A Brief Summary of the Delaware Valley College Research and Demonstration Center for On-Lot Sewage Systems Project

NOWRA CONFERENCE
2024

Joseph A. Valentine
VW Consultants, LLC

Disclaimer

The materials being presented here are the opinion of the presenter and do not reflect the opinions of NOWRA.

RESEARCH AND DEMONSTRATION CENTER
ON-LOT SYSTEMS AND SMALL FLOW TECHNOLOGIES
DELAWARE VALLEY COLLEGE
DOYLESTOWN, PA

Project Funding Provided by:
Pennsylvania Dept. of Environmental Protection

Phase I

Request for Proposal

Identify Six Technologies used in the USA or the world and determine their effectiveness for use in PA

- Research information and consolidate data on existing technologies used in USA and other countries.
- Select 6 technologies which have application to PA climate, geology and soil.
- Construct full scale installations with three replicates of each technology.

Background

- Evaluate and sample the installations for three years in Phase I and three years in Phase II.

- Develop a final report with conclusions on systems applicability to PA soils, climate and geology. Reports are posted on the PADEP Web site

Technologies Selected

1. Constructed wetlands
2. Community at-grade system using sand filter pretreatment
3. Septic tank geometry and compartments
4. Media Filters: pressure sand filter; Gravity sand filter; Recirc Sand Filter; Up-flow sand filter

Technologies Selected

5. Shallow limiting zone at-grade systems

6. Drip irrigation

Renovation Thickness-Control Technology

Septic tank effluent applied to a DEP at-grade system on a soil with no LZ to 72 inches

Phase I

Technology A

Constructed Wetlands

Two Cell Wetland

Two cell wetland system. Each cell is approximately 17 feet by 17 feet. Designed for 400 gallons per day, the cell in the foreground is the infiltration cell and the cell in the background is the treatment cell.

WL Cell 1 Lined

Treatment cell in foreground is completely lined with 20 mil PVC liner.

WL Cell 2 Infiltration

Second cell is an infiltration cell. It is lined only along the edges. The bottom is open. The infiltration cell is filled with aggregate.

WL Cell 1 and 2

Here the first cell has now been filled with aggregate and the second cell has a mulch layer over the aggregate and is ready for planting.

Finished WL Treatment Cells

System ready for planting. Effluent enters first cell from septic tank and is distributed by a header pipe buried along the full length of the first cell. The effluent then travels horizontally through the cell and into the second infiltration cell by way of the concrete flow control box in the center of the photo.

Phase I

Technology B

Re-circulating sand filter
to a sloping at-grade community system servicing three houses on a deep, moderately well drained soil.

Three residences including the college President residence

TECHNOLOGY B - DENITRIFICATION SAND FILTER WITH AT- GRADE PRESSURE DISTRIBUTION

Septic tank in foreground sends effluent to rock filter tank (left background). From rock filter tank effluent is pumped to sand filter tank (right background) for nitrification then back to rock filter tank for denitrification.

.

TECHNOLOGY B - DENITRIFICATION SAND FILTER WITH AT- GRADE PRESSURE DISTRIBUTION

Close up of unit used to make ridges and furrows in the bed.

TECHNOLOGY B - DENITRIFICATION SAND FILTER WITH AT- GRADE PRESSURE DISTRIBUTION

Another view of bed after ridges and furrows have been made on contour.

TECHNOLOGY B - DENITRIFICATION SAND FILTER WITH AT- GRADE PRESSURE DISTRIBUTION

Here stone is being placed on a prepared bed.

TECHNOLOGY B: SLOPING AT- GRADE PRESSURE DISTRIBUTION

Pressure distribution pipe within bed area.

Phase I

Technology C: Septic Tanks

- 1000 gal. Single Compartment Round
- 1000 gal. Single Compartment Rectangular
- 1500 gal. Dual Compartment Rectangular
- Two 1000 gal. round tanks in series

Phase I

Technology C: Sand Filter Bank

-Two Tank Recirc. Sand Filter with anoxic zoned for nitrogen removal

- Single Pass Sand Filter (pressure)

- Single Pass Sand Filter (gravity)

- Up Flow Sand Filter

TECHNOLOGY C - SAND FILTER BANK

Construction of different types of sand filters for effluent treatment.

TECHNOLOGY C - SAND FILTER BANK

Sampling box for sand filters being installed in foreground.

Phase I

Technology D

Single pass sand filter (pressure dosed) effluent to an at-grade system on a deep, somewhat poorly drained soil.

