Preliminary Hydrogeological Evaluations

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ARM Group
Engineers and Scientists

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Preliminary Hydrogeological Evaluations

- Regulatory Framework - when and why do you need a preliminary hydro evaluation
- Evaluation Requirements - calculations and inputs
- Case Studies

Regulatory Framework

Act 537 – Sewage Facilities Act

Chapter 71 – Administration of Sewage Facilities Planning Program

Subchapter D – Official Plan Requirements for Alternative Evaluations

§71.62. Individual and community onlot sewage systems

Regulatory Framework

§71.62. Individual and community onlot sewage systems

(a) Official plans and official plan revisions proposing individual and community onlot sewage systems shall evaluate general site suitability to establish their use as a feasible alternative, as specified in subsection (b).

Regulatory Framework

§71.62. Individual and community onlot sewage systems

(b) When an official plan or revision proposes the renovation of sewage effluent by means of a subsurface absorption area or a spray irrigation system, the following shall be provided:

(1) Anticipated raw waste characteristics of the sewage.

(2) Documentation that the soils and geology of the proposed site are generally suitable for the installation of the systems including:

(i) Soils mapping
(ii) Contour lines
(iii) Soil profiles
(iv) Percolation tests

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Regulatory Framework

§71.62. Individual and community onlot sewage systems

(c) This chapter does not preclude the use of individual and community onlot sewage systems using subsurface soil absorption areas on lots less than 1 acre in size or the use of large volume onlot sewage systems. Because of the potential for the creation of a public health hazard or pollution of the waters of this Commonwealth from high density use, improper system siting or inadequate maintenance of individual and community onlot systems, particular attention shall be given in official plans and revisions to the technical and institutional feasibility of using the systems.

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Regulatory Framework

§71.62. Individual and community onlot sewage systems

(c)(1) Additional permeability testing is required when an official plan or revision proposes the use of a large volume onlot sewage system or a community onlot system with a sewage flow in excess of 10,000 gpd, and may be required for other onlot system proposals where the total absorption area is greater than 5,000 square feet or where soil profiles or geology reveal slowly permeable conditions below the depth at which the percolation test was performed. Sufficient testing shall be conducted to:

(i) Determine the permeability of an identified restrictive soil, geologic or hydraulic layer.

(ii) Determine the vertical rate and the horizontal rate of flow in or above the restrictive layers in inches per hour.

(iii) Determine the application rate required as derived from the information contained in subparagraphs (i) and (ii). When this application rate is more stringent than that derived from percolation testing, as contained in Chapter 73, the more stringent rate shall be used to size the system.

(iv) Determine the impact of the system on groundwater mounding.

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Regulatory Framework

§71.62. Individual and community onlot sewage systems

(c) (2) A preliminary hydrogeologic evaluation is required when the use of subsurface soil absorption areas is proposed and one of the following exists:

(i) A large volume onlot sewage system will be used.

(ii) A subdivision of more than 50 equivalent dwelling units with a density of more than one equivalent dwelling unit per acre is proposed.

(iii) The Department has documented that the quality of water supplies within 1/4 mile of the proposed site exceed five parts per million (ppm) nitrate-nitrogen.

(iv) The Department has determined that known geological conditions for the proposed site may contribute to the potential for groundwater pollution from the systems.

(v) The municipality requires it through ordinance.

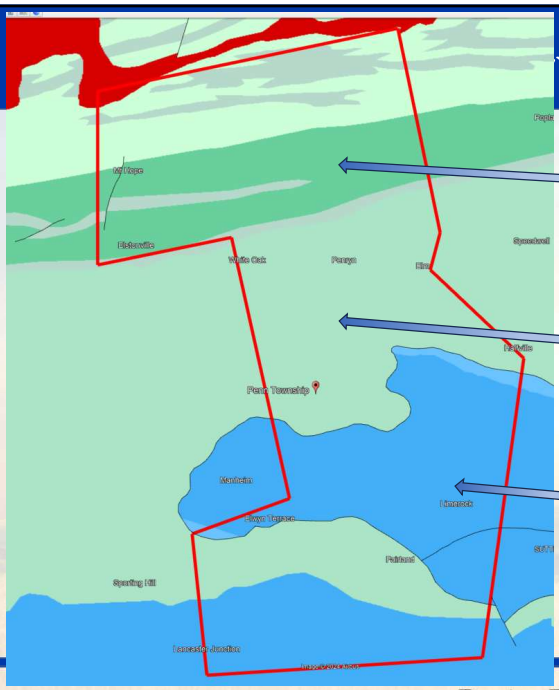
Regulatory Framework

(v) The municipality requires it through ordinance.

Penn Township, Lancaster County
§ 18-206Sewage Testing and Hydrogeologic Studies Required for All Proposed Lots.
[Ord. 2004-06, 10/25/2004, § 6]

All planning modules for land development except planning modules for land development which propose sewer service by means of a public sewer service provider sewer system shall be accompanied by hydrogeologic tests performed in accordance with all applicable DEP regulations. The Township shall not approve any planning module for land development which does not contain hydrogeologic studies which demonstrate that the proposed sewage disposal facilities will not adversely affect the groundwater or that measures will be utilized, such as dispersion plume easements, which will address the impacts of the proposed sewage disposal facilities.

y Framework



Trn: New Oxford Formation Light-gray to buff, commonly arkosic sandstone interbedded with red shale, mudstone, and fine-grained sandstone.

Oco: Cocalico Formation Gray phyllitic shale, maroon shale, siltstone, and silty, siliceous shale; some interbedded argillaceous and quartzose sandstone.

Oe: Epler Formation Very finely crystalline, light-gray limestone interbedded with gray dolomite.

Evaluation Requirements

§71.62. Individual and community onlot sewage systems

(c)(3) A preliminary hydrogeologic evaluation shall include as a minimum, in map and narrative report form:

(i) The topographic location of the proposed systems in relation to groundwater or surface water flow, or both.

(ii) Estimated wastewater dispersion plume using an average daily flow of 262.5 gallons per equivalent dwelling unit per day or other flow supported by documentation.

(iii) Identification and location of existing and potential groundwater uses in the estimated area of impacted groundwater.

