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ALTERNATIVE ON-LOT TECHNOLOGY RESEARCH • SOIL-BASED TREATMENT SYSTEMS

DELAWARE VALLEY COLLEGE 2005

Alternative On-Lot Technology Research

Soil-Based Treatment Systems

Delaware Valley College
Research and Demonstration Center
for On-Lot Systems and Small Flow Technology

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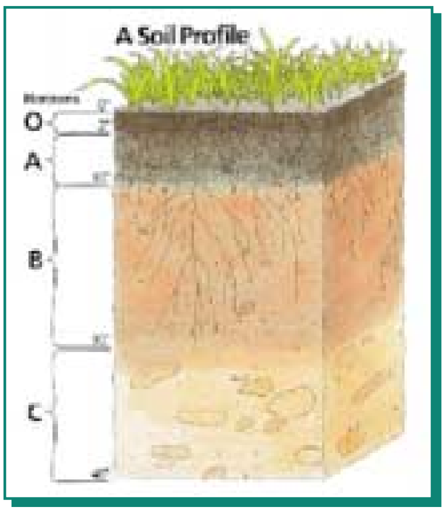
Introduction:

This publication summarizes research conducted on the alternative on-lot wastewater treatment systems installed at Delaware Valley College. The alternative systems studied were a combination of primary, secondary, and soil based components that would be conducive with the climate, geology and soil conditions found throughout Pennsylvania. These systems were installed in a number of different soil types from somewhat poorly drained to well drained and on varying slopes anywhere from 1-24%.

Adjustments were made to conventional system designs in the attempt to improve their effectiveness on non-prime agricultural soils. These changes include the use of the bio-active soil zone or soil horizons close to the surface to renovate the effluent. Effluent was dosed on the A and B-horizons making up the bioactive zone, instead of the C-horizon or area beneath the bioactive zone, as typically used in conventional systems.

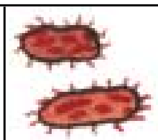
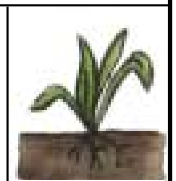


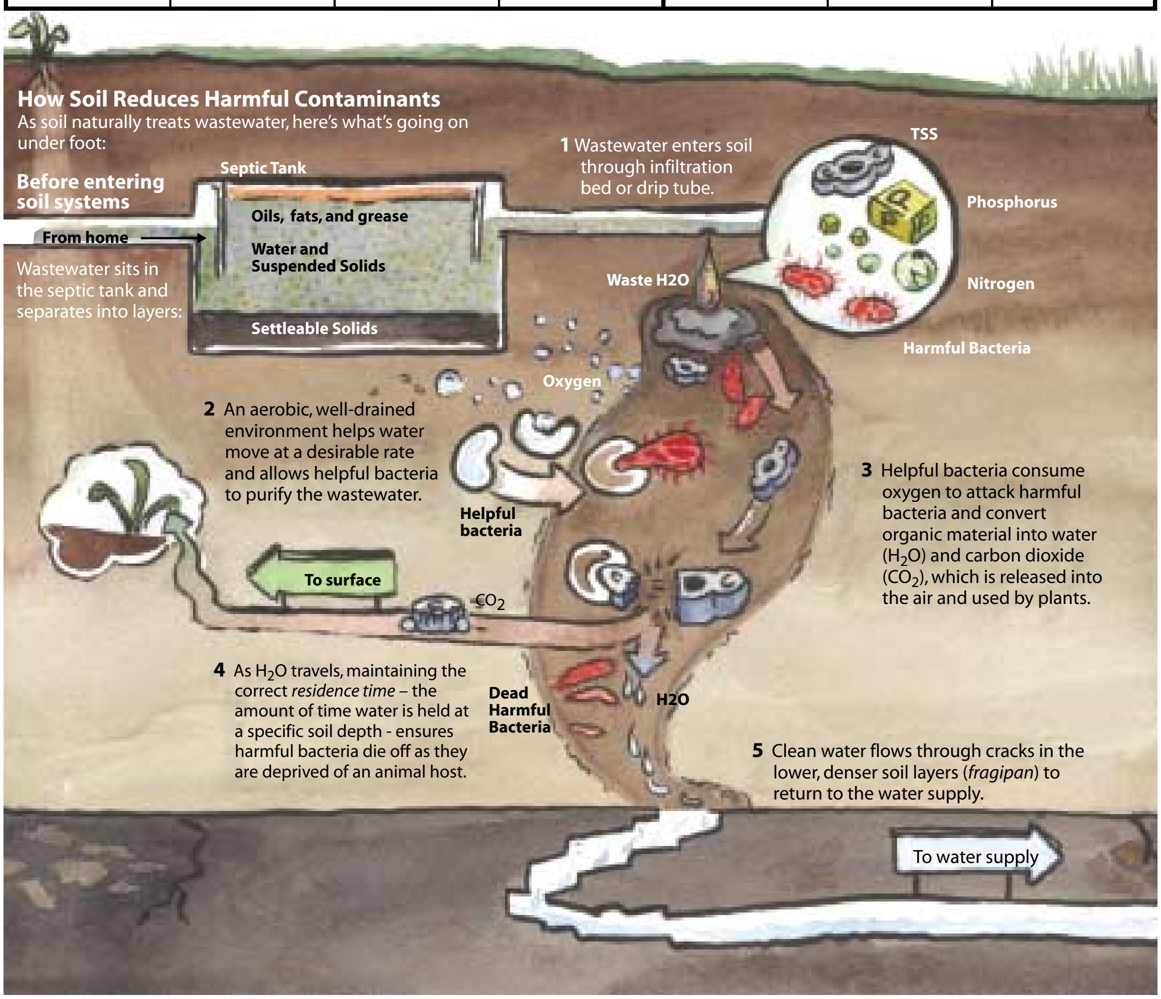
Soil based treatment systems reduce contaminants in wastewater by utilizing the natural physical, chemical, and biological processes that occur in the soil. These natural mechanisms used to reduce contaminants include filtration, chemical absorption, and microbial activity. Water flow in unsaturated conditions is also an important factor in allowing sufficient treatment to occur.

The following info graphic illustrates these treatment processes.

An Introduction to Soil-based Treatment Processes

Soil and its natural properties can be used to eliminate contaminants in wastewater before it is reintroduced into the earth for use by plants, animals, or people. Water must remain in a controlled environment long enough for these processes to work effectively. The following "players" impact this natural cycle:

Found in Wastewater				Found in Soil		
						
Biochemical Oxygen Demand (BOD) High BOD levels deplete soil of oxygen, killing helpful bacteria. Proper systems reduce BOD by the end of water treatment.	**Total Suspended Solids (TSS)** This organic material is high in carbon and requires high amounts of oxygen for decomposition and removal of harmful bacteria.	**Nitrogen and Phosphorus** These elements are useful to plants but high levels can be harmful to the greater ecosystem.	**Harmful Bacteria** These bacteria once found in the gut of warm-blooded animals cause disease. They die in soil if given enough time outside a host.	**Helpful Bacteria** Naturally occurring soil bacteria perform necessary decomposition and kill harmful bacteria.	**Oxygen** Helpful bacteria require oxygen to survive.	**Plants** All plants consume nitrogen and phosphorus. In addition, wetlands plants put oxygen back into the soil.



Wastewater Infiltration and Testing:

One important component of soil-based treatment is to introduce the wastewater in a fashion that allows unsaturated flow to occur through the soil. Unsaturated flow allows for long residence times in the soil and provides the needed oxygen for microbial and chemical processes to treat the wastewater.

At-grade beds and drip irrigation are two methods of introducing wastewater into the soil to maintain unsaturated flow conditions. Eventually, saturated flow conditions will occur and gravity will move the treated water down through the soil profile.

