Chesapeake Bay TMDL Steering Committee

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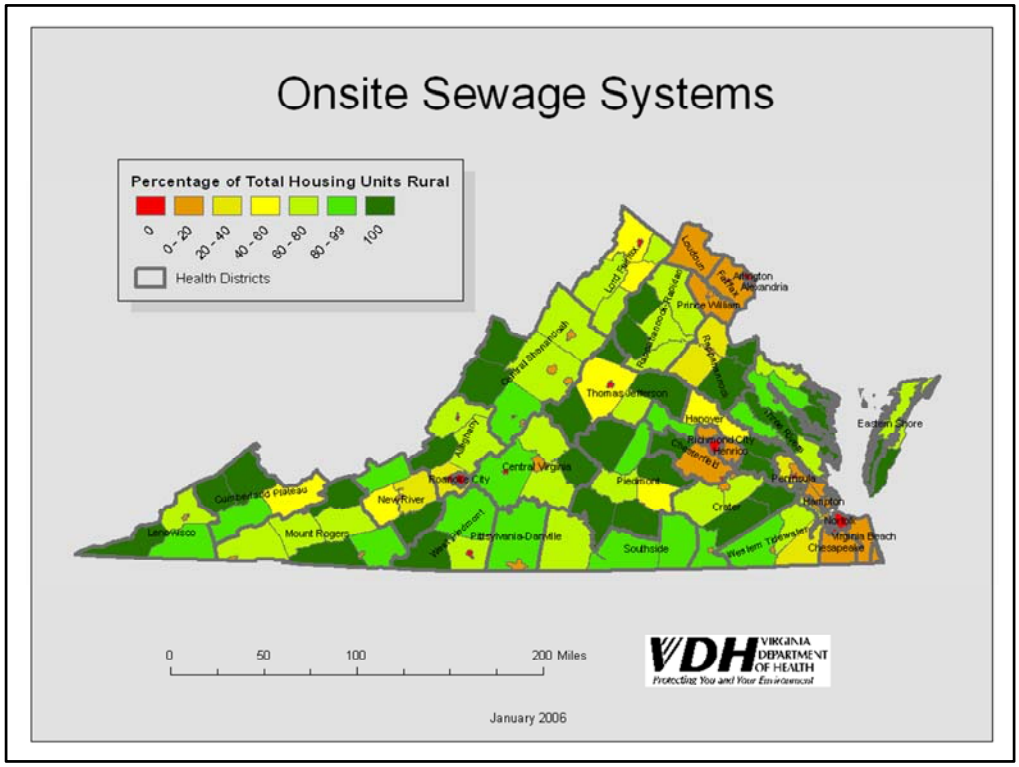
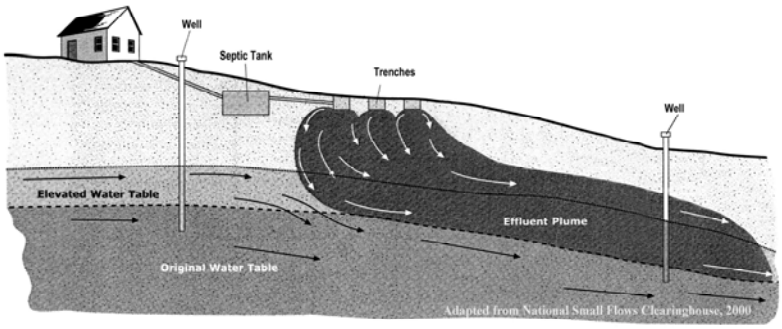


This slide shows the distribution of rural housing in Virginia as of 2006. As you can see, much of Virginia is completely rural, and even those areas that have large concentrations of people have relatively high percentages of rural housing.

VDH estimates there are about one million onsite sewage systems in Virginia….we believe that about 600,000 of those are in the Chesapeake Bay Watershed

Conventional System: Drainfield



Talk about the sponge model- let's do a thought experiment: take a cutting board and prop it up on something so that it slopes toward your kitchen sink. Now place a dry kitchen sponge on the cutting board. Slowly, begin pouring water onto the sponge. At first the sponge absorbs the water. But as you add more and more water, eventually the sponge becomes saturated and water begins to seep from the bottom of the sponge. When the water encounters the relatively impermeable surface of the cutting board it begins to flow along the board and into the sink. The sponge represents our soil environment, the cutting board represents the water table, and the sink is the Chesapeake Bay. Water from onsite sewage systems percolates downward through the soil until it becomes part of the water table. From there it moves more or less on top of the water table into a stream or other surface water body. Whatever wastewater constituents are not removed, either in the treatment process or in the soil, travel essentially unimpeded into surface waters.