(iv) Prepared and signed by a licensed Professional Geologist

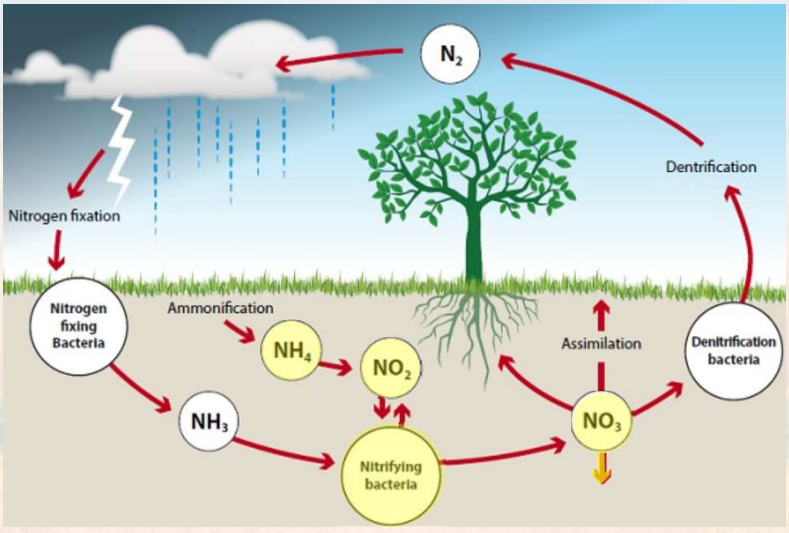
Evaluation Requirements

Contaminants of Concern

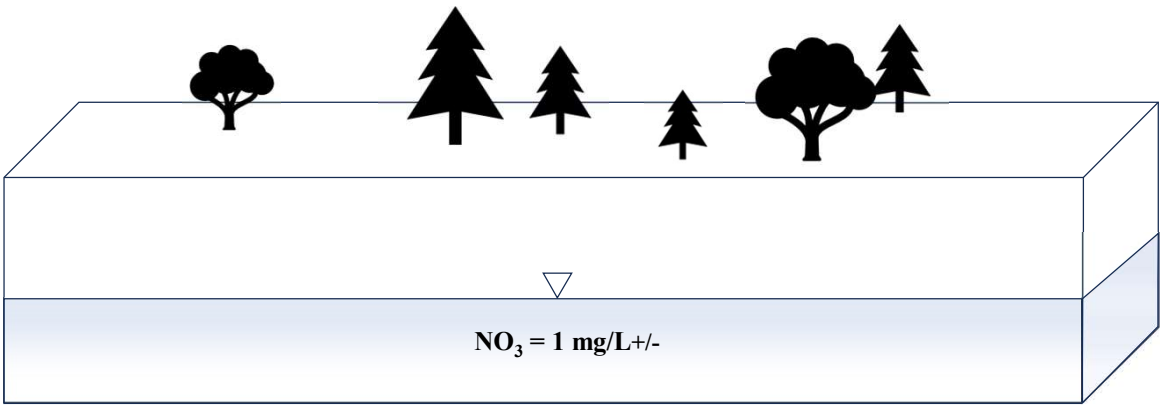
Nitrate-nitrogen (NO_3) – EPA maximum contaminant level 10 mg/L (ppm)

and ??????