The sampling procedure used in this project captured water as it moved by gravity down through the soil profile. The collected treated wastewater samples were then lab analyzed for a number of different contaminants, such as fecal bacteria, biological oxygen demand, total suspended solids, nitrogen, and phosphorus.

The following info graphic illustrates these methods.

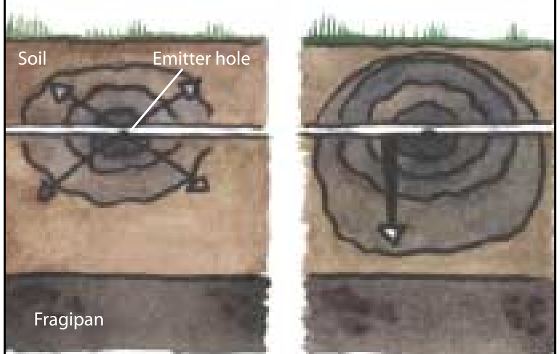
The Basics of Wastewater Infiltration and Testing Methods

This study used two methods of introducing water into the soil for treatment. One was at-grade pressure dosed beds containing underground pipes with evenly spaced holes dosing constructed beds and the second was drip irrigation using flexible tubes with evenly spaced emitters trickling water into drip irrigation areas.

In the **drip irrigation** methods, water seeps into soil at controlled intervals, spreading as such:

1 Dry soil pulls moisture sideways and upward as much as gravity pulls it down.

2 As soil above becomes more saturated, gravity has more influence.

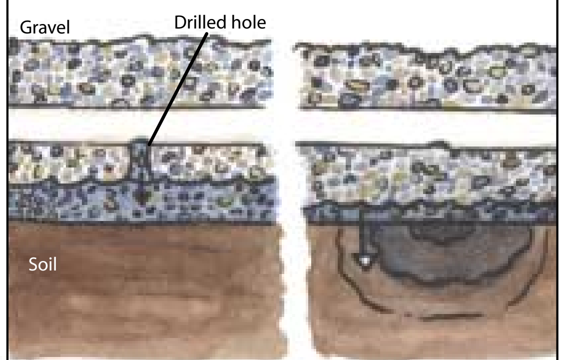


3 Moisture continues until it hits bedrock or a *fragipan* – a dense layer of soil forming an anaerobic atmosphere that is already saturated with water. Wastewater needs to be safe before it hits these layers to avoid harmful results to the ecosystem, as the anaerobic nature of a fragipan renders it a poor soil-based treatment technique.

In the **pressure dosed** at grade bed:

1 Water fills the gravel and spreads over the soil during dosing.

2 Water moves down through the soil.

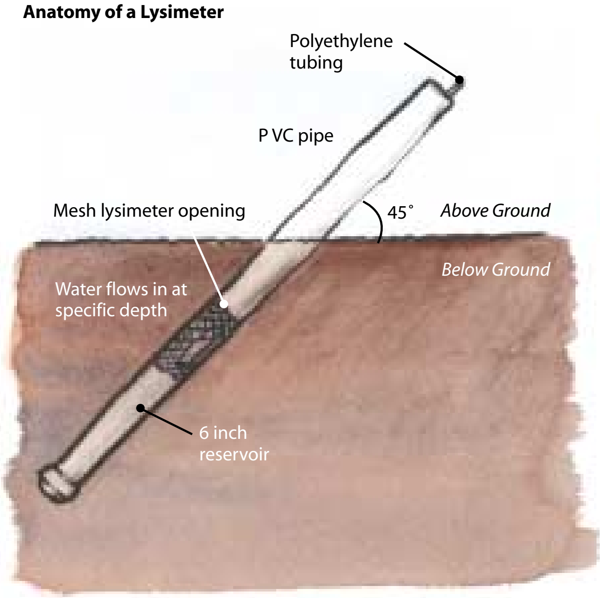


3 Moisture continues until it hits bedrock or a fragipan.

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

Statistical Analysis of Alternative Systems:

Multiple statistical methods such as graphs, charts, descriptive statistics, and hypothesis tests were used to interpret lab results obtained from wastewater samples collected at each of the alternative systems studied. Data values for each test parameter were graphed in relation to the date sampled (time series) in order to observe any concentration changes and fluctuations for each sampling site. Histograms, bar charts of relative frequencies of data set values, helped to determine if the data sets distribution was skewed, followed a normal bell-shaped curve, and or contained outliers. These indicators determined the type of hypothesis testing or significance test performed on the data. A hypothesis test is a formal procedure used to draw conclusions from the collected data. Most of the collected site parameter data was skewed and contained outliers, thus non-parametric statistical tests were performed.

The Wilcoxon rank sum test was used to determine the statistical significance between two variables and the Kruskal-Wallis test was used to determine the statistical significance among three or more variables. To test the statistical significance of the lab results, a pre-determined alpha of .05 was used for accepting or rejecting the null hypothesis, which stated that there was no significant difference between the compared sampling site parameter values. When the calculated p-value was .05 or greater, the null hypothesis was accepted. Accepting the null hypothesis supported evidence that there was no significant difference between sampling site parameter values. When a significant difference was indicate using the Kruskal-Wallis test, the Pairwise Comparison test was performed to identify which specific depths were significantly different. In addition, if a significant difference was seen, the test calculated mean rank was used as a location parameter to determine which site was higher or lower.

The descriptive statistics in the form of a 5-number summary along with the number of site data values (N) were charted to describe the center (average or midpoint) and spread (variability) of each data set. The 5-number summary consists of the minimum or lowest data value, the 1st quartile or value where 25% of the values fall at or below it, the median or middle value (50% of values at or below), the 3rd quartile or value where 75% of the values fall at or below it, and the maximum or highest data value.

Alternative Systems Tested:

Tech A – Constructed Wetlands – somewhat poorly drained soil

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

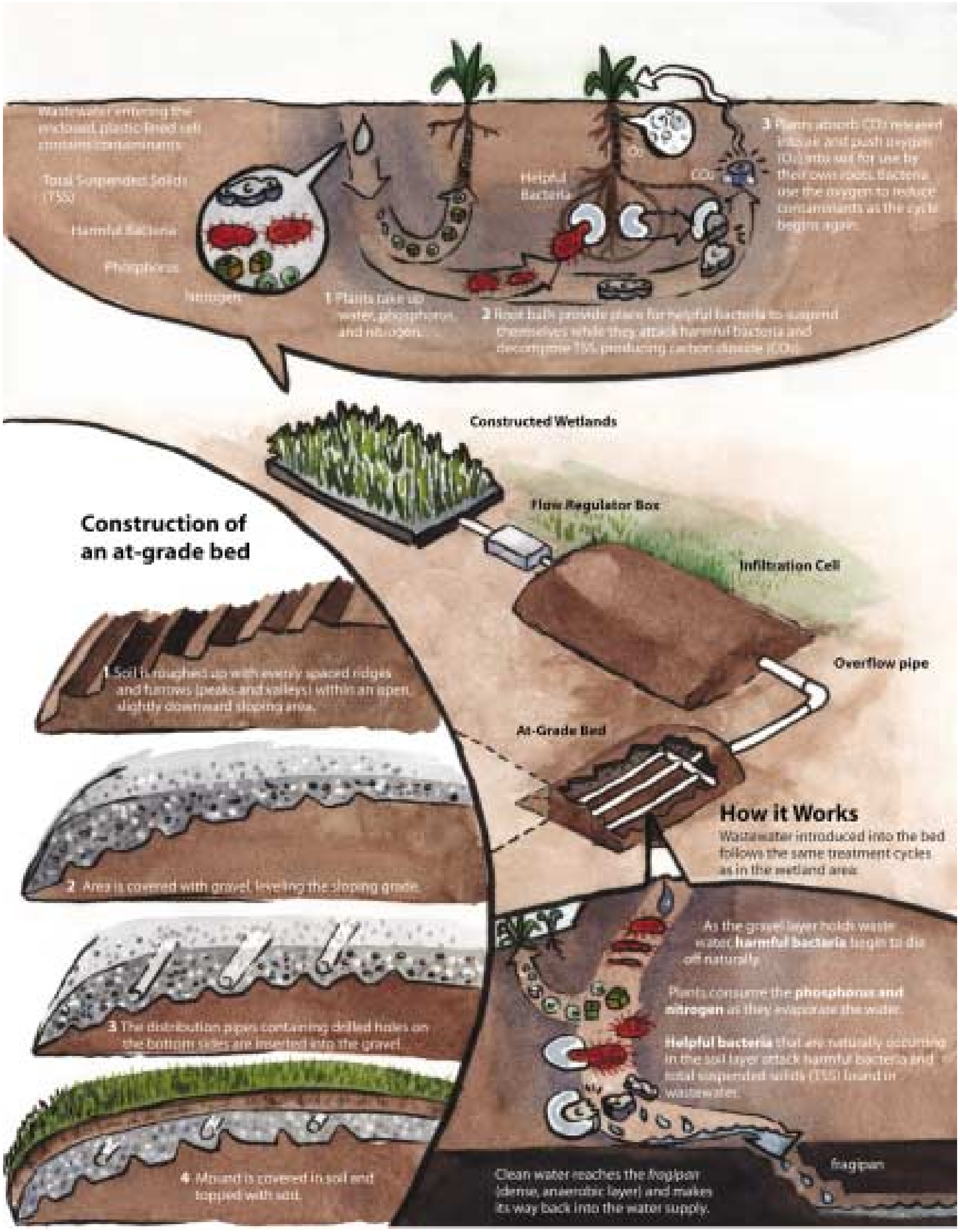
Tech F – Septic tank effluent with timed dosed soil distribution
– well drained soil