Soils, and their associated biological communities, do a good job of removing particulates and the organic components of sewage. Unsaturated soils also will do a good job of removing phosphorus. Soils do not do much of anything to remove nitrogen. I'll talk more about that later.

Conventional Onsite System

An aerial view of an onsite sewage system. The green stripes clearly show the outline of the drainfield trenches and give you an idea about what happens to at least some of the nitrogen!

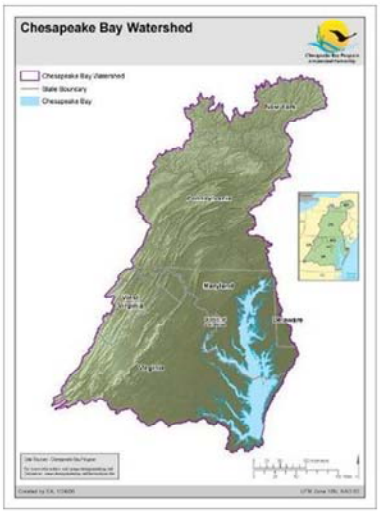
Where is the drainfield for this house? What does our model of onsite sewage systems and ground water tell us about a setup like this?

Then on the other hand, we still have thousands, tens of thousands, of Virginian's living without basic wastewater and water systems.

We have our work cut out for us!

The Chesapeake Bay TMDL

- EPA sets pollution diet to meet states' Bay clean water standards
- Caps on nitrogen, phosphorus and sediment loads for all 6 Bay watershed states and DC
- States set load caps for point and non-point sources
- Target: 2025



