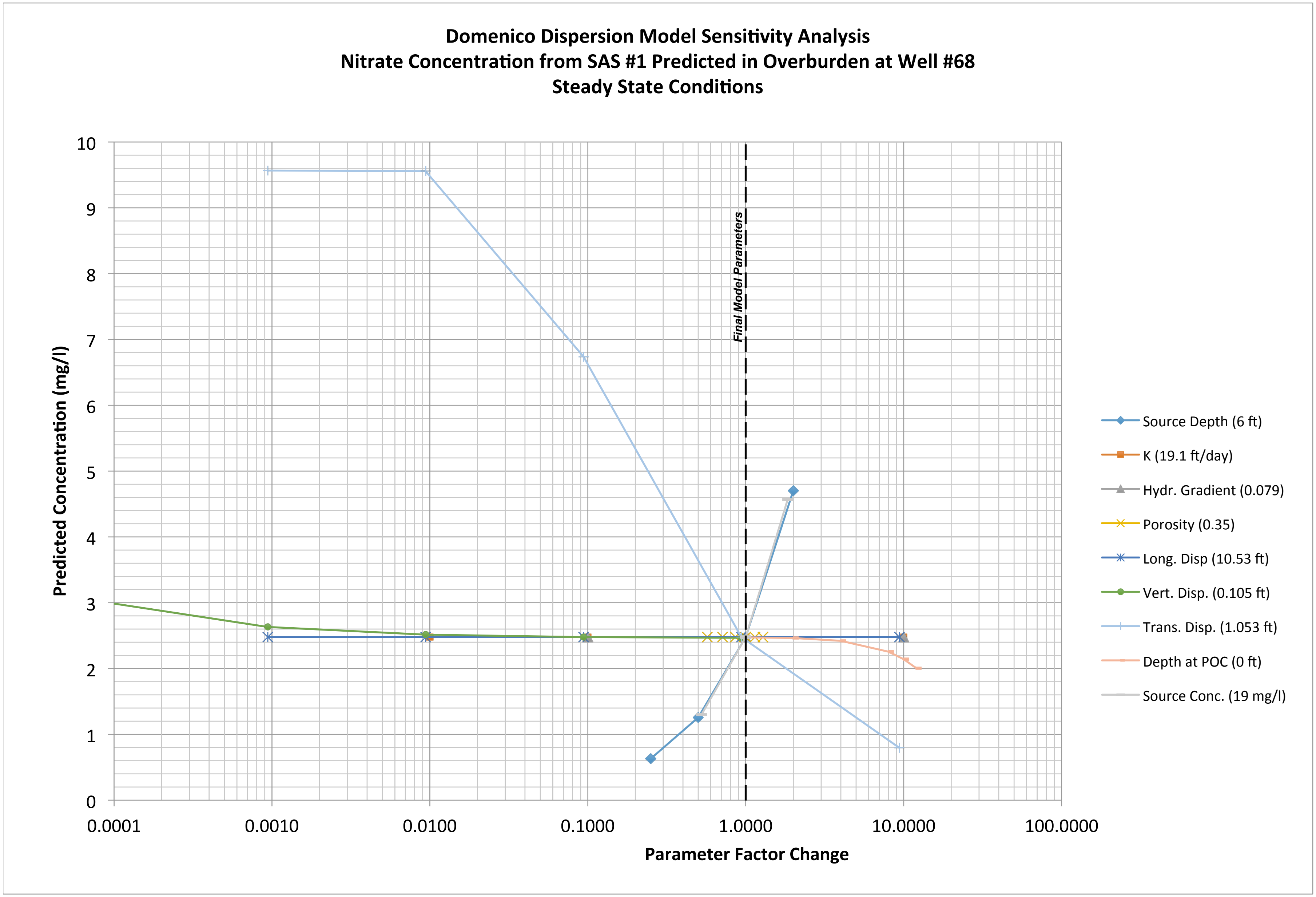
GROUNDWATER CONTOUR MAP - SAS#1
LIFETIME GREEN HOMES
100 LONG RIDGE ROAD
CARLISLE, MASSACHUSETTS

NGI REF: Fig2SitePlan
Drafted By: JAF | Date: 01/04/2017
Source: Meisner Brem, MassGIS, ArcGIS.com

