Septic system discharge – water quality impacts

Passive Treatment of Nitrate in Groundwater

October 2019

ROCKINGHAM COUNTY CONSERVATION DISTRICT

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Domestic/Commercial Septic Discharge

In addition to bacteria and BOD

- Nitrogen – (inorganic N – nitrate-N dominant if oxidation complete) impacts tidal/estuarine water bodies
- Phosphorus (inorganic P bioavailable) – impacts fresh water bodies – can contribute to eutropication, cyanobacteria
- Personal care products/ pharmaceuticals, https://silentspring.org/news/drugs-and-other-pollutants-found-private-wells-cape-cod
- Other household/commercial products including PFAS and other persistent compounds, https://www.sciencedirect.com/science/article/pii/S0048969716320654?via%3Dihub

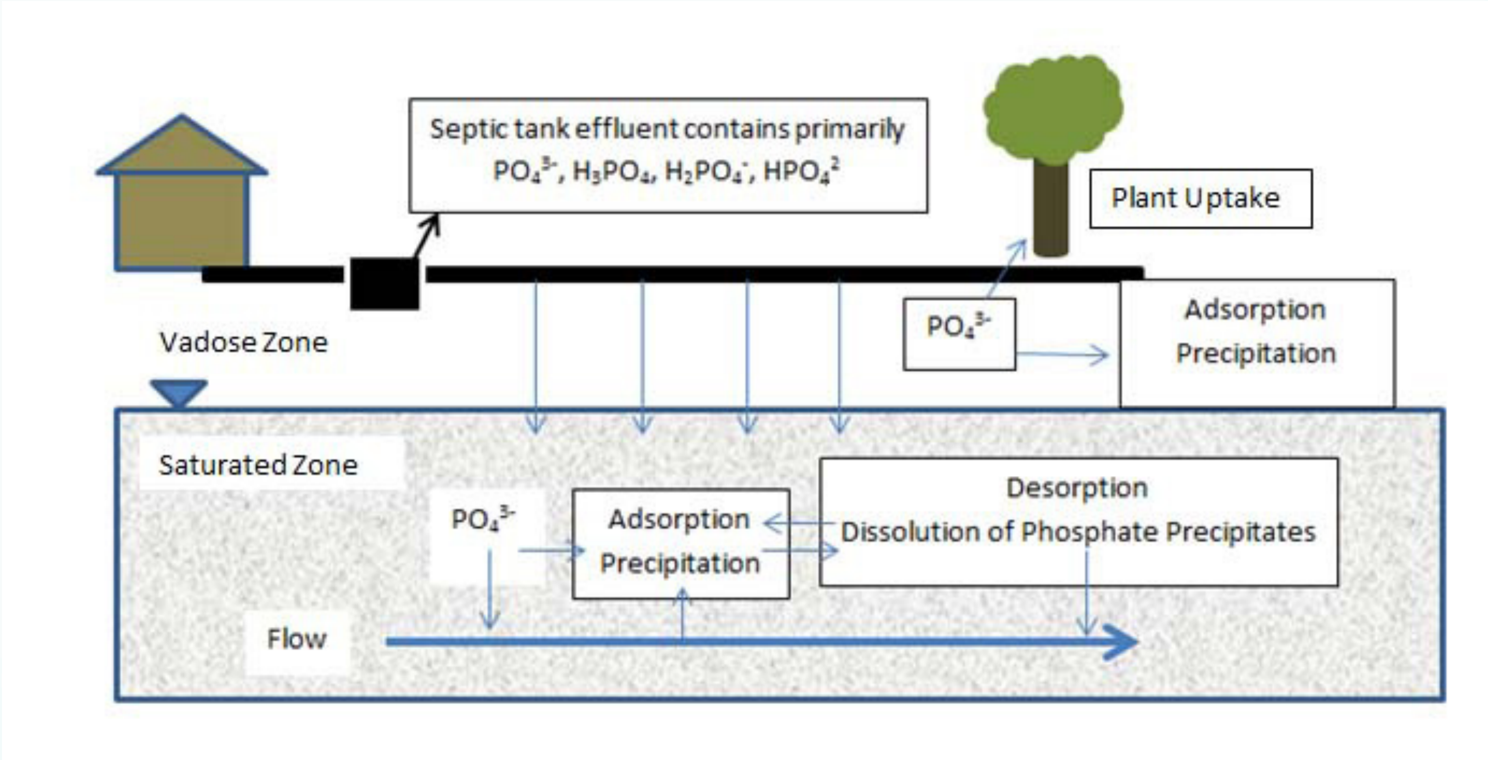
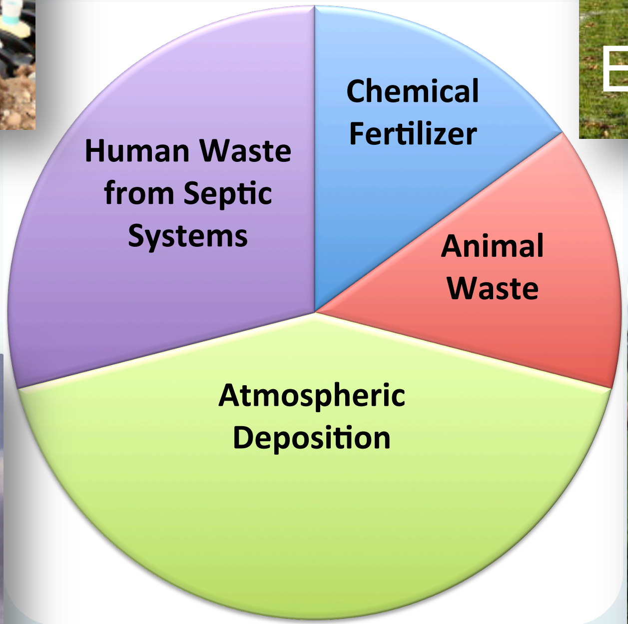