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

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

Constructed Wetlands and At-Grade Bed Technologies

Wetland plants, especially bulrush, help significantly in reducing contaminants within a constructed wetland system:



Technology A:

The Constructed Wetland System is a natural method of treating water. The physical and chemical processes that nature provides can be adjusted by altering factors including depth, media, and vegetation in the wetland.

There are two major categories of constructed wetlands: the free-water surface and the subsurface flow. A free-water surface wetland has water exposed to the atmosphere, while the water in a subsurface flow wetland remains below the surface of the media. This project utilized subsurface flow wetlands.

The subsurface wetlands can have horizontal flow through the wetland, or vertical flow through the system. The wetlands on this project were designed to function by either flow method depending on valve settings. The root zone in a typical horizontal flow bed remains saturated and must rely on the macrophyte plants to supply the oxygen required for the conversion of ammonia nitrogen to nitrate nitrogen. Nitrate nitrogen can then be converted to gaseous nitrogen in the anaerobic areas and released to the atmosphere. Scirpus sp., commonly known as bulrush, is a well-suited macrophyte due to its high ammonia nitrogen tolerance and highly oxygenated rhizome. In addition, Juncus and other wetland plants (see plant list) could be utilized.

Tennessee Valley Authority sizing guidelines were employed. Hydraulic loading rate calculations were performed in order to predict the minimum cross sectional area and surface area required to treat the biochemical oxygen demand. Each wetland system consisted of two 16' by 16' cells approximately 2.5ft. deep. The first cell was lined with a 20-mil PVC liner. The second cell was open at the bottom, but lined around the sidewalls. The media used was 3/4" clean stone. A gravity dosed at-grade bed containing one - 4in. PVC pipe was used to handle any overflow from the infiltration cell.

Both wetland systems received septic tank quality effluent.

Wetland Cell construction

At-grade bed for wetland overflow

Technology A: Soil and Site Conditions

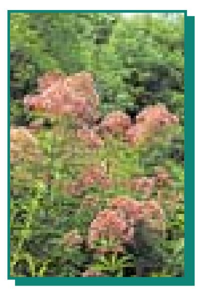
Abbottstown, somewhat poorly drained soil. Redox features (mottles) and polygonal structural cracks were present in the Bx horizon. A seasonal high water table was present at 10" beneath the surface.

Native wetland plants, such as the ones listed in the table below, can be used to enhance the appearance of a wetland system.

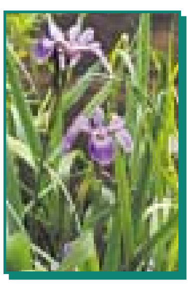
Native Wetland Plants

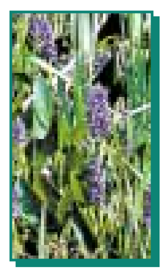
Botanical Name	Common Name	Plant Height
Acorus americana	Sweet Flag	2 feet
Iris versicolor	Blue Iris	2-3 feet
Eupatorium fistulosum	Joe Pye Weed	5-8 feet
Peltandra virginica	Arrow Arum	12-20 inches
Lobelia cardinalis	Cardinal Flower	2-5 feet
Pontederia cordata	Pickrel Rush	2-3 feet
Typha anagustifolia or latifolia	Cattails	3-9 feet
Scirpus tabermontanii	Soft Stem Bulrush	3-9 feet
Juncus canadensis	Canada Rush	1-4 feet