FIGURE 1

# APPENDIX A

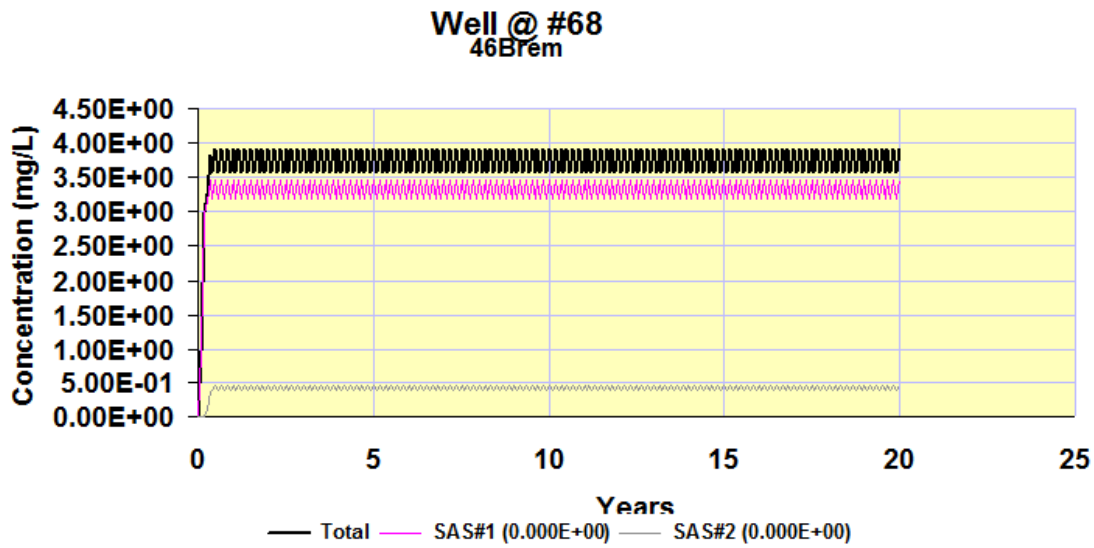
NORTHEAST GEOSCIENCE INC
*Water Supply & Environmental Consulting*


Domenico Dispersion Model Sensitivity Analysis
Nitrate Concentration from SAS #1 Predicted in Overburden at Well #68
Steady State Conditions
Predicted Concentration (mg/l)
Parameter Factor Change
Final Model Parameters
0.0001
0.0010
0.0100
0.1000
1.0000
10.0000
100.0000
Source Depth (6 ft)
K (19.1 ft/day)
Hydr. Gradient (0.079)
Porosity (0.35)
Long. Disp (10.53 ft)
Vert. Disp. (0.105 ft)
Trans. Disp. (1.053 ft)
Depth at POC (0 ft)
Source Conc. (19 mg/l)

# APPENDIX B

NORTHEAST GEOSCIENCE INC
*Water Supply & Environmental Consulting*

**SOLUTE TRANPORT MODEL RESULTS USING AT123D**
**SAS #1 and SAS #2 to Well at #68**
**Assuming Groundwater Flow in Vicinity of SAS#1 12/30/2016**
**100 Long Ridge Road**
**Carlisle, Massachusetts**

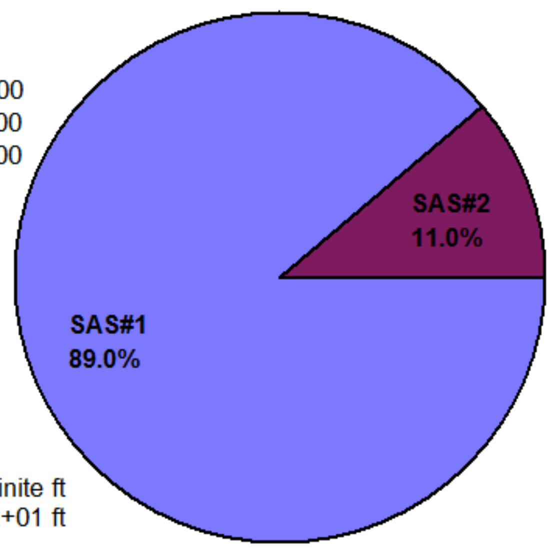



**Maximum Concentration: 3.917E+00 mg/L**
**Year of Maximum Concentration: 0.67**

**INPUT PARAMETERS**

| | |
|---|---|
| **Organic Carbon (percent):** | 0.02000 |
| **Effective Porosity:** | 0.35000 |
| **Hydraulic Gradient (m/m):** | 0.07900 |

| Dispersivities | Meters | Feet |
|---|---|---|
| Longitudinal: | 3.011E+00 | 9.878E+00 |
| Lateral: | 3.011E-01 | 9.878E-01 |
| Vertical: | 3.011E-02 | 9.878E-02 |