Redox depletions at 10 inches

TECHNOLOGY D - SOMEWHAT POORLY DRAINED SOIL WITH SAND FILTER EFFLUENT AND AT GRADE PRESSURE DISTRIBUTION

Stone being placed in bed. Bed construction similar to Technology B.

TECHNOLOGY D - SOMEWHAT POORLY DRAINED SOIL WITH SAND FILTER EFFLUENT AND AT GRADE PRESSURE DISTRIBUTION

Beds are time dosed as opposed to demand dosed. Time of day and amount of dose can be adjusted with this controller. Currently beds are dosed four times per day at 70 gallons per dose.

TECHNOLOGY D - SOMEWHAT POORLY DRAINED SOIL WITH SAND FILTER EFFLUENT AND AT GRADE PRESSURE DISTRIBUTION

Completed beds on somewhat poorly drained soils. Three beds have been constructed on this wooded site.

Phase I

Technology E

Single pass sand filter (pressure) to a drip dispersal system on a deep, moderately well drained soil.

26 inches to redox depletions

TECHNOLOGY E - DRIP OR TRICKLE IRRIGATION

Installation of drip irrigation tubing using vibratory plow. Site receives **400 gallons per day** sand filter effluent. Emitters occur every two feet in tubing. System doses 10 times per day. Three systems have been constructed

TECHNOLOGY E - DRIP OR TRICKLE IRRIGATION

Tubing has been installed over one site. Look closely and you can see ends of tubing still to be connected in the foreground of picture. Minimal site disturbance during installation.

TECHNOLOGY E
DRIP IRRIGATION

Controller being installed for drip irrigation system.

Phase I

Renovation Thickness-Control Technology

Septic tank effluent applied to an at-grade system on a deep, well-drained soil

No redox depletions to 72+ inches

Experimental Control: Renovative thickness

All other technology results compared to the results of this labeled Tech F in data and report

TECHNOLOGY F - WELL DRAINED SITE WITH AT GRADE PRESSURE DISTRIBUTION

Site receives septic tank quality effluent. Bed construction shown in the photo. Three beds were constructed.

Site Testing

- Soils were evaluated using backhoe excavated test pits.
- Soils were described and sampled by the staff of the USDA-NRCS (Ed White, John Chirbirka) and Dr. Robert Cunningham (retired) Penn State University.
- Percolation tests and hydraulic conductivity tests were performed by the staff of DelVal Soil and Delaware Valley College.

PERMEABILITY TESTING FOR EACH SITE INCLUDED BOTH PERCOLATION TESTING AND HYDRAULIC CONDUCTIVITY TESTING. HERE SITE D IS BEING TESTED.