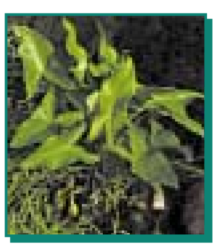

Sweet Flag

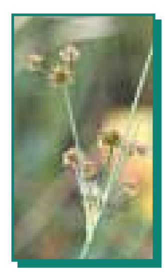

Joe Pye Weed


Cattails

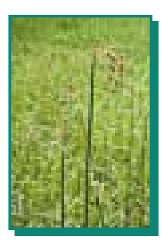

Blue Iris


Pickrel Rush

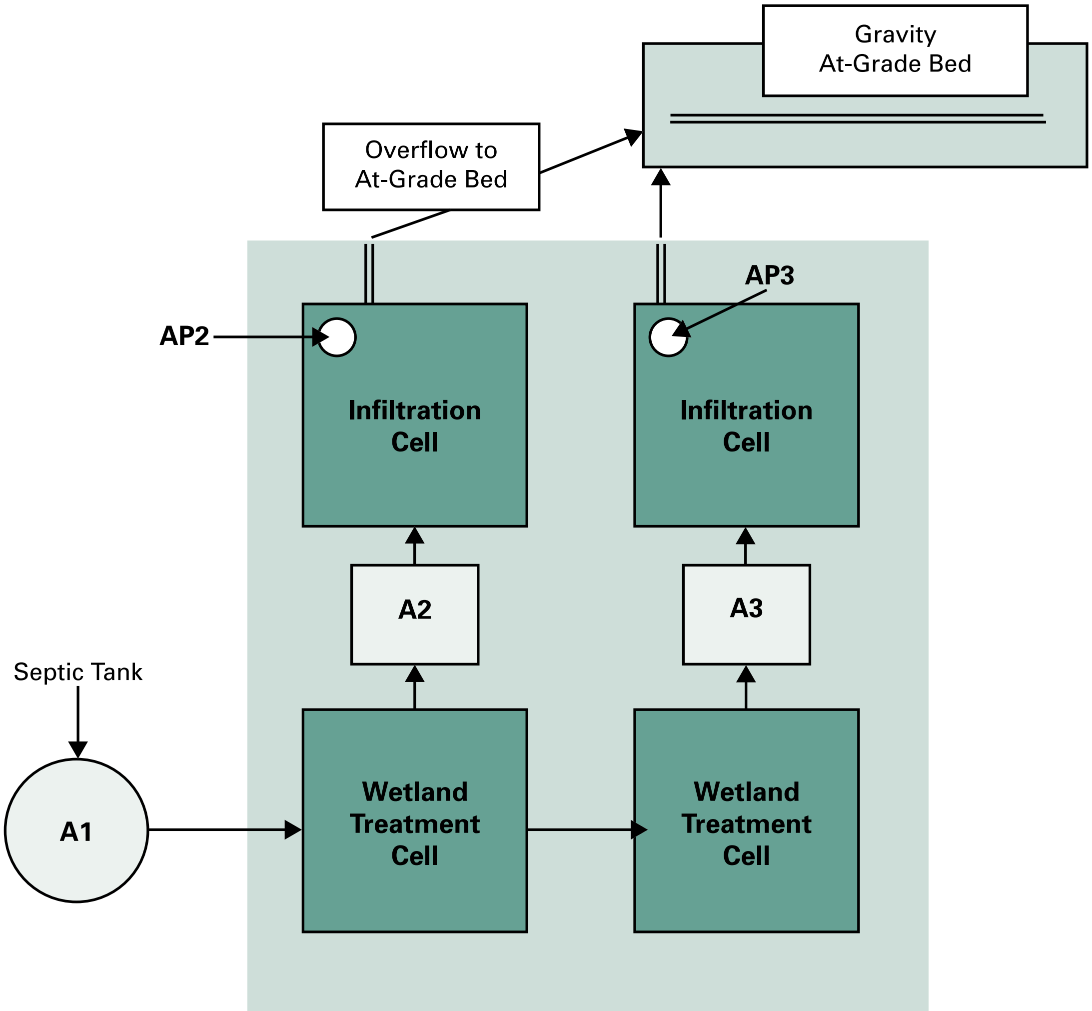

Arrow Arum


Canada Rush


Cardinal Flower


Soft Stem Bulrush

Technology A: Wetland System Schematic

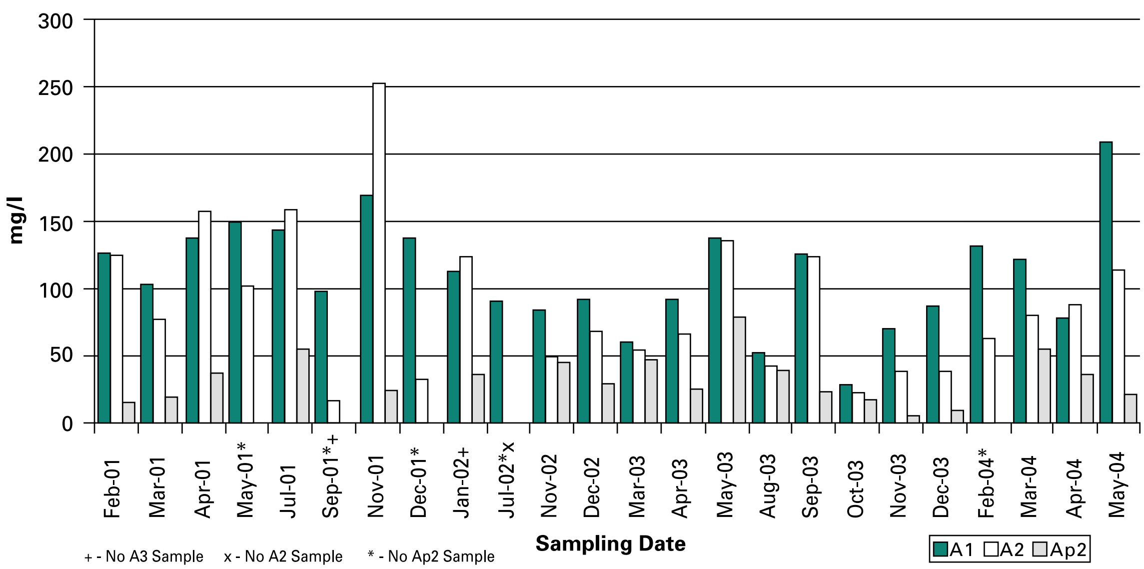


Wetland Treatment Cell

Technology A: Test Results

Lab results for wastewater samples collected monthly from the septic tank (A1), the treatment cells (A2, A3), and the infiltration cell (Ap2) were examined using graphs, descriptive statistics, and hypothesis testing. Non-parametric tests were used and the preset alpha of .05 determined whether the null hypothesis of no significant difference was accepted or rejected. See Statistical Analysis of Alternative Systems, page 5, for more detailed information.

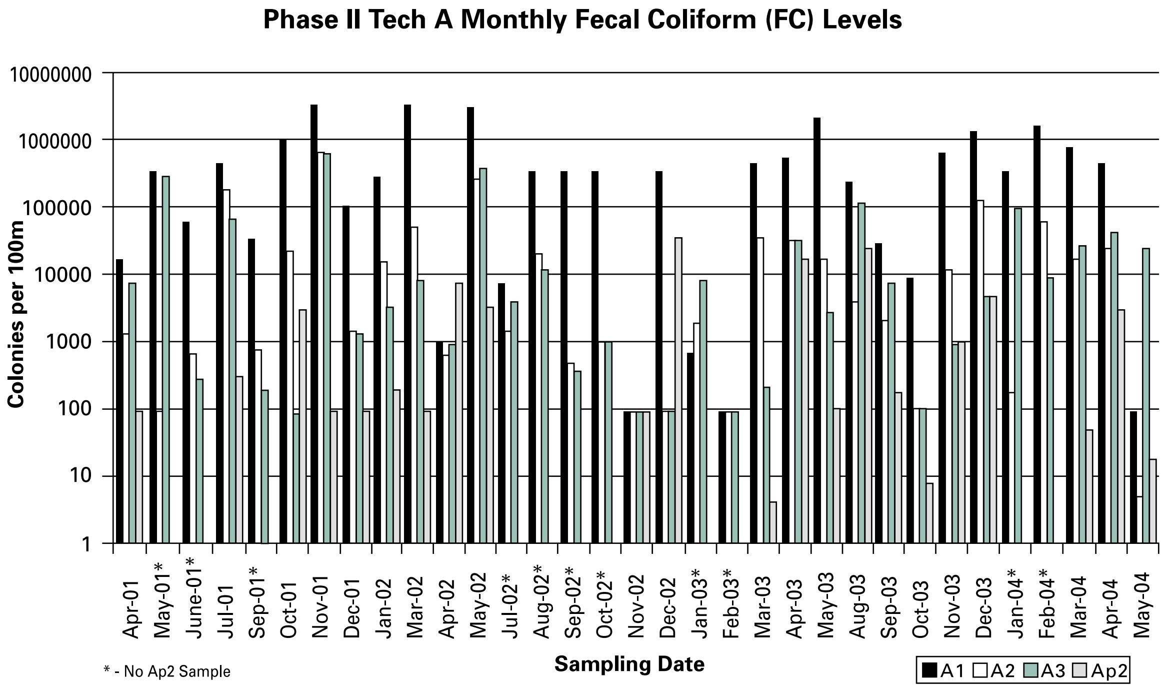
Phase II Tech A Monthly Biological Oxygen Demand (BOD) Levels



BOD (biological oxygen demand): The Wilcoxon calculated p-values for the comparison of A1 to A2, A3 and Ap2 (p=.0198, p=.0002, p=.0000) were all below the preset alpha of .05, indicating a significant difference between the effluent quality of the compared sites. When comparing the treatment cells (A2, A3), the Wilcoxon calculated p-value indicated no significant difference between the two cells (p=.0785). A significant difference was found between treatment cell A2 and its corresponding infiltration cell Ap2 (p=.0007). There were higher than usual BOD levels in July 2001 at A3 and in Nov 2001 at A2 (230.82mg/l, 252.22mg/l). The median or measure of center decreased from the septic tank to the infiltration cell. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech A BOD (mg/l)

	A1	A2	A3	Ap2
N	24	24	22	19
Minimum	28.80	0	0	4.20
1st Quartile	79.28	39.00	17.27	18.49
Median	100.50	66.92	48.90	28.35
3rd Quartile	137.35	111.11	78.16	44.50
Maximum	208.80	252.22	230.82	78.60