| | | | | |
|---|---|---|---|---|
| **Aquifer Width:** | Infinite m | Infinite ft | | |
| **Aquifer Depth:** | 3.910E+00 m | 1.282E+01 ft | | |
| **Retardation Factor:** | 1.000E+00 | | | |
| **Soil Bulk Density:** | 1.590E+03 kg/m3 | 1.590E+00 g/cm3 | | |
| **Molecular Diffusion:** | 0.000E+00 m2/hr | 0.000E+00 cm2/sec | | |
| **Decay Coefficient:** | 0.000E+00 1/hr | 0.000E+00 1/day | | |
| **Hydraulic Conductivity:** | | | 2.425E-01 m/hr | 6.736E-03 cm/sec |
| **Carbon Adsorption** | | | | 0.0000E+00 (ug/g)/(ug/ml) |
| **Kd:** | | | 0.000E+00 m3/kg | 0.000E+00 (ug/g)/(ug/ml) |
| **Retarded Darcy Velocity:** | | | 5.474E-02 m/hr | 1.520E-01 cm/sec |
| **Retarded Longitudinal Disp. Coefficient:** | | | 1.648E-01 m2/hr | 4.577E-01 cm/sec |
| **Retarded Lateral Dispersion Coefficient:** | | | 1.648E-02 m2/hr | 4.577E-02 cm/sec |
| **Retarded Vertical Dispersion Coefficient:** | | | 1.648E-03 m2/hr | 4.577E-03 cm/sec |

# APPENDIX C

NORTHEAST GEOSCIENCE INC
*Water Supply & Environmental Consulting*

**EPA Dilution Factor Calculation**
**SAS #1 100 Long Ridge Road**
**Carlisle, Massachusetts**

***DF = 1+ (Kid/IL)***
***d = (0.0112L^2)^0.5 + da{1-exp[(-LI)/(Kid$_a$)]}***

| | | |
|---|---|---|
| ***EPA DAF Default Score:*** | **20** | ***(for sources up to 0.5 acres)*** |
| ***Calculated DF =*** | *24.2* | |

| | | | | |
|---|---|---|---|---|
| Estimated Mixing Zone Depth (d) = | *2.53* | ***m*** | | |
| Hydraulic Conductivity (K) = | 1,213 | m/yr | 10.9 | f/tday |
| Hydraulic Gradient (i) = | 0.079 | m/m | 0.079 | ft/ft |
| Annual Recharge (I) = | 0.457 | m/yr | 18 | in/yr |
| Source Length (L) Parallel to Flow = | 22.86 | m | 75 | ft |
| Aquifer Thickness ($d_a$) = | 3.75 | m | 12.3 | ft |

***(EPA, 1996. Soil Screening Guidance: User's Guide. Publication 9355.4-23)***

**EPA Dilution-Attenuation Factor Calculation**
**SAS #1 - 100 Long Ridge Road**
**Carlisle, Massachusetts**

$$DAF = 1 + (Kid/IL)$$
$$d = (2\alpha_v L)^{0.5} + d_a \{1 - \exp[(-LI)/(V_s n_e d_a)]\}$$

| | | | |
|---|---|---|---|
| ***EPA DAF Default Score:*** | **20** | | ***(for sources up to 0.5 acres)*** |
| ***Calculated DAF =*** | ***35.4*** | | |
| ***Concentration at Source =*** | 19 | mg/l | |
| ***Concentration at Receptor (#68 Well overburden):*** | ***0.54*** | mg/l | ***(assumes flow direct to receptor)*** |
| Mixing Depth (d) = | 3.75 | m | (< or = $d_a$) |
| Hydraulic Conductivity (K) = | 1,213 | m/yr | 10.9 f/tday |
| Hydraulic Gradient (i) = | 0.079 | m/m | 0.079 ft/ft |
| Annual Recharge (I) = | 0.457 | m/yr | 18 in/yr |
| Source Length Parallel to Flow (L) = | 22.86 | m | 75 ft |
| Aquifer Thickness ($d_a$) = | 3.75 | m | 12.3 ft |
| Vertical Dispersivity ($\alpha_v = 0.056\alpha_L$) = | 0.29 | m | |
| Seepage Velocity ($V_s = Ki/n_e$) = | 274 | m/yr | |
| Effective Porosity ($n_e$) = | 0.35 | % | |
| Distance to Sensitive Receptor ($x_r$) = | 51.82 | m | 170 ft (@ Well #68) |
| Lognitudinal Dispersivity ($\alpha_L = 0.1\ x_r$) = | 5.18 | m | |

***(EPA, 1996. Soil Screening Guidance: Technical Background Document. EPA/540/R95/128)***

<u>Dilution Factor Model</u>. Physical, chemical, and biological processes acting upon contaminants tend to reduce their concentration in soil leachate as they migrate through soil and ground water to receptor locations such as a drinking water well. Essential processes acting on these chemicals include volatilization into empty air spaces, adsorption onto soil and aquifer media, chemical transformation (e.g., hydrolysis, precipitation, redox reactions, complexation), biodegradation, and dilution due to mixing of the leachate with ambient soil and ground water. The reduction in chemical concentration is expressed as the dilution attenuation factor (DAF), which is defined as the ratio of contaminant concentration in soil leachate to the concentration in ground water at the receptor point.