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May 4, 2015

Mr. Daniel C. Hill
HILL LAW
43 Thorndike Street
Cambridge, MA 02141

Re: Nitrogen Loading Analysis – 100 Long Ridge Road, Carlisle

Dear Mr. Hill:

Horsley Witten Group, Inc. (HW) has reviewed the NGI report and has conducted our own independent nitrogen loading analysis of the proposed development. HW has extensive experience in the field of nitrogen loading analyses, including the preparation of the NO3 (nitrate) loading model for the state Department of Environmental Protection (MADEP). This model serves as part of the basis for the current MADEP Guidelines for Title 5 Aggregation of Flows and Nitrogen Loading ("MADEP Guidelines"). This Guidance, adopted under MADEP's authority under Title 5 of the State Environmental Code, provides a standardized method to determine the water quality impacts that may occur at down gradient neighboring properties as a result of wastewater discharges to groundwater.

The purpose of this letter is to report the results of a "mass balance analysis" that is done in conformity with the MADEP Guidelines.[1] I note that Dr. James Vernon of Nobis recently presented his own analysis of the threat of the Project's septic systems on down gradient properties, using different analytical models. His findings are consistent with mine.

As we stated in our previous comment letter, the March, 2015 NGI letter-report that presented the Applicant's nitrogen loading analysis does not follow the MADEP Guidelines. Some of the discrepancies between the NGI report and Title 5 are as follows:

1. The NGI nitrogen loading analysis assumes dilution of the proposed wastewater with all of the recharge on the entire site (including the land on the east side of the brook that is not proposed to be developed) and ignores the groundwater flow patterns. MADEP's Guidelines requires that the proposed wastewater discharge be diluted with only the groundwater that is directly above and down gradient of the discharge area. This area is referred to the Area of Impact (AOI).

2. The NGI report uses a solute transport model (AT123D) to estimate down gradient nitrogen concentrations. This model relies upon two additional factors that assume reductions in

[1] A copy of the relevant sections of the MADEP Guidelines are attached as Exhibit A.

downgradient concentrations of nitrogen in groundwater - dispersion and decay. Neither of these factors is allowed in the MADEP nitrogen loading model. Utilizing these additional factors can underestimate nitrogen concentrations in groundwater.

3. The NGI analysis assumes 3 persons/house and 5.9 pounds of nitrogen per day. The MADEP guidance requires using actual nitrogen concentrations in wastewater effluent (35 mg/liter for standard septic systems and 19 mg/liter for alternative systems) and Title 5 design wastewater flows (110 gallons/bedroom).

HW has applied the MADEP Guidance and our results are as follows:

1. Area of Impact: Figure 6 of the NGI report shows groundwater flow conditions as a result of the proposed wastewater discharges. It shows that effluent from the proposed wastewater disposal area #1 flowing easterly and for areas #2 and #3 groundwater flows radially from the leaching areas in a northeasterly to southeasterly direction. This represents the Areas of Impact (AOI) as identified in the MADEP nitrogen loading guidance. See Figure 1 attached hereto.

2. In accordance with the MADEP Guidance, HW has applied the Title 5 wastewater design flows for each proposed disposal area, an effluent concentration of 19 mg/liter (representative of the proposed innovative & alternative septic technology) and a 9 inch/year recharge rate (consistent with the NGI recommendation of 20% of annual precipitation).

3. System #1 Results: The NGI groundwater map shows that the AOI extends easterly to the down gradient property boundary. Using a Title 5 design flow of 1980 gallons/day, a recharge rate of 8.2 inches/year, and an effluent concentration of 19 mg/liter the predicted concentration at the down gradient property boundary is 17.1 mg/liter. This takes into account fertilizer additions associated with the home #1 lawn and roof runoff infiltrated from home #1.

4. Systems #2 and 3 Results: The NGI groundwater map shows that as the wastewater effluent leaves the proposed disposal area it fans out in a northeasterly to southeasterly flow direction. It also shows that the effluent and associated groundwater intersects a down gradient property boundary very close to the wastewater source along the northern property boundary. To determine the concentrations at this property boundary we have delineated an AOI that runs onto the down gradient and adjacent properties to the north. At the 105-foot water table contour on the NGI map this analysis predicts an average nitrate-nitrogen concentration of 17.1 mg/liter in this area. Higher concentrations of nitrogen can be expected at the down gradient property boundary closer to the wastewater disposal beds (for example in there are where the 110-foot contour intersects with the property boundary).