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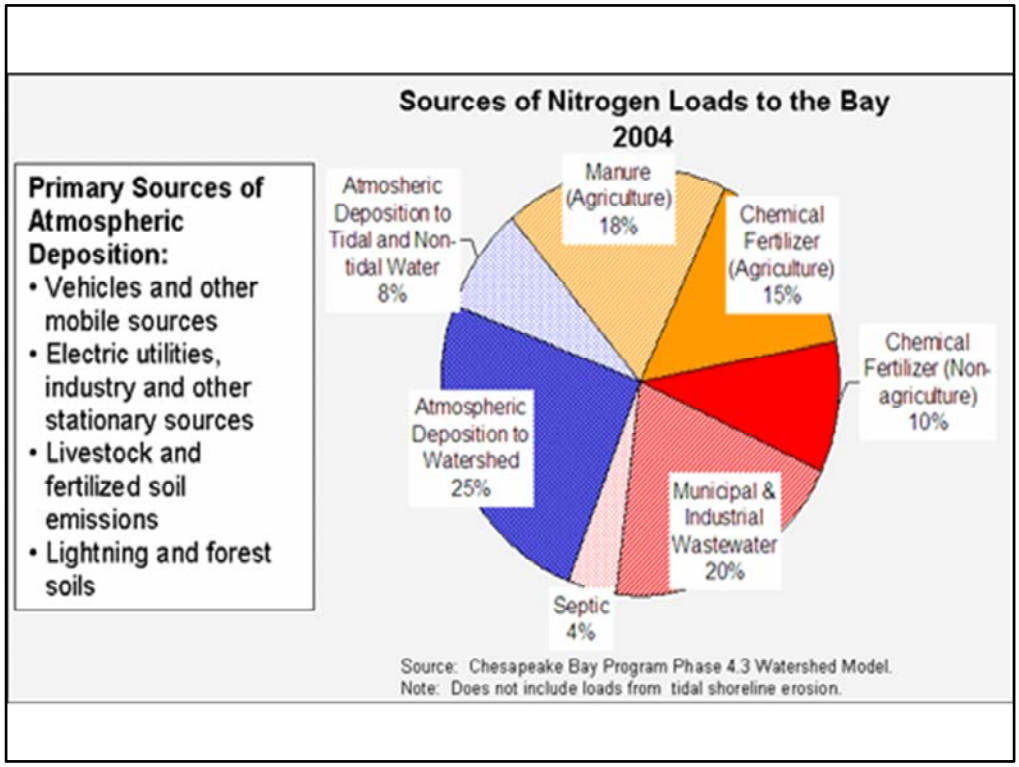
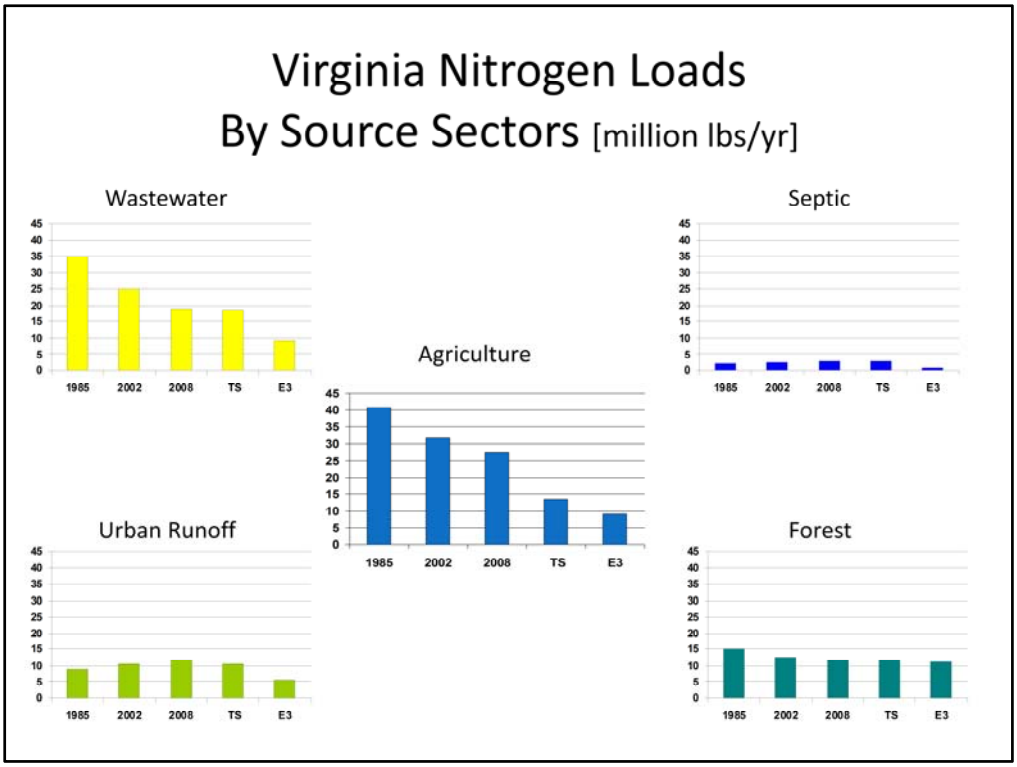
We started with a discussion of onsite sewage systems. So, now we turn to the TMDL for the Chesapeake Bay.

U.S. EPA is establishing a federal TMDL (**Total Maximum Daily Load**) or "pollution diet" for the tidal segments of the Chesapeake Bay and its tidal tributaries and embayments that are listed as impaired under Section 303(d) of the Clean Water Act due to excess nutrients and sediment. The TMDL will establish limits on the amount of nitrogen, phosphorus, and sediment that can enter the Bay.



Onsite sewage systems are a “source sector” that accounts for 4% of the Nitrogen pollution in the Bay according to EPA’s model.



Another look at the source sectors over time- scales are the same.

Based on these numbers, Ag [with most load] and Wastewater [with second most load] have had the most success in reducing loads over the years.

Urban runoff and on-site septic systems, have seen increases in loads.

Chesapeake Bay Significance: Onsite Sewage Systems

- EPA estimates 540,000 systems
- 2.9 Million pounds of N per year
- 4% of the total current N load
- EPA estimates 40% of N from every system reaches a stream
- The current WIP reduces onsite systems to 2.405 Million pounds
- This is a CAP

Best estimates based on 2008 data

According to EPA Forty percent (40%) of the nitrogen from each onsite sewage system is passed through to a stream. Not all streams have the same delivery factor…but all systems are assumed to deliver 40%.