Nitrogen Cycle

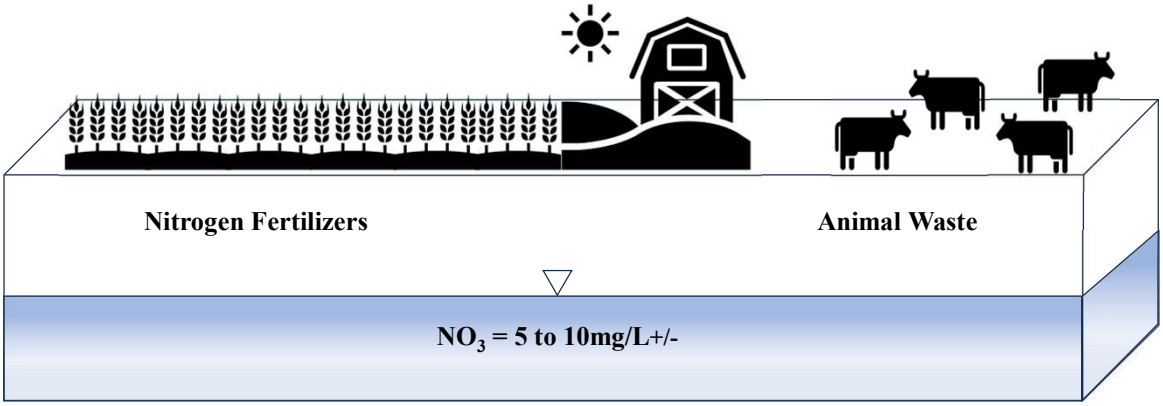


Nitrate-Nitrogen Plume Analysis



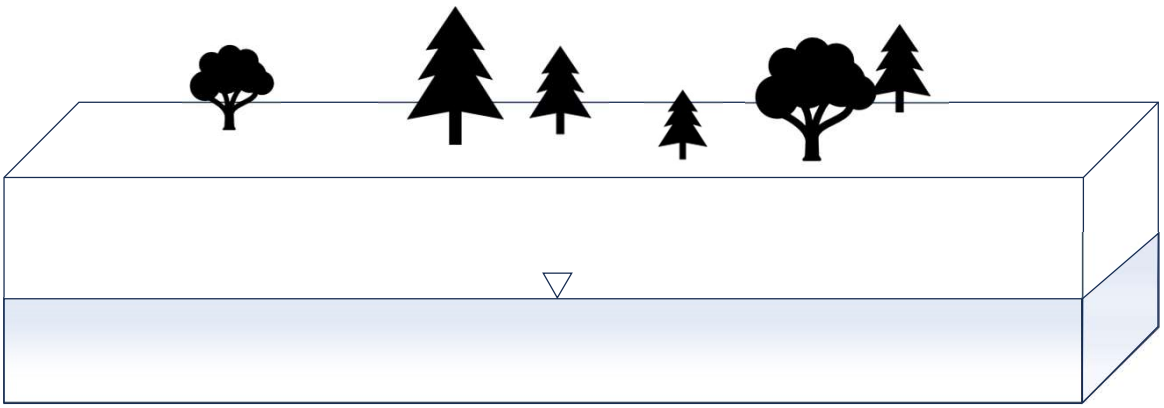
BACKGROUND CONDITIONS

Nitrate-Nitrogen Plume Analysis



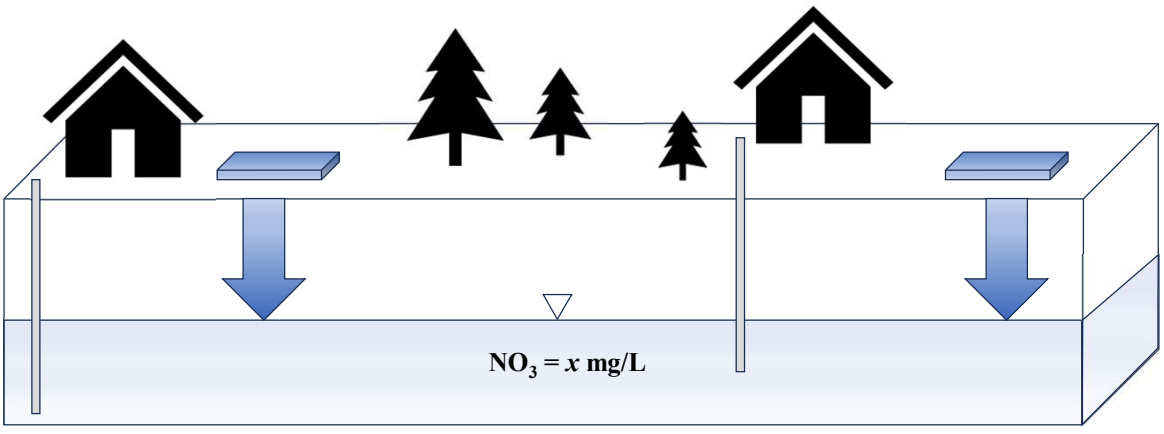
BACKGROUND CONDITIONS

Nitrate-Nitrogen Plume Analysis



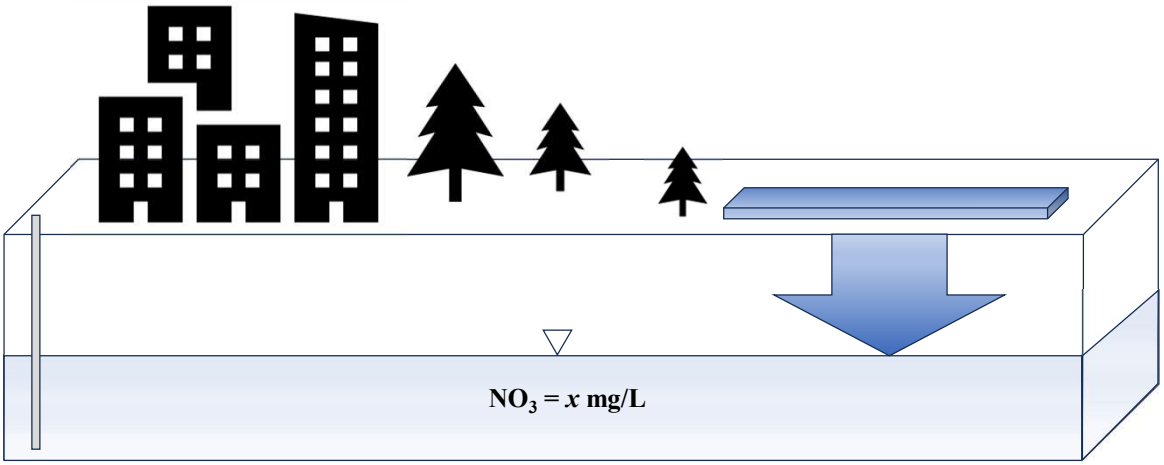
BACKGROUND CONDITIONS

Nitrate-Nitrogen Plume Analysis



DEVELOPMENT CONDITIONS

Nitrate-Nitrogen Plume Analysis



DEVELOPMENT CONDITIONS

Nitrate-Nitrogen Plume Analysis

WHAT IS HAPPENING?

Mixing a volume of effluent at a certain nitrate concentration with a volume of groundwater at a certain nitrate concentration

WHY DO WE CARE?

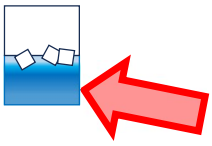
Nitrate-nitrogen at concentrations >10 mg/L are a potential health risk to infants

Nitrate-Nitrogen Plume Analysis

Final Concentration =

$$\frac{(\text{Volume1} \times \text{Concentration1}) + (\text{Volume2} \times \text{Concentration2})}{\text{Volume1} + \text{Volume2}}$$

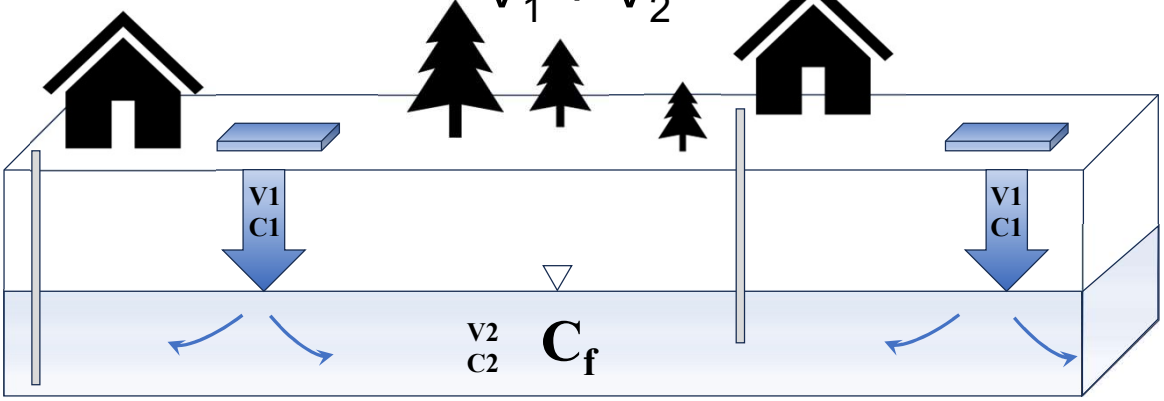
Nitrate-Nitrogen Plume Analysis



$$C_f = \frac{(V_1 \times C_1) + (V_2 \times C_2)}{V_1 + V_2}$$

Nitrate-Nitrogen Plume Analysis

$$C_f = \frac{(V_1 \times C_1) + (V_2 \times C_2)}{V_1 + V_2}$$



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Nitrate-Nitrogen Plume Analysis