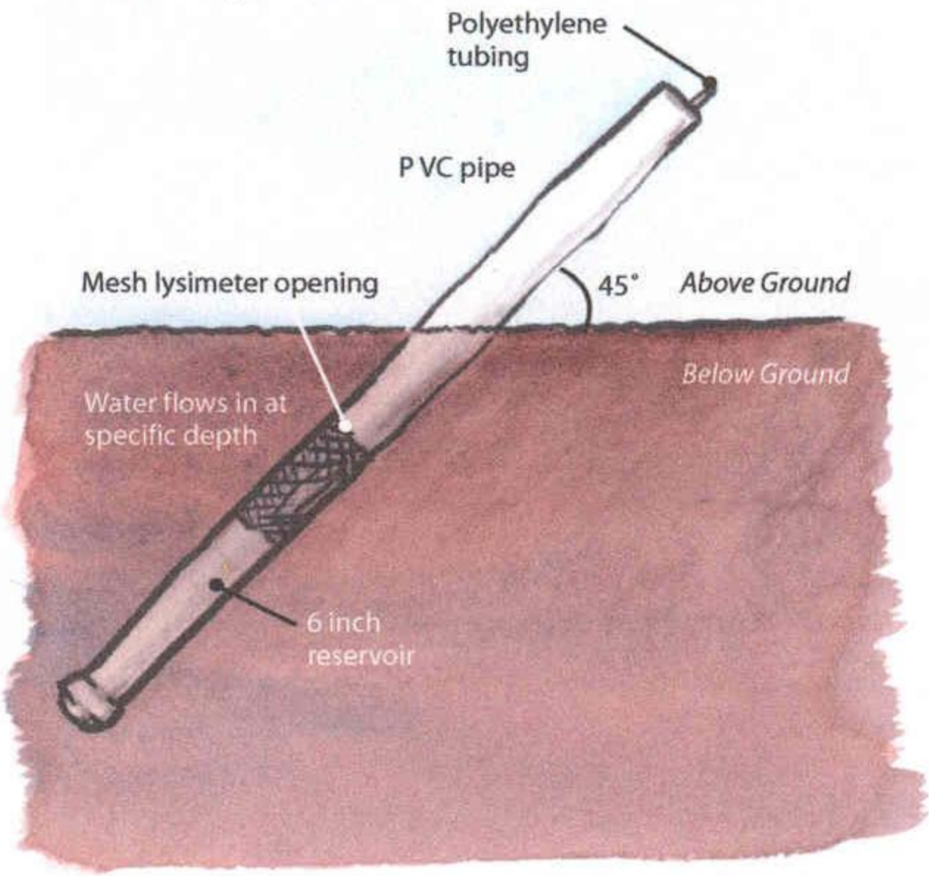
Flow Amount and Sampling

- At-grade absorption areas were constructed and dosed with effluent at 400 gpd.
- Gravity lysimeters were installed at 1, 2, 3 and 4 feet below the ground surface (two nests at each bed location)
- Lysimeters were sampled monthly for three years and analyzed for:
  - Nitrogen Series
  - Total Phosphorous
  - Fecal Coliform
  - Fecal Strep
  - Total Organic Carbon

Water Quality Testing

Lysimeters – groupings of pipes cut to varying lengths to reach different soil depths – allow samples to be extracted easily and in a controlled way. The samples are tested for harmful bacteria levels.

Anatomy of a Lysimeter



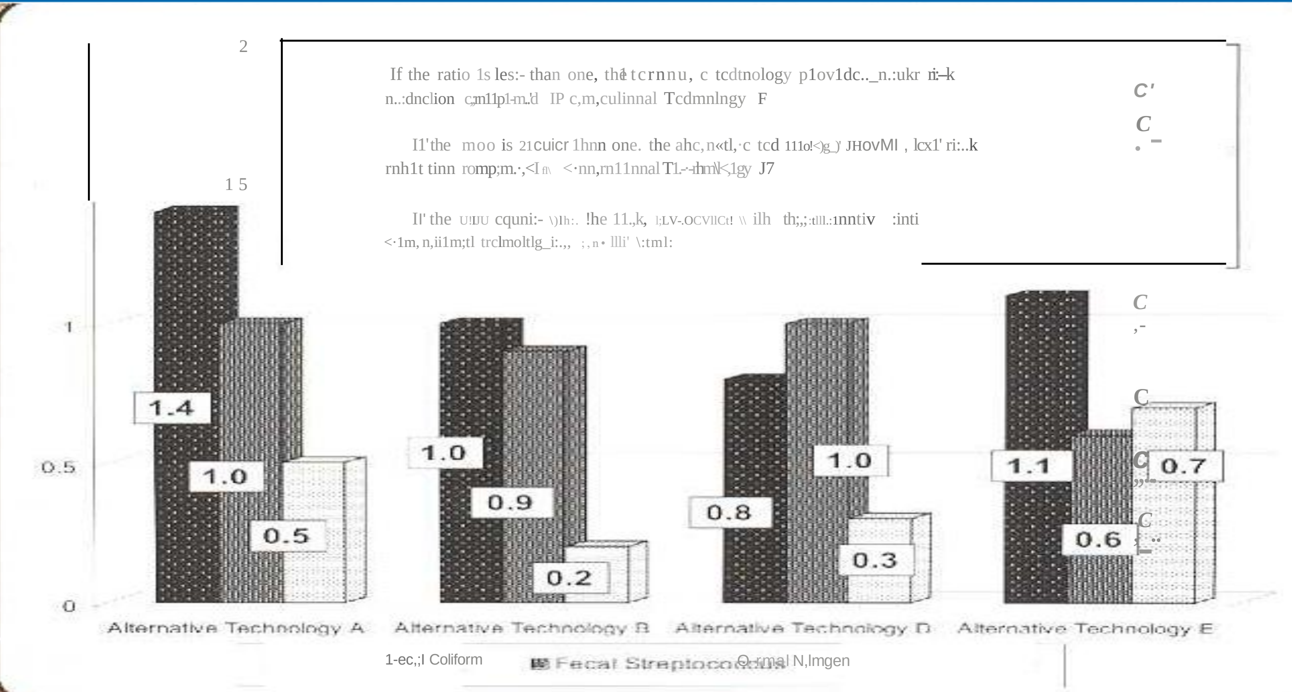
Lysimeters in the Field

SAMPLING

Installation of zero tension lysimeters at one, two, three, and four feet beneath the beds. All beds have two lysimeters at each depth.