The current Watershed Implementation Plan, approved in December 2011, requires a reduction in nitrogen from onsite sewage systems from the current amount of about 2.9 million pounds to 2.4 million pounds by 2025.

Virginia must account for growth as well. Loads cannot increase with population. There is no practical way to get 100% removal of N with onsite sewage systems. Net result- difficult problem since we are going to continue to grow.

N in Wastewater

- N is a component of amino acids and urea
- N in wastewater comes from
  - Bodily wastes
  - Discarded food material
  - Cleaning agents

Forms: Organic N and ammonia-N

Each person generates somewhere between 9 and 12 pounds of nitrogen each year.

Biological N Removal

Two Step Biological Process Required

Step 1 - Nitrification

Step 2 - Denitrification

Same thing happens in an aquarium- ammonia converted to nitrate (nitrification) in the water, then the nitrate is converted to N gas (dentrification) in the under-gravel filter.

With single family systems 50% removal of nitrogen is practical. This can be increased to about 75% if certain design considerations are taken into account: shallow installation, time dosing, etc…

Nitrification

$$2NH_4^+ + 3O_2 \xrightarrow{\text{Nitrosomonas}} 2NO_2^- + 2H_2O + 4H^+$$

Oxygen Required = 3.43 lb / lb N oxidized

Alkalinity Required = 7.14 lb as $CaCO_3$/ lb N oxidized

$$2NO_2^- + O_2 \xrightarrow{\text{Nitrobacter}} 2NO_3^-$$

Oxygen Required = 1.14 lb/ lb N oxidized

For both reactions together:

Total Oxygen Requirement = 4.57 lbs / lb N oxidized

Total Alkalinity Requirement = 7.14 lbs as $CaCO_3$ / lb N oxidized

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Ammonia/ammonium: NH_3 / NH_4^+

Nitrification Notes

- Lots of Oxygen
- Inorganic C for carbon (CO_3^{2-})
- Alkalinity
- Maintain a near Neutral pH

Denitrification

Nitrate + Organic carbon $\longrightarrow$ Carbon Dioxide + Nitrogen Gas + Alkalinity

$NO_3^- + CH_3OH$ (methanol) $\longrightarrow CO_2$(gas) + N_2(gas) + OH^-(alkalinity)

Organic carbon: BOD5/TKN of 4 to 5:1 required or
Methanol dose required = 2.5 to 3.0 lbs methanol per lb nitrate-N denitrified)

Alkalinity produced = 3.57 lbs as $CaCO_3$ per lb nitrate-N denitrified

$$2NO_3^- + 2H^+ \longrightarrow \overset{\text{Gas}}{N_2\uparrow} + H_2O + 2.5O_2$$

Oxygen equivalent = 2.86 lbs per lb nitrate-N denitrified

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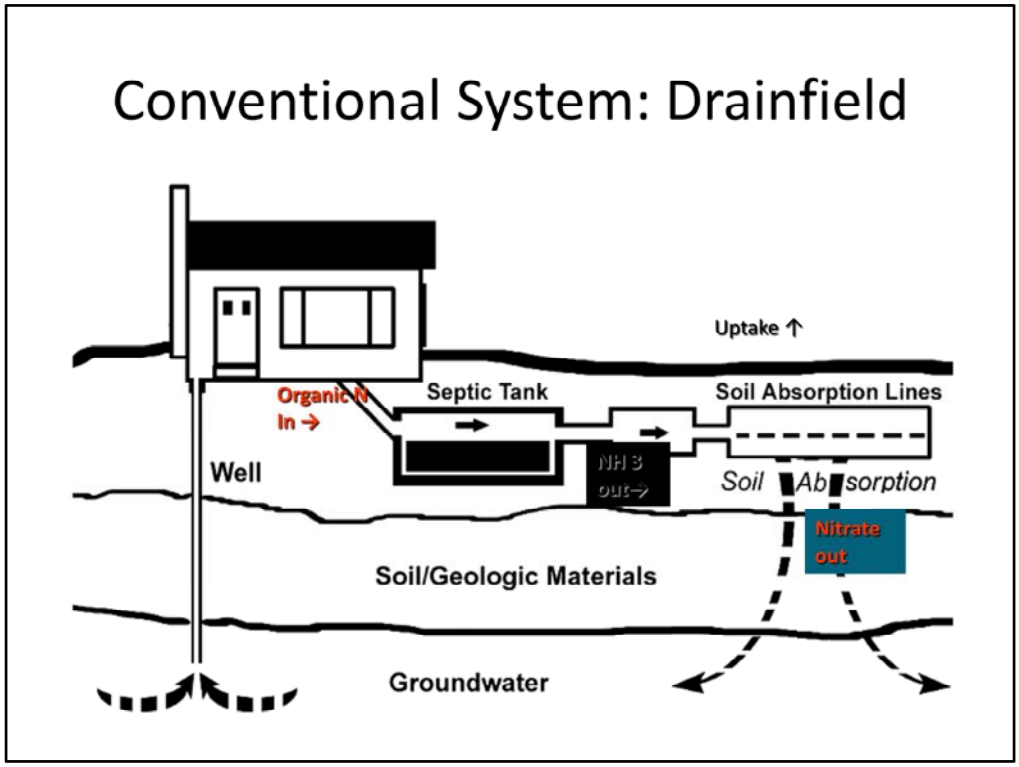
Organic carbon like glucose, carbohydrates, alcohols, etc.
PRODUCES Alkalinity so regain alkalinity and helps to stabilize the pH drop from nitrification
The nitrate supplies the oxygen so it really is an efficient way to reduce BOD