5. Conclusion: The resulting nitrogen loading analyses indicate that water quality will be degraded on down gradient, neighboring properties with nitrate-nitrogen concentrations exceeding the Maximum Contaminant Level of 10 mg/liter.

6. Limitations of this Analysis: This analysis was conducted using best currently available information. It assumes that nitrogen from the wastewater disposal systems is transported through the overburden (shallow soils) and does not take into account flow through the underlying fractured bedrock. Flow through the fractured rock is considerably faster than through the overburden and is not diluted by overlying recharge. Therefore higher nitrogen concentrations can be expected at down gradient property boundaries where flow occurs in fractured bedrock.

If you have any questions, please contact me at 508-833-6600.

Sincerely,

HORSLEY WITTEN GROUP, INC.

Scott Horsley
Principal

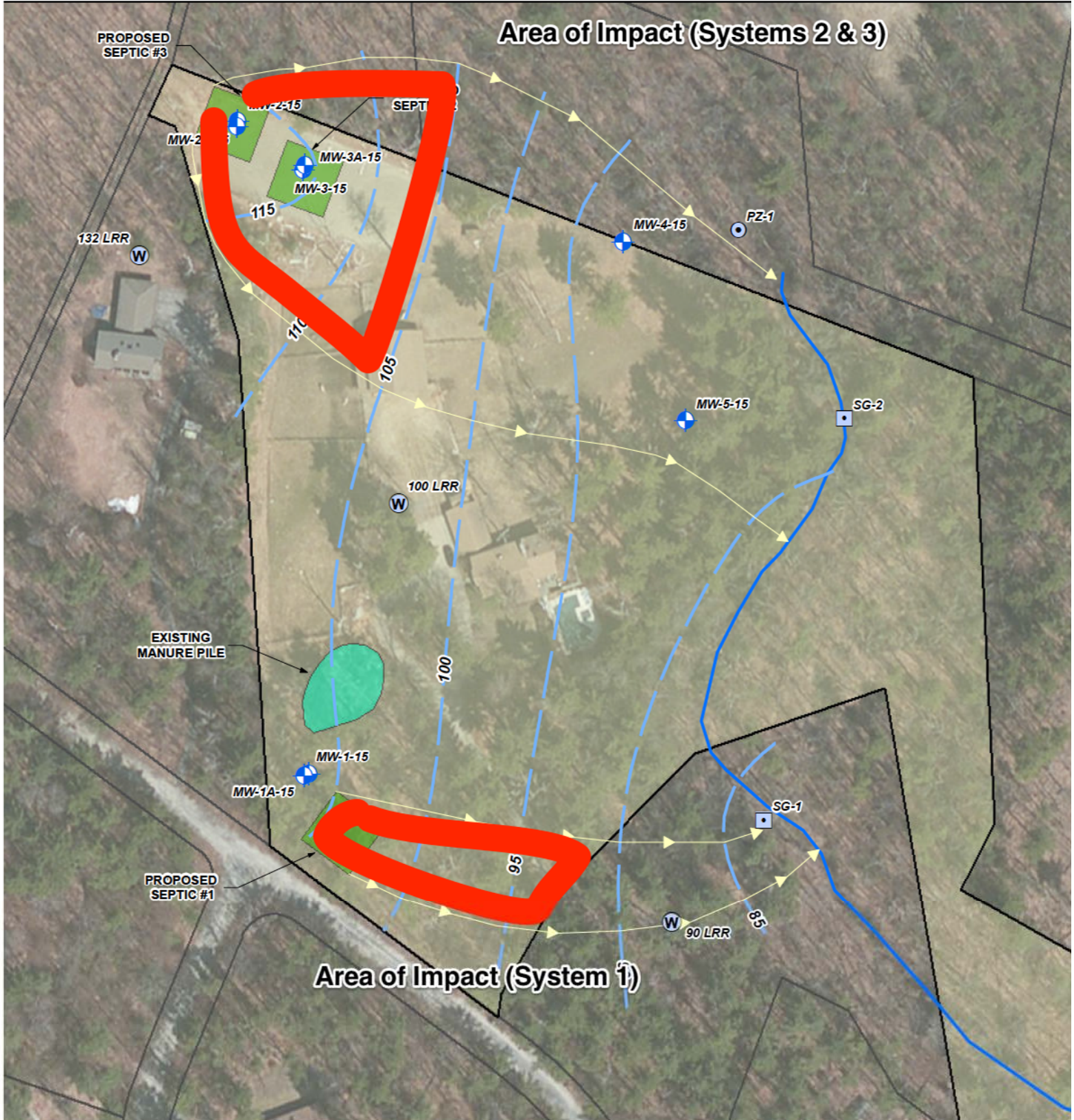
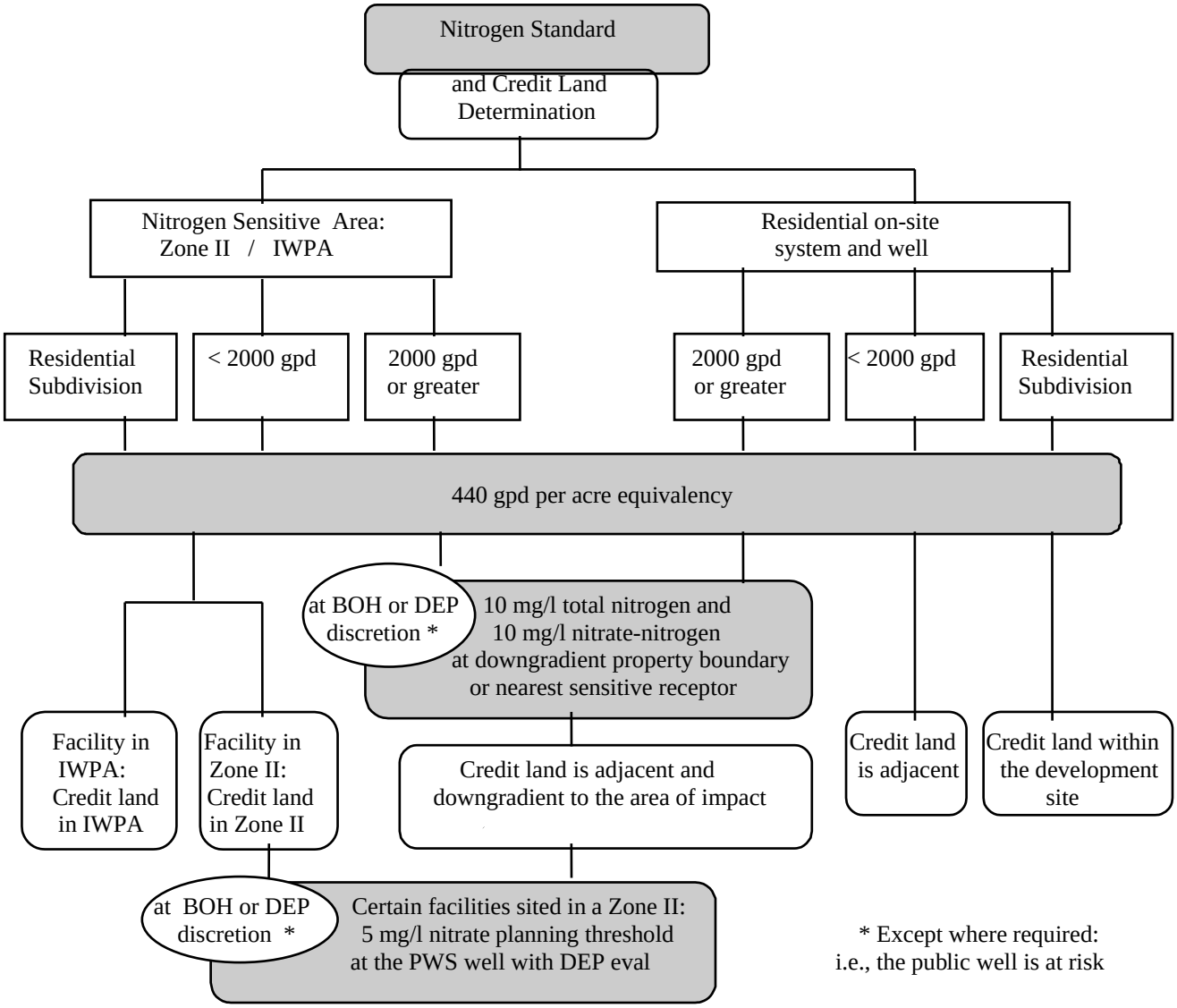