Figure 1. Fate and transport of phosphate (PO_4^{3-}) in a septic system. Most adsorption and precipitation reactions of phosphate are complete by the time the septic tank effluent reaches the water table. Thus, understanding how phosphate moves in the drain field is the key to determining the ultimate fate of phosphate from septic systems.
Credits: Mary Lusk, UF/IFAS.

Hydraulic failure large source of phosphate from septic, distance to SW and GW critical factors Source : https://edis.ifas.ufl.edu/ss551

Sources of nitrate in groundwater



Pie chart data – estimated sources of nitrogen from non-point sources from 2014 Great Bay Nitrogen Non-Point Source Study

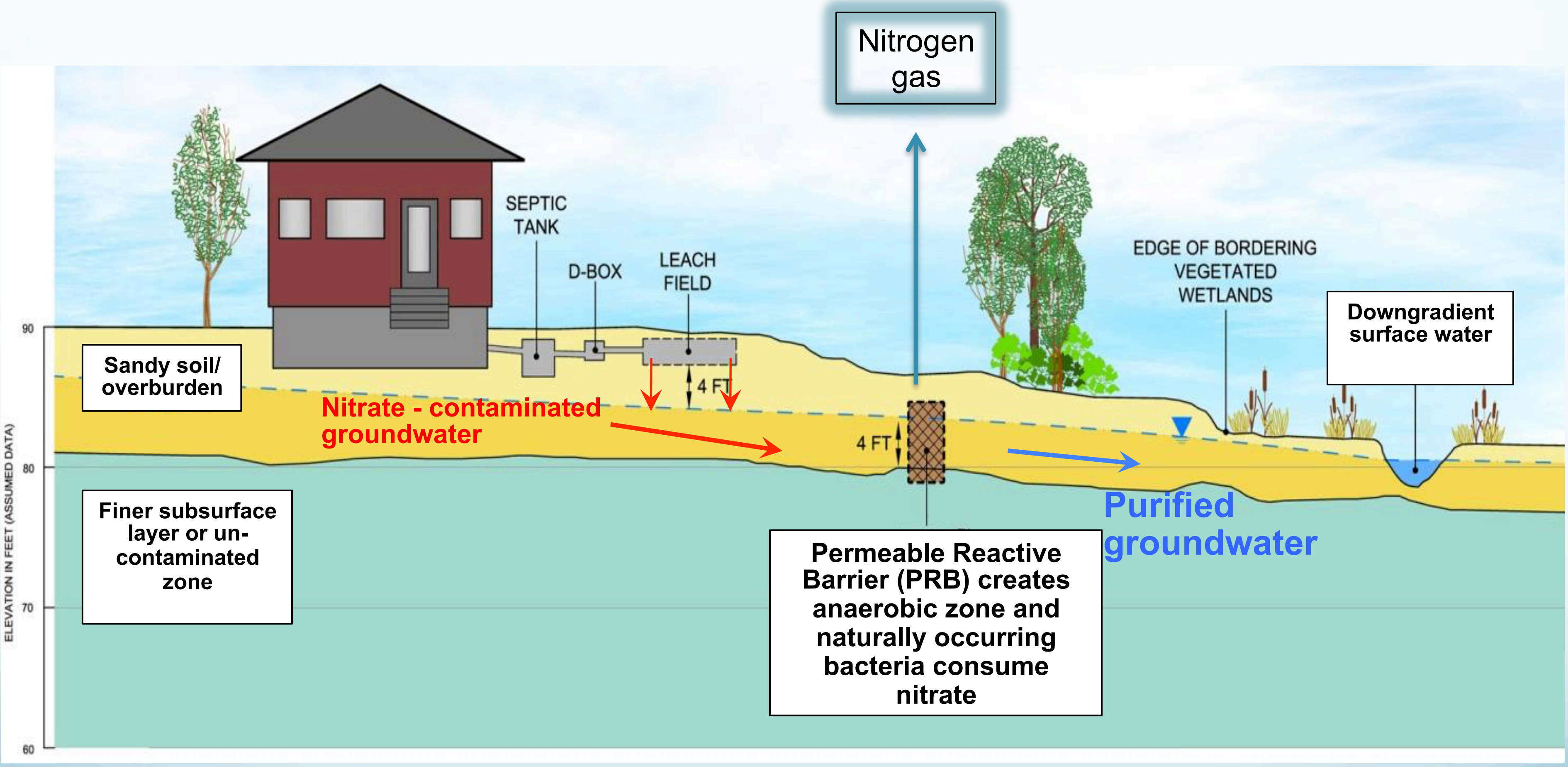
Why is excess nitrate a problem?

- Causes degradation of water quality and habitat from eutrophication of surface waters – coastal environments most vulnerable
- Excessive nitrate/nitrite in drinking water can be harmful to health, especially to infants – 10 mg/L/1 mg/L regulatory limit in drinking water
- Treatment – denitrifying septic systems/permeable reactive barriers, other innovative leach field technologies
- Long Island/Rhode Island/Cape Cod – multiple management efforts ongoing

What is a Permeable Reactive Barrier (PRB)

- Subsurface treatment zone *in the saturated zone* that groundwater passes through under natural flow conditions
- A supplemental carbon source is added in the treatment zone
- Creates chemically reducing conditions, decreases dissolved oxygen in groundwater – enhances environment for naturally occuring denitrifying (anaerobic) bacteria
- Wood chip carbon source for shallow appplications, injected emulsified vegetable oil (EVO) for deeper, more extensive zones
- No mechanical infrastructure needed but requires monitoring and maintenance; EVO requires periodic re-injection

How does a PRB reduce nitrate?