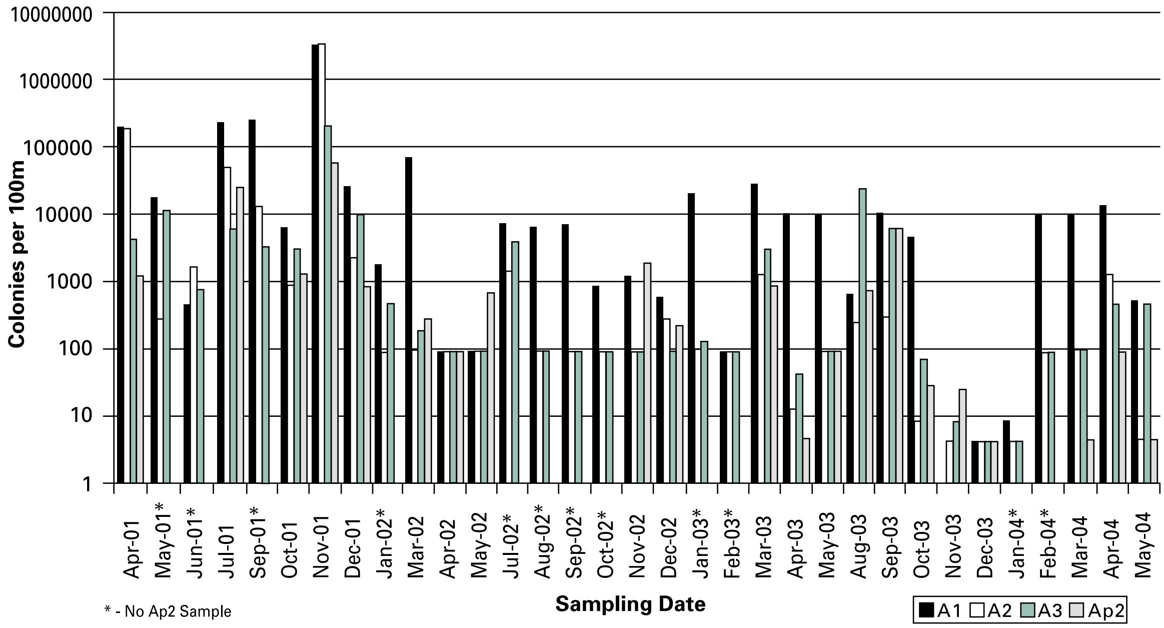


FC (fecal coliform): The Wilcoxon calculated p-values for the comparison of A1 to A2, A3, and Ap2 (p=.0000, p=.0000, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing A2 and A3, the Wilcoxon calculated p-value indicated no significant difference between the two cells (p=.8928). A significant difference was found between A2 and Ap2 (p=.0038). A2 and A3 FC counts were greater than 200 col/100ml, a PA water quality criterion (PA Code, Ch93, and Ch72.42) 26:33 times (78.7%) and for Ap2 10:22 times (45.5%). Maximum FC counts were recorded for A1, A2, and A3 in Nov 2001 and for Ap2 in Dec 2002. The median or measure of center decreased from the septic tank to the infiltration cell. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech A FC (colonies/100ml)

	A1	A2	A3	Ap2
N	33	33	33	22
Minimum	90	4	90	4
1st Quartile	21500	540	315	90
Median	300000	1800	4500	180
3rd Quartile	645000	26500	27500	3000
Maximum	3.00E+06	660000	640000	30000

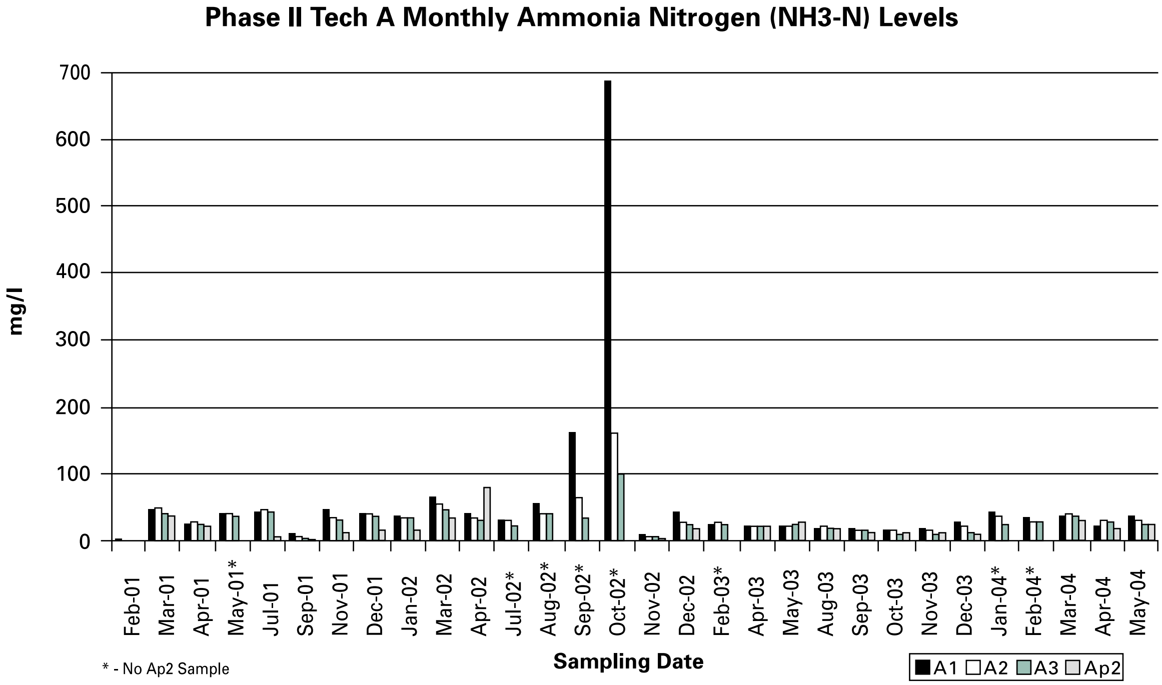
Phase II Tech A Monthly Fecal Strep (FS) Levels



FS (fecal strep): The Wilcoxon calculated p-values for the comparison of A1 to A2, A3, and Ap2 (p=.0010, p=.0027, p=.0057) indicated a significant difference between the effluent quality of the compared sites. When comparing A2 and A3, the calculated p-value indicated no significant difference between the two cells (p=.3971). The calculated p-value (p=.8654) indicated no significant difference between A2 and Ap2. FS counts that occurred most frequently were those in the 10^4-10^2 range for A1, 10^2-10^1 for A2, 10^3-10^1 A3, and 10^2-10^1 for Ap2. Higher than usual FS levels were recorded in Nov 2001, the maximum counts for each site. The median or measure of center decreased from the septic tank to the infiltration cell. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech A FS (colonies/100ml)

	A1	A2	A3	Ap2
N	33	33	33	21
Minimum	1	4	4	4
1st Quartile	485	90	90	25
Median	6000	91	91	270
3rd Quartile	17500	1050	2900	1250
Maximum	3.00E+06	3.00E+06	200000	51000