RISK COMPARISOM OF PHASE I TECHNOLOGIES

Relative Hazard Ratios for Biological and Chemical Parameters
Technologies A, B, D, E, & F



Benchmarks
Fecal coliform > 200 mpn/100mL
Fecal streptococcus > 200 mpn/100mL
Total Nitrogen > 24mg/L
Total Phosphorous > 1 mg/L

A relative hazard ratio for comparative risk evaluation of five of the on-lot systems was computed. Data from Technology A and from the four foot lysimeters installed in Technologies B, D, E, and F are used for comparison.

Excedence frequencies for fecal coliform and fecal strep bacteria, using 200 bacteria/100mL as the reference base, were computed for each system. Excedence frequencies for total nitrogen, using 24mg/l (level of Technology F), were computed for each system.

Excedence frequencies are calculated by computing the number of months the baseline (200 bacteria or 24mg/l TN) is exceeded, and dividing by the total number of months with available data. Excedence frequency of experimental technologies A, B, D, or E is then divided by the excedence frequency of the conventional technology (Technology F) to calculate a relative hazard ratio.

One Example of Phase I Results Tech D vs Tech F

Tech D

Sand filter effluent to a somewhat poorly drained soil 10 inch limiting zone at rate of .08 gal/ft^2

@ 4 ft depth ave. 1025 mpn/100 ml

Tech F

Septic tank effluent to a well-drained soil 72 inch plus limiting zone at a rate of .5 gal/ft^2

@ 4 ft depth ave. 13,333 mpn/100 ml

PHASE II TECHNOLOGIES

Tech A – Constructed Wetlands – somewhat poorly drained soil with a serial distribution to an at-grade bed

Tech B – Recirculation Sand Filter/Denitrification System with at-grade soil absorption – moderately well drained soil

Tech D – Intermittent sand filter with time dosed surface drip irrigation – somewhat poorly drained soil

Tech E – Septic tank effluent with subsurface drip irrigation – moderately well drained soil

PHASE II TECHNOLOGIES

Tech F – Septic tank effluent with timed dosed soil distribution and modification of lateral design – well drained soil

Community Systems 2000 gpd– Septic tank effluent with subsurface drip irrigation – somewhat poorly drained soil

- Aerated Turf
- Non-aerated Turf
- Crops
- Pasture

Comparison of One Technology Results between Phase I and II-Drip Irrigation

Tech E- Phase I

Sand filter effluent to the drip irrigation fields

@ 122 cm depth 4 ft

<u>geometric mean 220 mpn/100 ml</u>

Tech E- Phase II

Septic tank effluent to the drip irrigation fields

@ 122 cm depth 4 ft

<u>geometric mean 285 mpn/100 ml</u>

General Conclusions

- Placement of systems on the ground surface (at-grade) maximizes the use of the bio-active soil horizons. Better renovation occurs in the surface bio-active zone due to better O_2/CO_2 exchange and a more robust microbial population.
- TSS, BOD and FC reduction by pre-treatment is needed to minimize FC transport through somewhat poorly drained soils with slow permeability.

General Conclusions

- Loading rates well below measured saturated HC is needed to promote unsaturated flow and maximize effluent renovation.
- Placement of effluent on the soil surface vs. subsurface avoids macro pore flow when loading rates are well below measurable K_{sat} promoting unsaturated flow.

General Conclusions

- Aquitards such as fragipans maybe beneficial in restricting FC transport.
- Somewhat poorly drained soils may be utilized for wastewater renovation if the effluent is pre-treated, applied to the soil surface and the loading rates are sufficiently low to promote unsaturated flow.

General Conclusions

- Flush events may transport fecal coliform through the soil profile regardless of soil drainage class.

- The presence of a fragipan or aquitard may minimize flush events through the soil profile to the regional water table.

Phase I and II Reports are available on the PADEP Web Site

https://www.dep.pa.gov/Business/Water/CleanWater/WastewaterMgmt/Act537/OnlotDisposal/Pages/default.aspx

Project Primary Researchers and Advisors

Lawrence Hepner, Jr.-Delaware Valley College

Joseph Valentine and Stephen C. Yates, PE
DelVal Soil & Environmental Consultants

Robert Cunningham, PhD -Penn State University

Milt Lauch, Gary Obleski, Robert Hawley, Karen Fenchak, Susan Weaver -PA DEP

Thank you

Joseph A. Valentine
VW Consultants, LLC
267-784-6873
jvalentine@vw-consultants.com

Questions and Discussion