Volume1 = average daily effluent flow (gpd)

Concentration1 = nitrate concentration in effluent (mg/L)

Volume2 = average daily groundwater recharge (gpd)

Concentration2 = nitrate concentration in groundwater (mg/L)

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Nitrate-Nitrogen Plume Analysis

Volume1 = average daily effluent flow (gpd)
1 EDU = 262.5 gpd

Use **total <u>average</u>** daily flow

Example:
10 lot subdivision = 2625 gpd

Nitrate-Nitrogen Plume Analysis

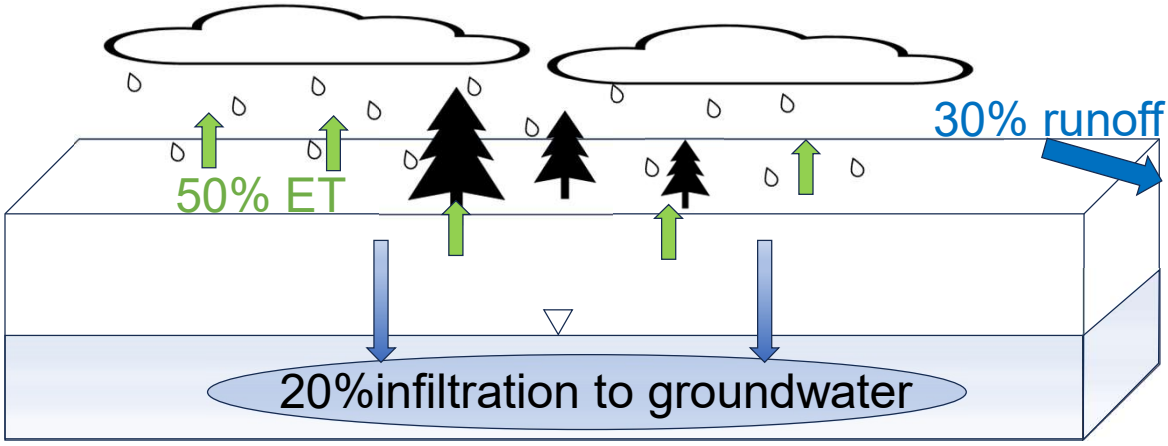
Concentration 1 = nitrate concentration in effluent (mg/L)

Septic tank effluent
45 mg/L

Advanced treatment examples
20 mg/L Orenco
5 mg/L MBR

Nitrate-Nitrogen Plume Analysis

Volume2 = average daily groundwater recharge



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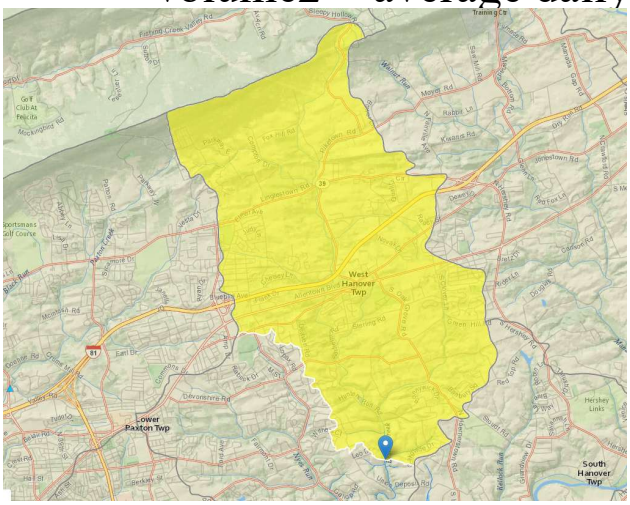
Nitrate-Nitrogen Plume Analysis

Volume2 = average daily groundwater recharge



PA StreamStats
https://streamstats.usgs.gov/

16.8 square miles

Mean annual flow = 20.7 ft^3/second

1,250 gpd/acre recharge

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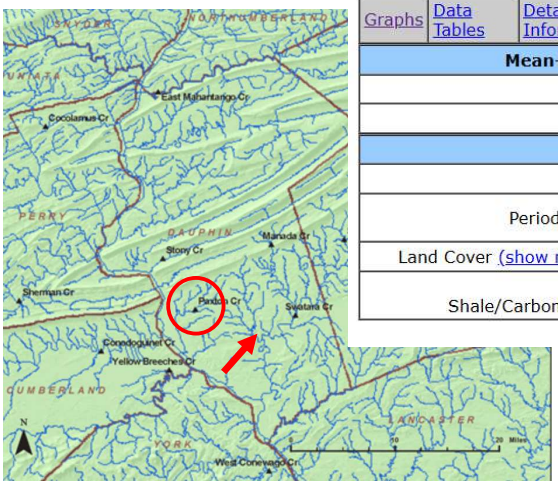
Nitrat

Volume2



Estimates of Mean-Monthly & Annual Ground-Water Recharge

Paxton Creek near Penbrook: 01571000

Available Options							
Graphs	Data Tables	Detailed Station Information	Land Use Map	Geology Map	Back to county map	Back to state map	Main Page

Mean-Annual Recharge Estimates for Period of Record, in inches	
From Recession Curve Displacement (RORA) Method	13.3
From Hydrograph Separation of Baseflow (PART) Method	10.4