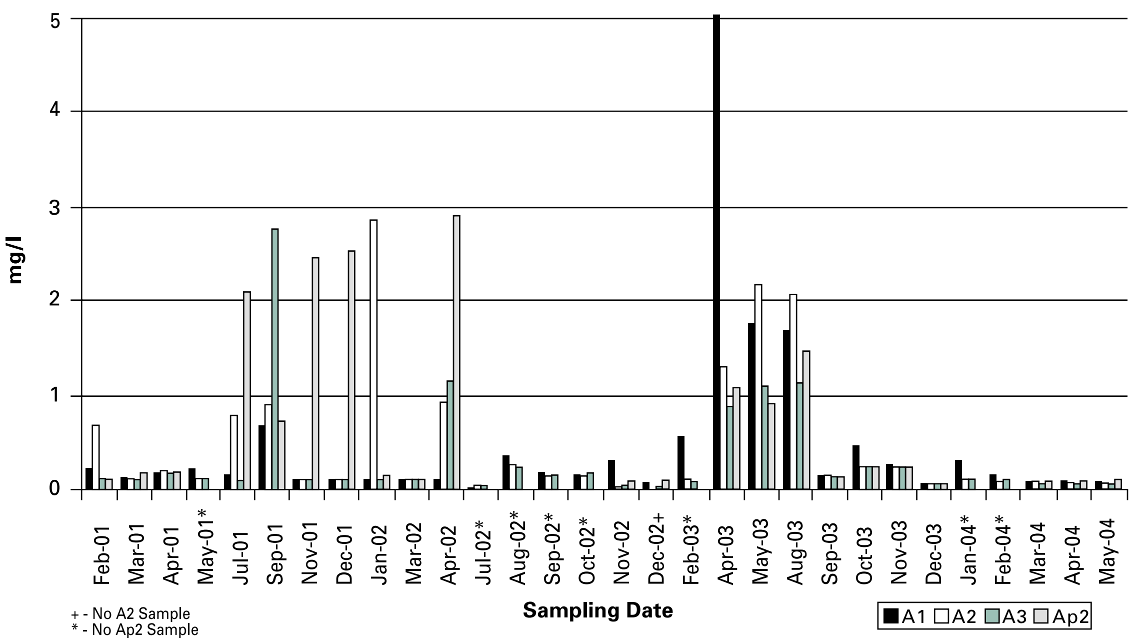


NH3-N (ammonia nitrogen): The Wilcoxon calculated p-values for the comparison of A1 to A2 and A3 (p=.4917, p=.1054) indicated no significant difference between the effluent quality of the compared sites. The comparison of A1 and Ap2 (p=.0012) indicated a significant difference between the two sites. When comparing A2 and A3, the calculated p-value indicated no significant difference between the two cells (p=.3377). A significant difference was found between A2 and Ap2 (p=.0033). Feb 2001 exhibited lower than usual levels for all sites, which were also the minimum values. The majority of NH3-N levels were below 50mg/l with the year 2003 exhibiting the lowest levels overall (<29mg/l). The maximum levels for the A1, A2, and A3 were recorded in Oct 2002 and in Apr 2002 for Ap2. The median or measure of center decreased from the septic tank to the infiltration cell. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech A NH3-N (mg/l)

	A1	A2	A3	Ap2
N	30	30	30	22
Minimum	0.21	0.68	0.10	0.10
1st Quartile	19.98	20.16	18.09	11.04
Median	35.58	29.70	25.12	16.01
3rd Quartile	42.32	39.77	36.02	26.03
Maximum	688.52	159.67	102.32	79.21

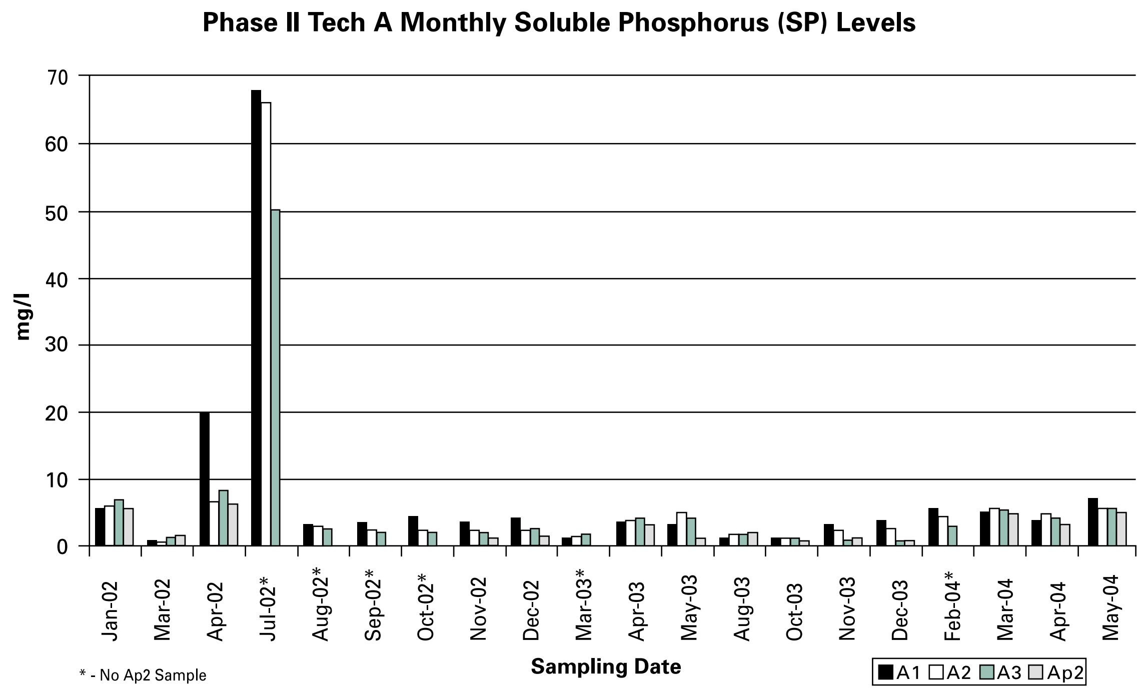
Phase II Tech A Monthly Nitrate Nitrogen (NO3-N) Levels



NO3-N (nitrate nitrogen): The Wilcoxon calculated p-values for the comparison of A1 to A2, A3, and Ap2 (p=.7721, p=.1308, p=.4181) indicated no significant difference between the effluent quality of the compared sites. When comparing A2 and A3, the calculated p-value indicated no significant difference between the two cells (p=.2674). No significant difference was found between A2 and Ap2 (p=.3851). NO3-N levels never exceeded the PA water quality criterion of 10mg/l (Pa Code, Ch93). The majority of NO3-N levels were below .50mg/l. The year 2003 exhibited consistently higher levels than all other years. The median or measure of center is approximately the same from the septic tank to the infiltration cell. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech A NO3-N (mg/l)

	A1	A2	A3	Ap2
N	30	29	30	22
Minimum	0.02	0.03	0.00	0.07
1st Quartile	0.10	0.10	0.08	0.10
Median	0.16	0.13	0.10	0.18
3rd Quartile	0.32	0.73	0.23	1.18
Maximum	5.03	2.87	2.77	2.90



SP (soluble phosphorus): The Wilcoxon calculated p-values for the comparison of A1 to A2, A3, and Ap2 (p=.5609 p=.2503, p=.0772) indicated no significant difference between the effluent quality of the compared sites. When comparing A2 and A3, the calculated p-value indicated no significant difference between the two cells (p=.5338). No significant difference was found between A2 and Ap2 (p=.1236). There were higher than usual SP levels in Jul 2002 (A1, A2, A3 maximum levels) and in Apr 2002 for Ap2 and A1 (maximum level, 19.77mg/l). The majority of SP readings were below 6mg/l. The median or measure of center decreased from the septic tank to the infiltration cell. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech A SP (mg/l)

	A1	A2	A3	Ap2
N	30	29	30	22
Minimum	0.82	0.60	0.75	0.22
1st Quartile	3.20	2.38	1.85	1.07
Median	3.80	2.81	2.66	1.72
3rd Quartile	5.51	5.57	5.01	4.82
Maximum	67.90	66.16	50.05	6.40

Technology B:

The Recirculation Sand Filter/Denitrification System is a small community system handling three individual homes. The system for each home consisted of a septic tank, a recirculation sand filter, and a limestone rock bed. After treatment, the effluent from each system flowed to a common pump chamber for distribution in a community at-grade pressure distribution bed. A summary of key components is as follows:

- 1500-gallon concrete septic tank.
- 1500-gallon concrete two compartment anoxic tank with pump chamber and rock filled chamber.
- 1500-gallon sand filter with 2ft of 2mm uniform sand (coefficient of uniformity <2).
- Raw effluent flowed from house through septic tank, through rock-filled chamber into pump chamber of second tank. Effluent was then pumped into sand filter for bacteria reduction, BOD reduction, and nitrification. Effluent then traveled back to anoxic tank (rock-filled) for denitrification. A recirculation valve in the sand filter determined amount of effluent sent through sand filter and amount sent to soil absorption field. Recirculation ratio of 3:1 was utilized.
- Dosing cycle: At-grade beds were demand dosed.