Area of Impact (Systems 2 & 3)
PROPOSED SEPTIC #3
MW-2-15
MW-3A-15
MW-3-15
115
132 LRR
MW-4-15
PZ-1
110
105
MW-5-15
SG-2
100 LRR
EXISTING MANURE PILE
100
MW-1-15
MW-1A-15
SG-1
PROPOSED SEPTIC #1
95
85
90 LRR
Area of Impact (System 1)

Figure 1. Nitrogen Standard and Credit Land Determination Flow Chart



7. SITE-SPECIFIC MASS BALANCE ANALYSIS

Where the proposed discharge from a facility is 2000 gpd or greater, but less than 10,000 gpd, and may impact sensitive receptors, the Board of Health or DEP may require a site-specific mass balance analysis to ensure adequate protection of public health, safety or the environment. In this event, the applicant must demonstrate that, in addition to meeting the 440 gpd per acre equivalency standard, the groundwater compliance standard of 10 mg/l total nitrogen and 10 mg/l nitrate-nitrogen will be met at the downgradient credit land property boundary or the nearest downgradient sensitive receptor.

To demonstrate that a proposed facility's discharge meets the 10 mg/l standards, the applicant must complete a hydrogeologic report with the following components:

A) Hydrogeologic Assessment
B) Mounding Analysis
C) Nitrogen Analysis
D) Groundwater Monitoring Program

A) Hydrogeologic Assessment

The applicant must assess and describe the hydrogeologic conditions present at the proposed system site. A pre-application proposal letter outlining the scope of work should be submitted for comment to the approving authorities, to confirm study protocols and objectives. A pre-application conference may also be advisable. The hydrogeologic assessment must include:

- a soil evaluation in accordance with Title 5 requirements
- determination of seasonal high groundwater
- determination of aquifer parameters sufficient for the calculation of mounding potential
- development of a groundwater flow map
- determination of groundwater flow direction
- determination and identification of all downgradient sensitive receptors within the area of impact of the proposed discharge

B) Mounding Analysis

The applicant must conduct a mounding analysis for the proposed discharge and demonstrate that the appropriate thickness of unsaturated material required by Title 5 (310 CMR 15.240) separates the bottom of the soil absorption system (SAS) and the mounded, seasonal high water table. Mounding calculations must be conducted to stabilization at the proposed design flows and be reflected on the water table map.

The DEP methodology used to assess mounding potential may be relatively simple analytical calculations (e.g., Hantush or Finnemore). The purpose of the mounding analysis is to determine the extent of mounding perpendicular to the direction of groundwater flow. All raw data and calculations used as part of the analysis must be included in the hydrogeologic report.