Nitrate contaminated groundwater passes through the PRB and nitrate is converted to nitrogen gas

Wood Chip Bioreactor PRBs

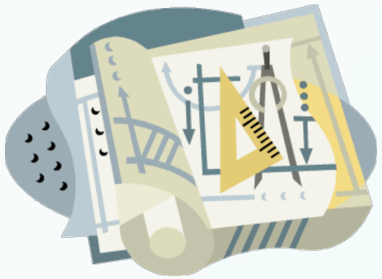
- Trench or zone with a low cost carbon source (wood chips) for denitrification
- Creates environment for naturally occurring anaerobic bacteria to thrive and transform nitrate to nitrogen gas
- Shallow reactive barriers can be simple to install and maintain

Bioreactor wood chips similar to wood chips used for playgrounds

Emulsified Vegetable Oil PRBs

- Emulsified vegetable oil (EVO) that is forumlated for the treatment setting is injected into treatment zone
- Utilization of EVO in subsurface is monitored and periodically refreshed
- Can be used in areas of deeper/more extensive contamination

What information is needed for proper design and installation?



- Subsurface geology
- Concentration of nitrate in groundwater
- Potential/actual depth of nitrate impact
- Basic groundwater geochemistry in treatment area
- Direction of groundwater flow from nitrate source
- Depth to groundwater
- Groundwater flow rate
- Annual groundwater level fluctuation

Optimal settings for PRB use in New England

- Developments near sensitive areas – can treat combined septic system/stormwater discharges
- To supplement a traditional septic system that will treat nitrate to WQ standard at property line
- Surrounding a community septic field for protection of sensitive area (water supply, stream, etc..)
- Near a water supply well – to remediate or prevent elevated nitrate migration from a source area
- Site where hydrogeologic study already completed or required


Location of Pilot PRB Sites
Legend
Maine
Great Bay
Durham
Brentwood
Rockingham
entwood
New Hampshire
Atlantic Ocean
Kingston
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2018 Google
N
8 mi