Profile being written for Technology B

Septic, rock, and sand filter tanks

Technology B: Soil and Site Conditions

Lawrenceville Series, moderately well drained soil. Faint mottles were found at 16 inches, prominent mottles at 24 inches, and a fragipan at 24 inches beneath the surface. The site slope ranged from 8.2-10.1%.

- Percolation rate: Average 10.4 to 36.5 minutes per inch.
  Range was 6.5 minutes per inch, to 120 minutes per inch.

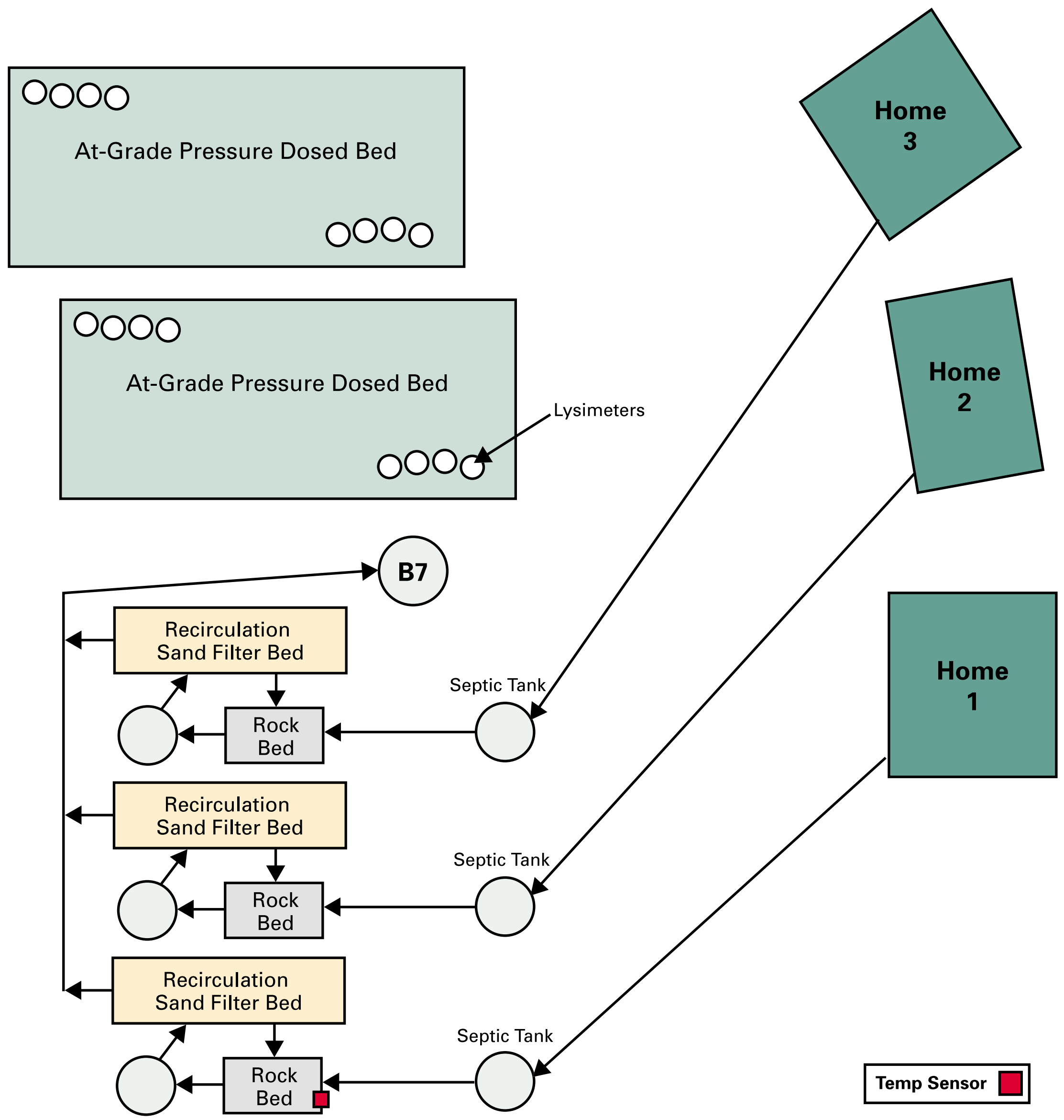
- Hydraulic conductivity rates; 2.0 cm/day to 4.2 cm/day.