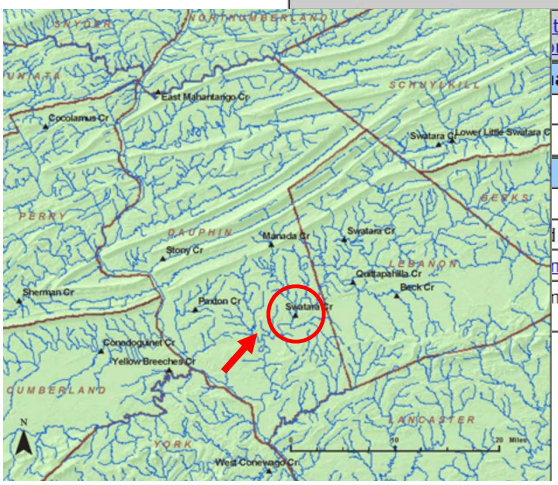
Basin Characteristics	
Drainage Area (square miles)	11.2
Period of Record Used for Estimating Recharge (calendar year)	1941-49; 1985-87; 1992-94
Land Cover (show map) (Forest/Agriculture/Developed/Other) as % of Area	32.6/29.1/37.9/0.3
Rock Types (show map) (Sandstone and Shale/Carbonate/Crystalline/Unconsolidated Sediments) as % of Area	87.8/12.1/0/0

13.3 inches/year

870 gpd/acre recharge

Nitr

Volum



Estimates of Mean-Monthly & Annual Ground-Water Recharge

Swatara Creek near Hershey: 01573560

Available Options						
tation n	Land Use Map	Geology Map	Back to county map	Back to state map	Main Page	

al Recharge Estimates for Period of Record, in inches	
From Recession Curve Displacement (RORA) Method	17.3
From Hydrograph Separation of Baseflow (PART) Method	14.0

Basin Characteristics	
Drainage Area (square miles)	483
l of Record Used for Estimating Recharge (calendar year)	1976-2001
map) (Forest/Agriculture/Developed/Other) as % of Area	45.4/46.8/5.3/2.4
ndstone and Shale/Carbonate/Crystalline/Unconsolidated Sediments) as % of Area	85.6/12.9/1.4/0

17.3 inches/year

1,280 gpd/acre recharge

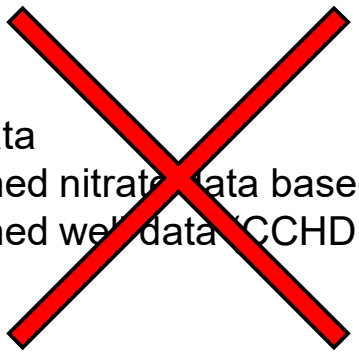
Nitrate-Nitrogen Plume Analysis

Concentration2 = nitrate concentration in groundwater (mg/L)

- Use existing data
  - Published nitrate data based on land use
  - Published well data (CCHD database)
- Sample existing wells
  - On-site vs. off-site
- Drill and sample new wells
  - Where and how many?

Nitrate-Nitrogen Plume Analysis

Concentration2 = nitrate concentration in groundwater (mg/L)



- Use existing data
  - Published nitrate data based on land use
  - Published well data (CCHD database)

Nitrate-Nitrogen Plume Analysis

Concentration2 = nitrate concentration in groundwater (mg/L)

- **Sample existing wells**

Small subdivisions (< 10 lots)

On-site better than off-site

Reliability is affected by the well's location relative to the proposed absorption area(s)

Collect sample ahead of any treatment systems

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Nitrate-Nitrogen Plume Analysis

Concentration2 = nitrate concentration in groundwater (mg/L)

- **Drill and sample new wells**

New wells are typically drilled to "first" water

Sample and analyze for NO_3

Locations selected to be representative of the recharge area

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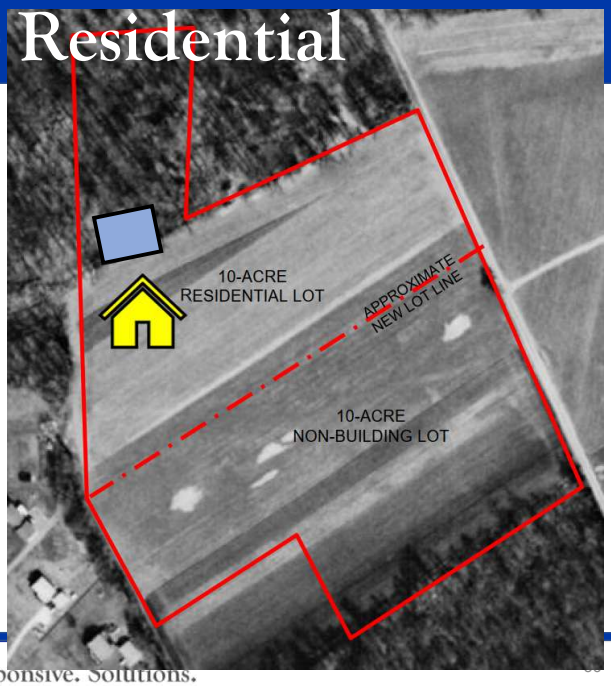
Case Studies

- Residential single-family house
- Large volume system
- Commercial subdivision

Case Study - Residential

Single, 10-acre residential lot subdivided from a 20-acre non-building lot

Preliminary hydro required because Chester Co. database documents water supplies with NO_3 concentrations > 5 mg/L within ¼ mile