Denitrification Notes

- No oxygen
- Must have nitrate
- Must have organic C source
- Produces alkalinity
- Uses nitrate as an alternate to oxygen



So, what learn is that conventional septic systems do an excellent job of converting the ammonia/ammonium into nitrate. But they do nothing to remove the nitrate. The conversion to nitrate takes place primarily in the drainfield where there is plenty of oxygen and inorganic carbon. However, those same soil conditions are not conducive to denitrification….either there is too much oxygen, or you don't have an organic carbon source. Bottom line - Nitrate is highly soluble in water and very mobile in the environment. It makes excellent fertilizer, and some of it is taken up by plants in the soil, but some finite amount leaves the drainield to go somewhere else- the Chesapeake Bay.

Many alternative onsite sewage systems are capable of reducing nitrogen. But, they can be expensive, and they require routine operation and maintenance.

So you need to introduce a dentrification process…or offset the N impact some other way.

WIP Elements: Onsite Sewage

- Reduce rate of growth through regulatory actions; propose offsets through Nutrient Credit Exchange
- Alternative Onsite Sewage System Regulations:
  - 50% reduction for all small AOSS
  - 3mg/l TN at project boundary for large AOSS
- Seek legislation to require all new and replacement systems to reduce N

Allocation: This plan attempts to reduce the rate of growth in this sector through regulatory actions and proposes to offset some loads through an expansion of the Nutrient Credit Exchange
Program.
· Implement amendments to Virginia Department of Health regulations for alternative systems. The proposed amendments require a minimum 50% reduction in delivered N for all new small alternative onsite systems in the Chesapeake Bay watershed resulting in an effective delivered load to the edge of the project boundary of 4.5 lbs TN/person/year. All large alternative onsite systems will demonstrate compliance with <3 mg/l TN at the project boundary.
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· As a component of the revisions to the Nutrient Credit Exchange law proposed in 2012, allow for increased loads from onsite/septic to be aggregated at a jurisdictional level and available for offsets
· Seek revisions to the Code of Virginia will be considered to require all new and replacement systems in the Chesapeake Bay watershed to utilize either (1) “shallowplaced” systems capable of reducing nitrogen loss or (2) denitrification technology to reduce nitrogen loss and consider requirements for additional nitrogen reducing technologies in certain defined sensitive areas.

WIP Elements Cont…

- Seek legislation to promote community systems
- Seek legislation to require pump-outs where currently not required
- Seek legislation for tax credits
- Encourage use of Betterment Loans and explore other financial incentives or relief

· Seek revisions to the Code of Virginia that will promote the use of community onsite systems which provide a greater reduction of TN.
· Seek legislative changes necessary to establish 5 year pumpout requirements for septic tanks in jurisdic tions within Virginia's Chesapeake Bay watershed (this mirrors the existing requirement for septic tanks within Chesapeake Bay Preservation Act areas).
· Seek legislative changes necessary to establish tax credits for upgrade/replacement of existing convent ional systems with nitrogen reducing systems.
· Encourage the use of currently authorized "Betterment Loans" for repairs to existing systems and explore other financial incentives or relief to encourage the upgrade of existing
systems especially for low and moderate income households.