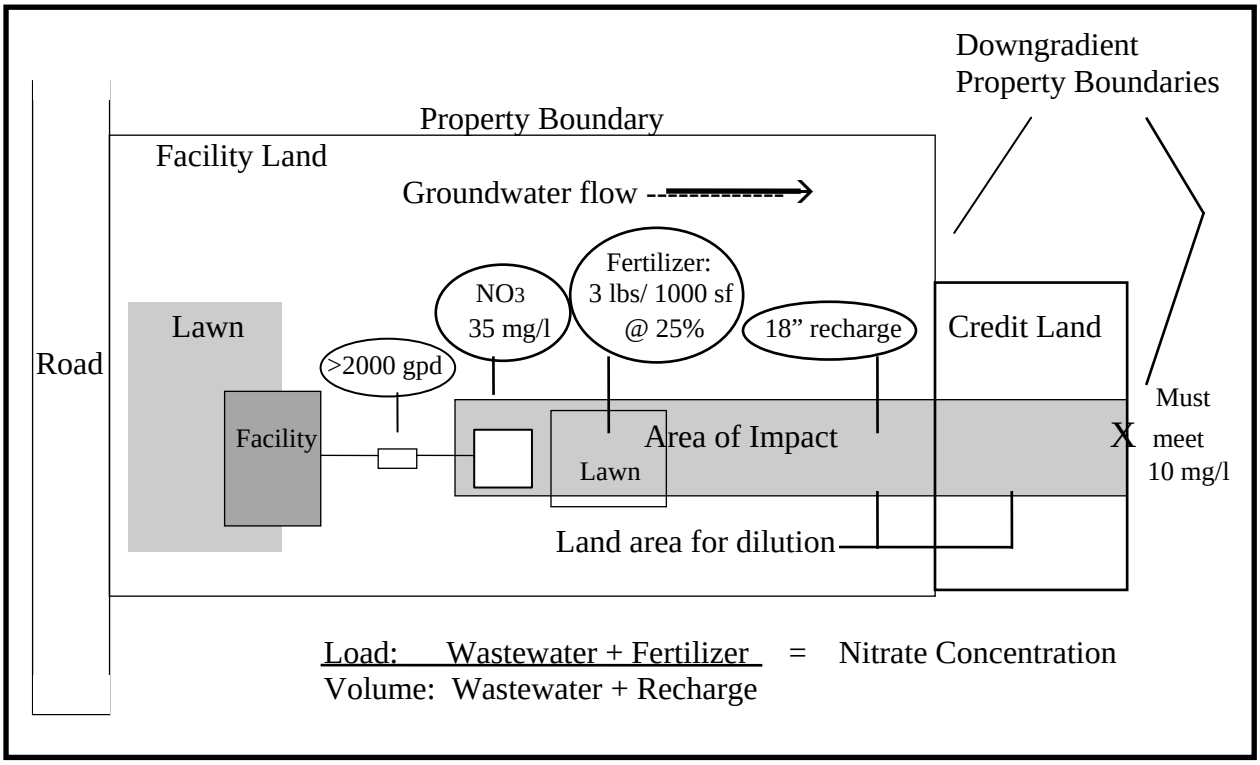
C) Nitrogen Analysis

The applicant must evaluate by mass balance analysis the amount of effluent and fertilizer dilution that is anticipated at the credit land's downgradient property boundary or sensitive receptors, assuming total mixing of the effluent plume and groundwater recharge due to precipitation. A discharge will be considered to be protective of sensitive receptors when the recharge in the land area within the discharge's Area of Impact (AOI) is sufficient to allow for dilution of total nitrogen and nitrate-nitrogen concentration (NO_3) to 10 mg/l at the credit land's downgradient property boundary or nearest downgradient sensitive receptor. *(See Figure 2).*

If the available land area downgradient of the discharge will be insufficient to dilute the groundwater nitrogen concentrations below 10 mg/l at the property boundary or sensitive receptor, the applicant must employ one or more of the following options:

- decrease the volume of proposed discharge
- decrease the nitrogen concentration in the effluent by increasing treatment
- relocate and/or reorient the SAS to maximize recharge to the Area of Impact
- obtain more land, that is, qualified credit land adjacent and downgradient to the Area of Impact

Figure 2. Conceptual illustration of mass balance analysis



To calculate the nitrogen impact, the project proponent must evaluate the downgradient total nitrogen and nitrate dilution as follows:

Step 1. Determine the Area of Impact (AOI) downgradient of the discharge by flownet analysis. The AOI will extend from the upgradient edge of the SAS to the downgradient credit land boundary. The lateral extent of the AOI must be established by the groundwater divides developed beneath the SAS at design flow.

- The AOI subject to recharge must be exclusive of impervious surfaces, such as buildings, pavement and rock outcrops.
- Where groundwater mounding is not significant, the lateral extent of the AOI will be the lateral extent of the leach bed or disposal area.