Pilot Study – Brentwood, NH – Community Septic Field

PRB Placement and Site Restoration

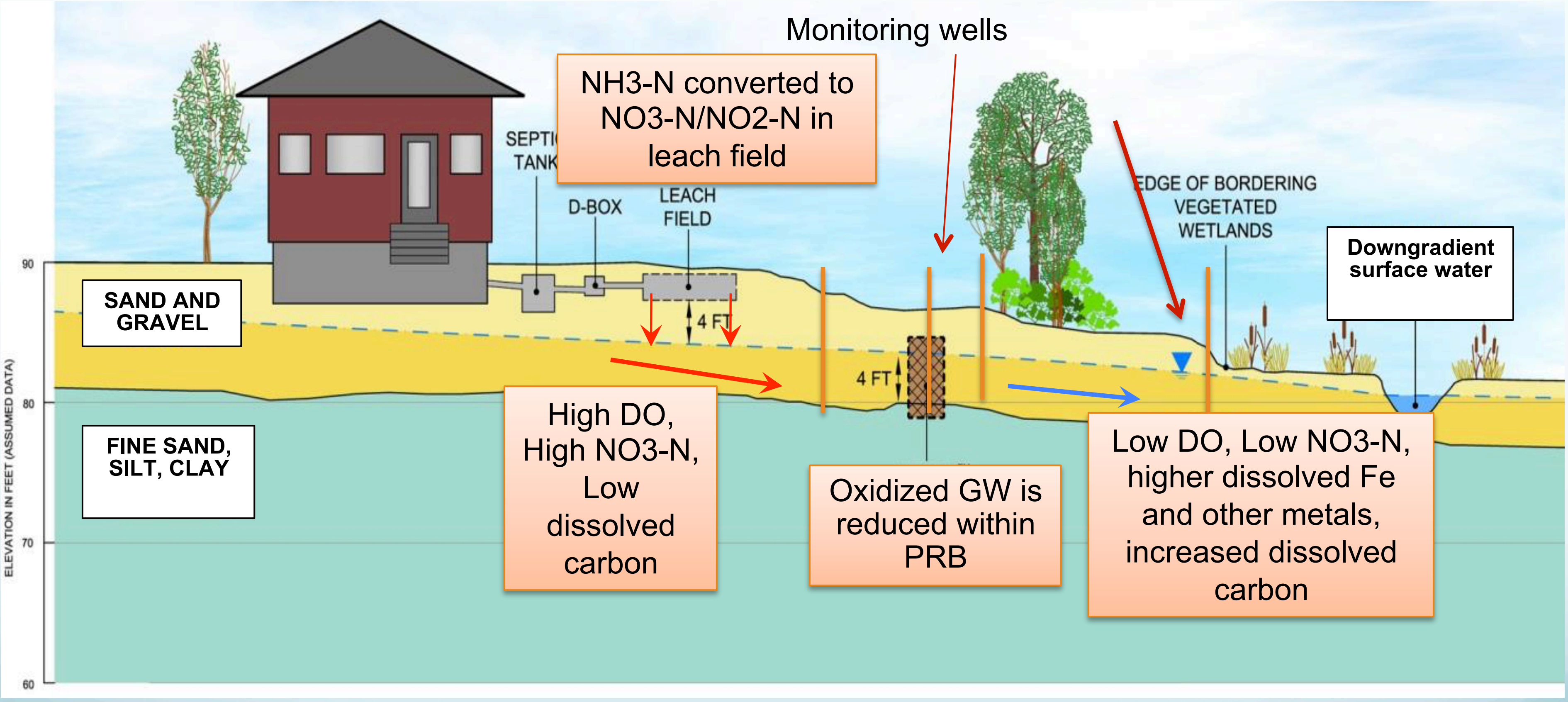

Filling trench with chips as trench is excavated


Geotextile cover at surface of trench


Filled Trench


Completed PRB

Water Chemistry Changes



Regular monitoring under various weather conditions to test effectiveness of PRB

Data summary

Measuring Point	Measurement Period	Nitrate-N – Mean (mg/L)	Dissolved Oxygen – Mean (mg/L)	Dissolved Iron – pre-post (mg/L)
Well MW-101 Untreated by PRB	All dates	37.0	5.6	BDL – 0.23
Well MW-102 Untreated by PRB	All dates	31.1	7.3	BDL – 0.35
Well MW-106 In PRB	Post installation	3.1	2.2	NM – 10.0
Well MW-107 5' DG of PRB	Post installation	5.9	2.5	NM – 5.6
Well MW-103 10' DG of PRB	Post Installation	9.3	1.9	BDL – 40.0
Well MW-104 70' DG of PRB	Post Installation	19.4	9.3	BDL – 2.4
Change in NO3-N concentration with PRB treatment	**MW-102 – MW-107**	**31 to 6 ppb**	**81% reduction**	

DG – downgradient;
PRB – permeable reactive barrier
BDL – below detection limit;
NM – not measured

Advantages of using wood chip Permeable Reactive Barriers (PRBs)

- Passive treatment of nitrate in groundwater – no mechanical systems to maintain