Questions

- How will the Alternative Onsite Sewage System (AOSS) Regulations relate to the Chesapeake Bay TMDL?
- When the Regulations are implemented, the N reductions required will help slow the rate of increase in the septic source sector.

Questions

- The Bay Model includes N loads from septic tanks. Is the loading rate typical for a residential septic tank?
- No such thing as a septic tank in the model, just a number..40% of each persons nitrogen is assumed to be delivered to the stream segment. Delivery factors can vary depending on where you are. The farther away from the Bay would reduce the delivery factor. Hampton Road would use a 1 to 1 with no reduction.

Question

- Could VDH provide guidance on loading rates for commercial tanks?
- The Model does not recognize a difference in residential and commercial. VDH's regulatory program has considered systems >1,000 GPD as mass drainfields since 1984. The regulations do not require a reduction in nitrogen. Dilution can be used to obtain a 5 mg/l N at the property boundary. Most mass drainfields achieve a 50% reduction due to treatment. Treatment is usually less expensive than land.

Question

- Does VDH keep records of commercial tanks in each locality?
- Yes

Question

- Did DCR use VDH's data for the number of septic tanks in the Phase 1 WIP?
- No. They used population data.

Question

- Could VDH compare the N loading rate of a typical septic tank to the loading rate of an AOSS option?
- An AOSS that includes an NSF-245 treatment unit should give a 50% reduction of N. Virginia is exploring 3 BMPs
- NSF-245 treatment unit to a shallow placed drainfield = 75% reduction of N
- Conventional system to a shallow placed drainfield = 25% reduction of N.
- Treatment Level 2 (TL-2) system to a shallow placed Drainfield = 50% reduction of N.

Question

- What are the triggers in the new AOSS regulations that would require or encourage people to upgrade their septic systems?
- When repairing a system failure where the site conditions require an AOSS. Expansion of an existing system where site conditions required an AOSS.

Question

- Can localities require upgrades? If so, under what circumstances?
- VDH is not in a position to advise localities on what authority they have.

Question

- Are there any state grants or programs that fund upgrades?
- VDH does not administer any funds or grants.

Question

- Are the AOSS requirements different in areas covered by the Chesapeake Bay Preservation Act compared to the rest of the state?
- No. There are different requirements for the Chesapeake Bay Watershed vs. the rest of the state.

Small AOSS

- All (not within Chesapeake Bay Water Shed)
  No nitrogen reduction requirement.
- Direct Dispersal to Groundwater
  (not within Chesapeake Bay Water Shed)
  5 mg/l TN at end of pipe.
- Direct Dispersal to Groundwater
  (within the Chesapeake Bay Water Shed)
  3 mg/l TN at end of pipe.
- Within Chesapeake Bay Water Shed
  50% reduction of TN

Large AOSS

(Not in Chesapeake Bay Water Shed)

- All AOSS

  5 mg/l TN at project boundary. Dilution can be used.

- Direct dispersal to groundwater.

  <5 mg/l TN at end of pipe

Large AOSS cont.

(Within Chesapeake Bay Water Shed)

- 1,000 GPD – 10,000 GPD

  50% reduction of TN

- Over 10,000 GPD

  8 mg/l TN end of pipe or

  5 mg/l TN in-situ monitoring, and

  3 mg/l TN end of pipe if direct dispersal

Question

- Are there any circumstances when a local government can require a property owner to hook up to sewer?
- Possibly through a local ordinance. Connection to public sewer is a BMP that VDH will need to track. We are looking for ways to partner with local governments to collect this data.

Question

- Are there any grants to fund hookups or pay sewer fees especially if a septic tank is close to a stream?
- Again, VDH does not administer funds or grants but, the Department of Housing and Community Development may.

Conclusion

- 2.9 million lbs of N/year in 2008
- EPA wants a reduction to 2.4 million lbs. of N/year in 2025.
- The only way to achieve this goal is to have every new system to produce zero N. Retrofit 40,000 existing systems.