Step 2. Determine the nitrogen load for the AOI from the system and lawn fertilizer.
Step 3. Determine the volume of water applied to the AOI from the discharge and recharge.
Step 4. Calculate the average daily NO_3 concentration (mg/l) at the downgradient extent of the AOI assuming total mixing of the wastewater plume and the overlying recharge using the equation:

$$C_n = (L_{ww} + L_{fert}) / (V_{ww} + V_r)$$

where the concentration of nitrate (C_n) is equal to the sum of the wastewater load (L_{ww}) and the fertilizer load (L_{fert}), divided by the sum of the wastewater volume (V_{ww}) and the volume of recharge (V_r).

Step 5. Compare the calculated NO_3 concentration to the 10 mg/l standard.

For DEP purposes, the mass balance approach assumes only the wastewater discharge and fertilizer as the significant nitrogen sources from facility land. The following assumptions apply to the mass balance analysis and are used in the examples in Figures 3 and 4:

- one gallon of wastewater discharge @ 35 mg/l nitrate contains 132 mg of nitrate
- on average, 1000 sf of lawn receives 933 mg of nitrate per day in fertilizer
- 18 in per yr of recharge over one acre of land = 5062 liters per day
- one gallon = 3.78 liters

The 35 mg/l nitrate assumes total conversion of nitrogen species in the effluent discharged from the SAS of conventional septic systems. These assumptions will apply in most cases. However, the applicant may use other assumptions, subject to DEP approval, to better address site specific conditions. For instance, in cases where Innovative /Alternative (I/A) technologies providing enhanced nitrogen removal are proposed, the nitrate concentration in the effluent would change, thereby changing the nitrogen load. (Concentration x Flow = Load)

Examples of nitrate-nitrogen concentrations from approved General Use, enhanced nitrogen removal I/A technologies:

		nitrate	@ one gallon of wastewater:
General Use	RSF	25 mg/l	95 mg of NO_3
General Use	RUCK	19 mg/l	72 mg of NO_3

With enhanced nitrogen removal technologies, lower nitrate values may substitute for the assumed 35 mg/l nitrate concentration from conventional septic systems.

Figure 3. The 10 mg/l standard is met.

The proposed project will have:

- 3,000 gpd design flow
- 20,000 sf lawn in area of impact
- groundwater mound expanding the area of influence
- 8 acres of land in area of impact

To calculate the loading:

- Wastewater: 3,000 gpd x 132 mg — 396,000 mg
- Lawn fertilizer: 20 x 933 mg/day — + 18,660 mg

Total 414,660 mg

To calculate the volume of wastewater discharge and recharge:

- Determine size of area of impact after mounding
- Wastewater: 3,000 gpd x 3.78 liters — 11,340 liters
- Natural surface 8 acres @ 18"/yr (5062 liters/day) — + 40,496 liters

Total 51,836 liters

Result: Load: 414,660 mg = 8.0 mg/liter
Volume: 51,836 liters

Having 8 acres in the area of impact downgradient of the discharge and within the credit land, maintains an overall NO_3 concentration below 10 mg/l and allows the project to proceed.

Figure 4. The 10 mg/l standard is not met.

The proposed project will have:

- 3,000 gpd design flow
- 20,000 sf lawn in area of impact
- groundwater mound expanding the area of influence
- 5.5 acres of land in area of impact

To calculate the loading:

- Wastewater: 3,000 gpd x 132 mg — 396,000 mg
- Lawn fertilizer: 20 x 933 mg/day — + 18,660 mg

Total 414,660 mg

To calculate the volume of wastewater discharge and recharge:

- Determine size of area of impact after mounding
- Wastewater: 3,000 gallons x 3.78 liters — 11,340 liters
- Natural surface 5.5 acres @ 18" /yr (5062 liters/day) — + 27,871 liters

Total 39,181 liters

Result: Load: 414,660 mg = 10.6 mg/liter
Volume: 39,181 liters

Having 5.5 acres in the area of impact downgradient of the discharge is not sufficient to dilute the volume of nitrate effluent to 10 mg/l. The project would not be allowed to proceed unless modified.