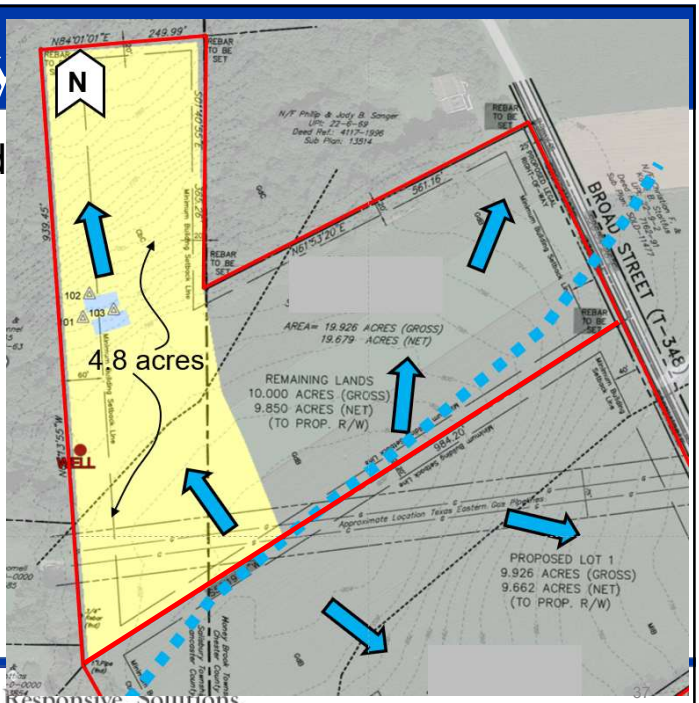
Case Study

Volume1 = 262.5 gpd

Concentration1 = 45 mg/L

Volume2 = 3960 gpd
(825 gpd/acre X 4.8 acres)

Concentration2 = 5 mg/L
(from sample of existing on-site agricultural well)



Nitrate-Nitrogen Plume Analysis

$$C_f = \frac{(V_1 \times C_1) + (V_2 \times C_2)}{V_1 + V_2}$$

$$\frac{(265.5 \text{ gpd} \times 45 \text{ mg/L}) + (3960 \text{ gpd} \times 5 \text{ mg/L})}{262.5 \text{ gpd} + 3960 \text{ gpd}} = 7.5 \text{ mg/L}$$

7.5 mg/L < 10 mg/L **PASS**

Reporting

From Component 2 Instructions:

The following information is to be submitted on a copy of the topographic map of the area and in narrative form:

a. Results of background sampling for total coliform, fecal coliform, pH, and nitrate-nitrogen.

b. If as a part of a Preliminary Hydrogeologic Study a well is drilled to assess the background nitrate-nitrogen concentrations in the shallow groundwater, the hydrogeologist shall provide a log of the well or wells. The log or logs shall provide the date of drilling, total well depth, depth to bedrock, depth to bottom of casing, depth to all water bearing zones, and the static water level. The well logs do not need to be graphical. In addition, the report should contain a discussion of the well purging protocol used prior to well sampling. The protocol must assure that a fresh sample is obtained from the shallow aquifer.

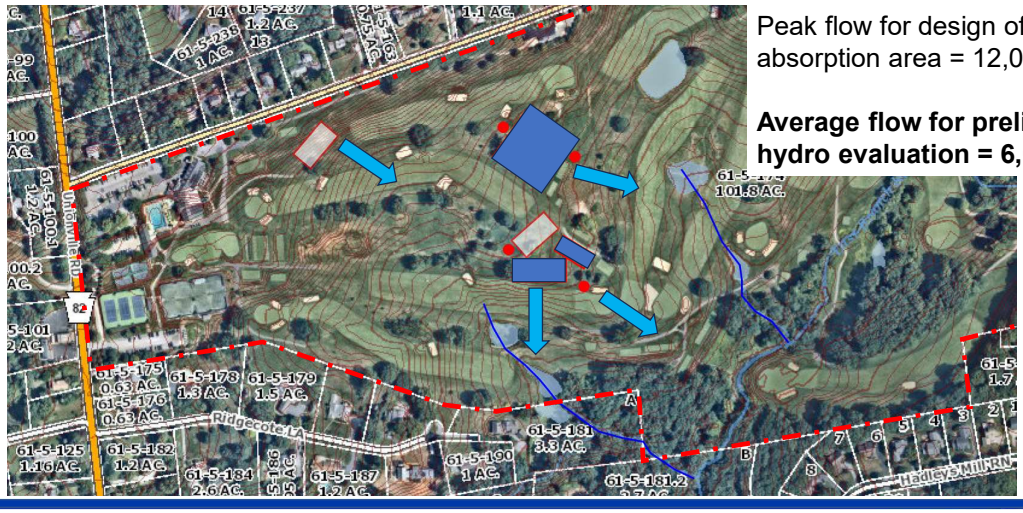
c. Topographic location of the proposed system(s).

d. Estimated area of impacted groundwater (dispersion plume and mixing zone within the dispersion plume) calculated from the surface topography and known geologic conditions.

e. Identification of existing and potential groundwater uses within the dispersion plume.

Case Study – Large Volume #1

Country Club - Existing systems installed without a permit and without proper planning



Peak flow for design of absorption area = 12,000 gpd

Average flow for preliminary hydro evaluation = 6,000 gpd

Case Study – Large Volume #1

Discharge to on-site streams = no off-site groundwater impacts

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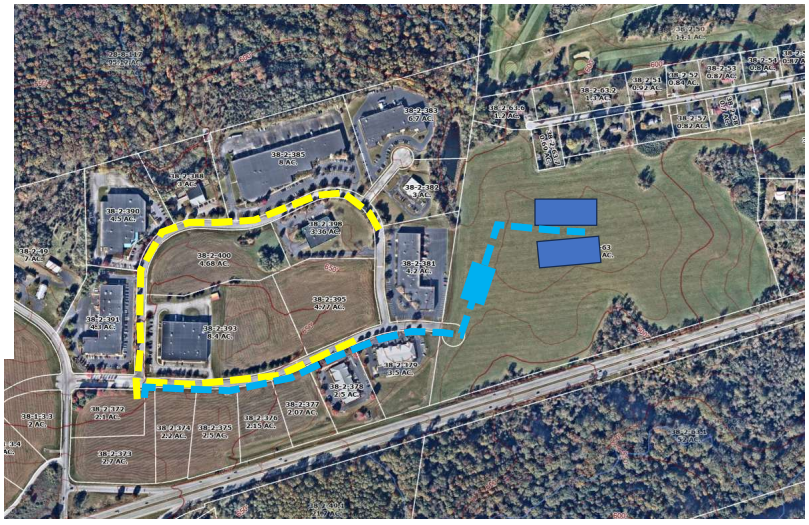
Case Study – Large Volume #2