- Wood chips for trench are locally available and low cost
- Wood chips are safe, plant based materials
- Can provide significant nitrate reduction
- Can be sited to treat multiple source areas
- Minor maintenance required once trench installed
- Expected lifetime – 20+ years

Examples of ongoing/pilot PRB installations

- Midwest and Canada – Agricultural applications – woodchip bioreactors
  - https://jbioleng.biomedcentral.com/articles/10.1186/s13036-017-0057-4
  - *www.tidescanada.org/.../D-1-9LauraChristiansonD-enitrificationWooD-chipBioreactor..*
  - https://engineering.purdue.edu/watersheds/conservationdrainage/bioreactors.html
- Brentwood, NH and Durham, NH – Pilot woodchip bioreactor trenches
  - http://www.rockinghamccd.org/presentations/nitrogen-septic-systems-great-bay-and-why-it-matters/
- Kingston, NH – All American Assisted Living – installed August 2019, water quality testing to begin in November 2019 – woodchip bioreactor
- Cape Cod - Orleans, MA – Injected EVO PRB – ongoing pilot study
  - https://www.town.orleans.ma.us/sites/orleansma/files/file/file/owqap_prb_breakout_group_presentation_final_0.pdf
- Cape Cod – Falmouth, MA – pilot EVO underway
- Martha's Vineyard – Hummock Pond – pilot EVO underway