18-Lot Office Park

Peak flow = 16,000 gpd

Preliminary hydro required because flow >10,000 gpd

Average flow for preliminary hydro evaluation = 8,000 gpd



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Case Study – Large Volume #2

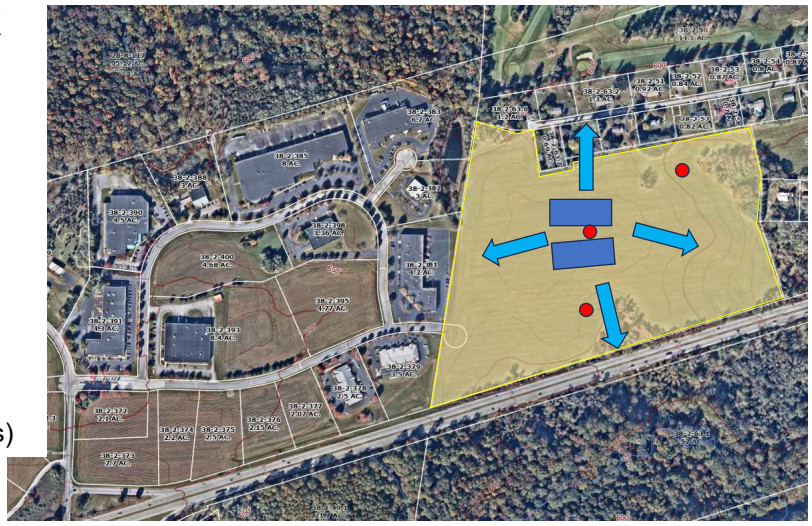
18-Lot Office Park

Volume1 = 8,000 gpd
average flow

Concentration1 = 45 mg/L
septic tank effluent

Volume2 = 52,500 gpd
(1250 gpd/acre x 42 acres)

Concentration2 = 4.2 mg/L
(average NO_3 from 3 new wells)



Nitrate-Nitrogen Plume Analysis

$$C_f = \frac{(V_1 \times C_1) + (V_2 \times C_2)}{V_1 + V_2}$$

$$\frac{(8{,}000 \text{ gpd} \times 45 \text{ mg/L}) + (52{,}500 \text{ gpd} \times 4.2 \text{ mg/L})}{8{,}000 \text{ gpd} + 52{,}500 \text{ gpd}} = 9.6 \text{ mg/L}$$

9.6 mg/L < 10 mg/L **PASS**

Case Study - Commercial

Proposed 2-lot office/warehouse subdivision of 12 acres

Wells within ¼ mile NO_3 > 5 mg/L

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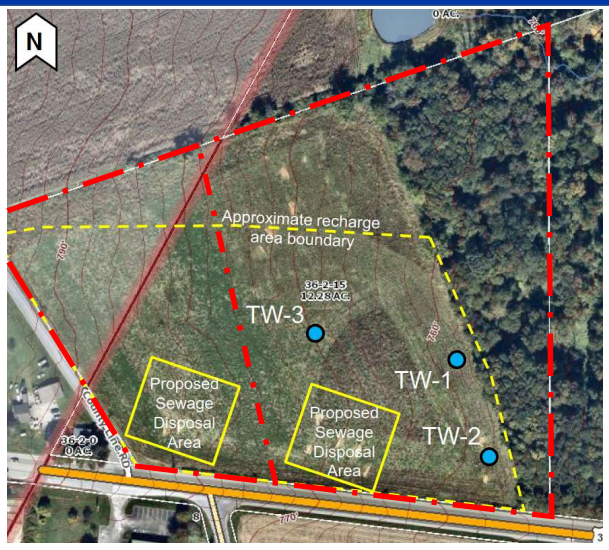
Case Study - Commercial

No existing wells on the property. Drilled 3 temporary well points, collected 3 samples

TW-1 17 mg/L
TW-2 12 mg/L
TW-3 10 mg/L

Average = 13 mg/L



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Case Study - Commercial

Volume1 = 525 gpd

Concentration1 = 45 mg/L

Volume2 =10,000 gpd
(1250 gpd/acre X 8 acres)

Concentration2 = 13 mg/L
(average from temp wells)

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Nitrate-Nitrogen Plume Analysis

$$C_f = \frac{(V_1 \times C_1) + (V_2 \times C_2)}{V_1 + V_2}$$

$$\frac{(525 \text{ gpd} \times 45 \text{ mg/L}) + (10000 \text{ gpd} \times 13 \text{ mg/L})}{525 \text{ gpd} + 10000 \text{ gpd}} = 14.6 \text{ mg/L}$$

14.6 mg/L > 10 mg/L **FAIL**

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Nitrate-Nitrogen Plume Analysis

Advanced Treatment?
Orenco treats to 20 mg/L

$$C_f = \frac{(V_1 \times C_1) + (V_2 \times C_2)}{V_1 + V_2}$$

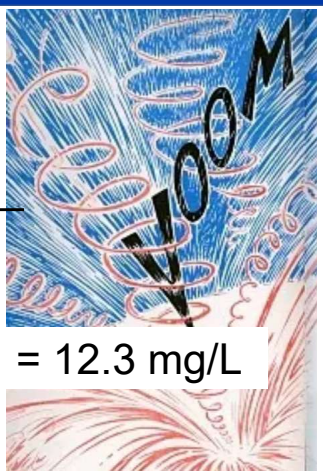
$$\frac{(525 \text{ gpd} \times \textbf{20 mg/L}) + (10000 \text{ gpd} \times 13 \text{ mg/L})}{525 \text{ gpd} + 10000 \text{ gpd}} = 13.3 \text{ mg/L}$$

13.3 mg/L > 10 mg/L **FAIL**

Nitrate-Nitrogen Plume Analysis

Super Advanced Treatment?
0 mg/L

$$C_f = \frac{(V_1 \times C_1) + (V_2 \times C_2)}{V_1 + V_2}$$



$$\frac{(525 \text{ gpd} \times \textbf{0 mg/L}) + (10000 \text{ gpd} \times 13 \text{ mg/L})}{525 \text{ gpd} + 10000 \text{ gpd}} = 12.3 \text{ mg/L}$$

12.3 mg/L > 10 mg/L **FAIL**

Nitrate-Nitrogen Plume Analysis

Options if the plume analysis results in >10 mg/L NO_3

Reduce $\mathbf{V_1}$ by reducing the number of lots/EDUs

AND/OR

Eliminate $\mathbf{V_1}$ by installing holding tanks or connecting to public sewer

AND/OR

Reduce $\mathbf{C_1}$ by using advanced treatment

AND/OR

Increase $\mathbf{V_2}$ by recharge easements/relocating absorption areas

Nitrate-Nitrogen Plume Analysis

Options if the plume analysis results in >10 mg/L NO_3

Prepare a Detailed Hydrogeologic Study per §71.62(c)(4).

Detailed hydrogeologic studies may be required by the Department when the preliminary hydrogeologic evaluation identifies a potential for a conflict between the proposal and existing or potential future uses of groundwater in the area. Detailed hydrogeologic studies shall identify constituents of the sewage which may pollute groundwater and shall evaluate methods for preventing the pollution of the waters of this Commonwealth. A detailed hydrogeologic study shall be submitted using the Department's sewage facilities planning module.

Summary

Preliminary Hydrogeological Evaluations are required by the PADEP or municipalities:

- for large volume systems
- for subdivisions of more than 50 lots with a density greater than 1 EDU per acre
- for subdivisions where documented NO_3 concentrations are >5 mg/L within ¼ mile
- in areas where geologic conditions exist that make groundwater pollution more likely
- just because

Summary

Preliminary Hydrogeological Evaluations estimate final groundwater NO_3 concentrations using:

- Total average daily flow (gpd)
- Effluent NO_3 concentration (mg/L)
- Average daily rainfall recharge in the drainage area (gpd)
- NO_3 concentration in groundwater (mg/L)

Summary

Preliminary Hydrogeological Evaluations support approval of new onlot sewage disposal systems if the resulting NO_3 concentration is:

- Less than 10 mg/L

Summary

Hire a PA-Licensed Professional Geologist

Coordinate with the PADEP Regional Hydrogeologist

QUESTIONS/DISCUSSION

Newtown Square, PA
38 Bishop Hollow Rd.,
Suite 200
Newtown Square, PA 19073
Phone: 610-325-5570

West Chester, PA
515 S. Franklin St.
West Chester, PA 19382
Phone: 610-692-577

Mechanicsburg, PA
4600 Lena Dr.,
Suite 201
Mechanicsburg, PA 17055
Phone: 717-508-0589

Ashland, VA
9560 Kings Charter Dr.
Ashland, VA 23005
Phone: 804-550-9200

Lehigh Valley, PA
3101 Emrick Blvd.,
Suite 201
Bethlehem, PA 18020
Phone: 610-248-7625

Columbia, MD
9175 Guilford Rd.,
Suite 310
Columbia, MD 21046
Phone: 410-290-7775

Marlton, NJ
11 Eves Dr.
Marlton, NJ 08053
Phone: 717-250-5581

State College, PA
2548 Park Center Blvd.
State College, PA 16801
Phone: 814-272-0455

Pittsburgh, PA
171 Hillpointe Dr.,
Suite 302
Canonsburg, PA 15317
Phone: 724-743-5793

Jessup, PA
1252 Mid Valley Dr.
Jessup, PA 18434
Phone: 570-489-8717

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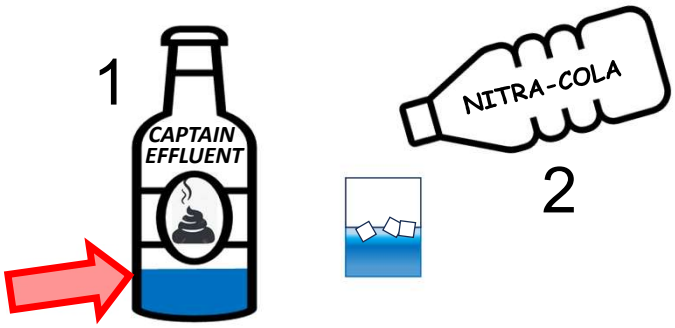
Engineers and Scientists

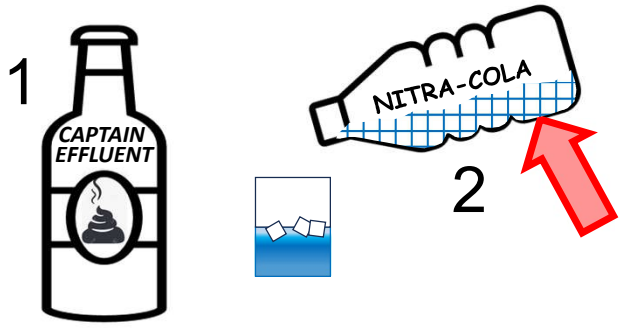
Precise. Responsive. Solutions.

Nitrate-Nitrogen Plume Analysis



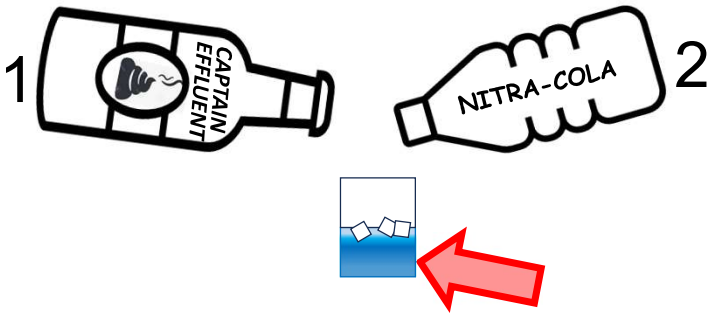
$$V_1 = \frac{V_2 \times (C_2 - C_f)}{C_f - C_1}$$

Nitrate-Nitrogen Plume Analysis



$$C_2 = \frac{(V_1 + V_2)C_f - V_1C_1}{V_2}$$

Nitrate-Nitrogen Plume Analysis



$$C_f = \frac{(V_1 \times C_1) + (V_2 \times C_2)}{V_1 + V_2}$$