Placement of gravel on at-grade beds

At-grade bed with distribution piping

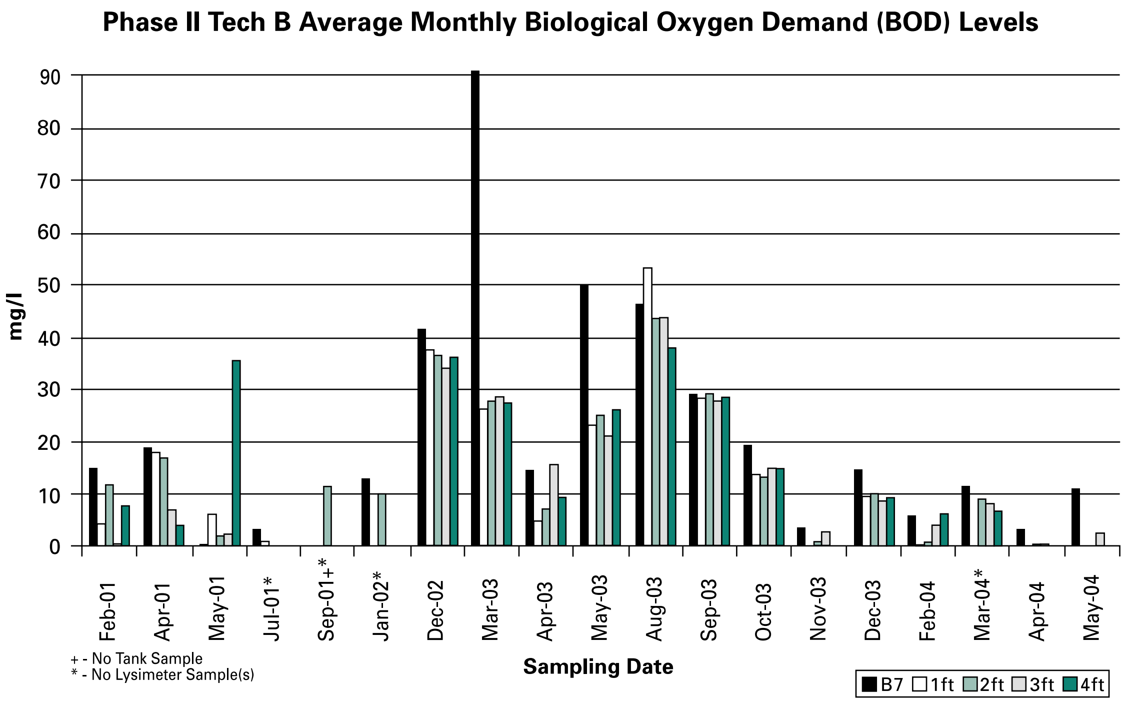
Landscaped at-grade beds

Technology B: Recirculation/Denitrification System Schematic



Technology B: Test Results

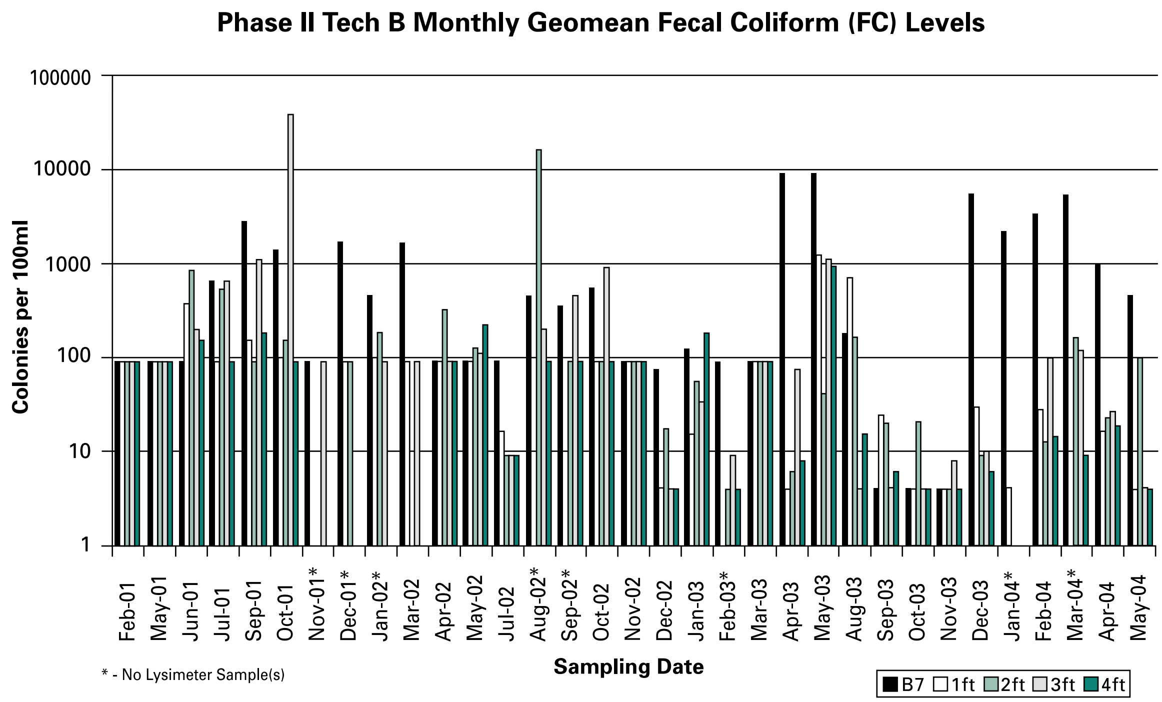
Lab results for wastewater samples collected monthly from the dosing tank (B7) and the soil absorption at-grade beds at 1ft, 2ft, 3ft, and 4ft depths were examined using graphs, descriptive statistics, and hypothesis testing. Non-parametric tests were used and the preset alpha of .05 determined whether the null hypothesis of no significant difference was accepted or rejected. See Statistical Analysis of Alternative Systems, page 5 , for more detailed information.



BOD (biological oxygen demand): The Wilcoxon calculated p-values for the comparison of B7 to 1ft, 2ft, 3ft, and 4ft depths (p=.3142, p=.4110, p=.1058, p=.3694) indicated no significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated no significant difference among the four depths (p=.7467). There were higher than usual BOD levels (34-53mg/l) in Dec 2002 and Aug 2003 (lysimeter maximum values). The B7 maximum value was recorded in Mar 2003. The median or measure of center decreased slightly from the dosing tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech B BOD (mg/l)

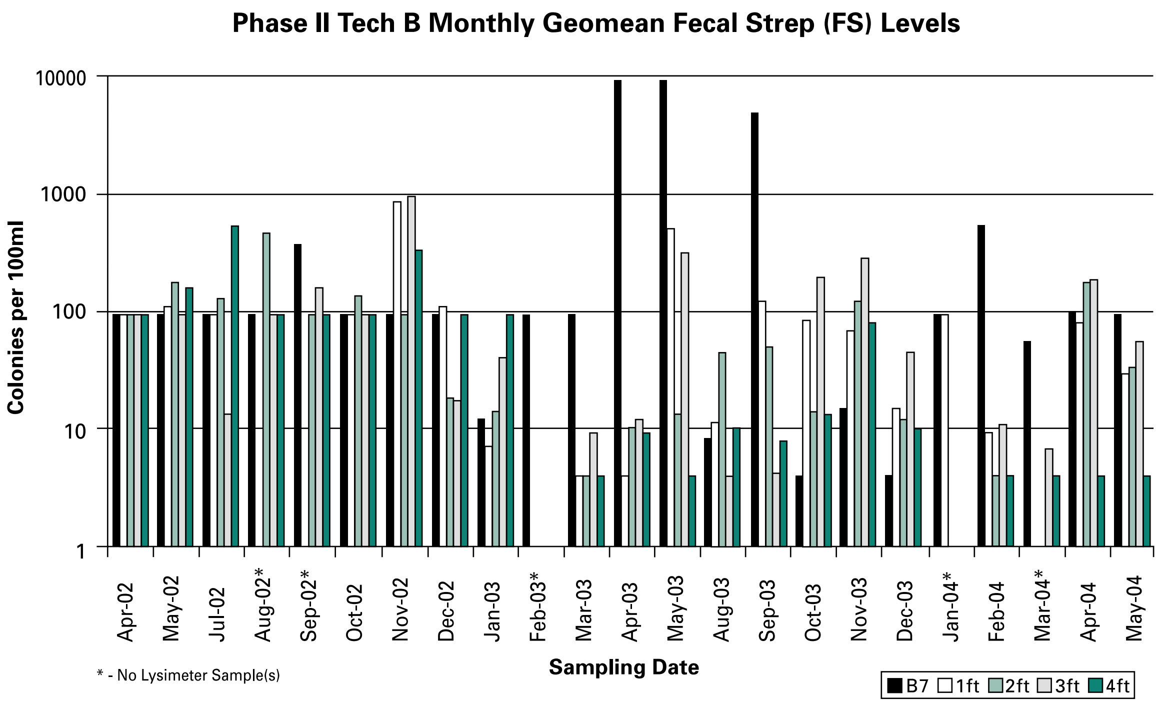
	B7	BL 1ft	BL 2ft	BL 3ft	BL 4ft
N	18	39	45	36	33
Minimum	0.49	0.00	0.00	0.00	0.00
1st Quartile	5.40	0.89	1.50	0.22	4.62
Median	14.40	13.80	12.00	7.74	12.60
3rd Quartile	31.95	28.80	29.70	26.10	27.60
Maximum	90.60	79.80	58.80	47.40	42.00



FC (fecal coliform): The Wilcoxon calculated p-values for the comparison of B7 to 1ft, 2ft, 3ft, and 4ft depths (p=.0000, p=.0003, p=.0005, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated no significant difference among the four depths (p=.1107). There were higher than usual FC counts in Oct 2001 at 4ft, in Aug 2002 at 2ft, in May 2003 at 4ft, and in Aug 2003 at 1ft, which were also the maximum levels recorded for all four depths. The mode or most frequent lysimeter counts were 90 colonies/100ml in 2001-2002 and 4 colonies/100ml in 2003-2004. FC counts were greater than 200 col/100ml, a PA water quality criterion (PA Code, Ch93 and Ch72.42) 7:70 times (10%) at 1ft, 20:89 times (22.5%) at 2ft, 13:67 times (19.4%) at 3ft, and 5:53 times (9.4%) at 4ft. The median or measure of center decreased slightly from the dosing tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech B FC (colonies/100ml)

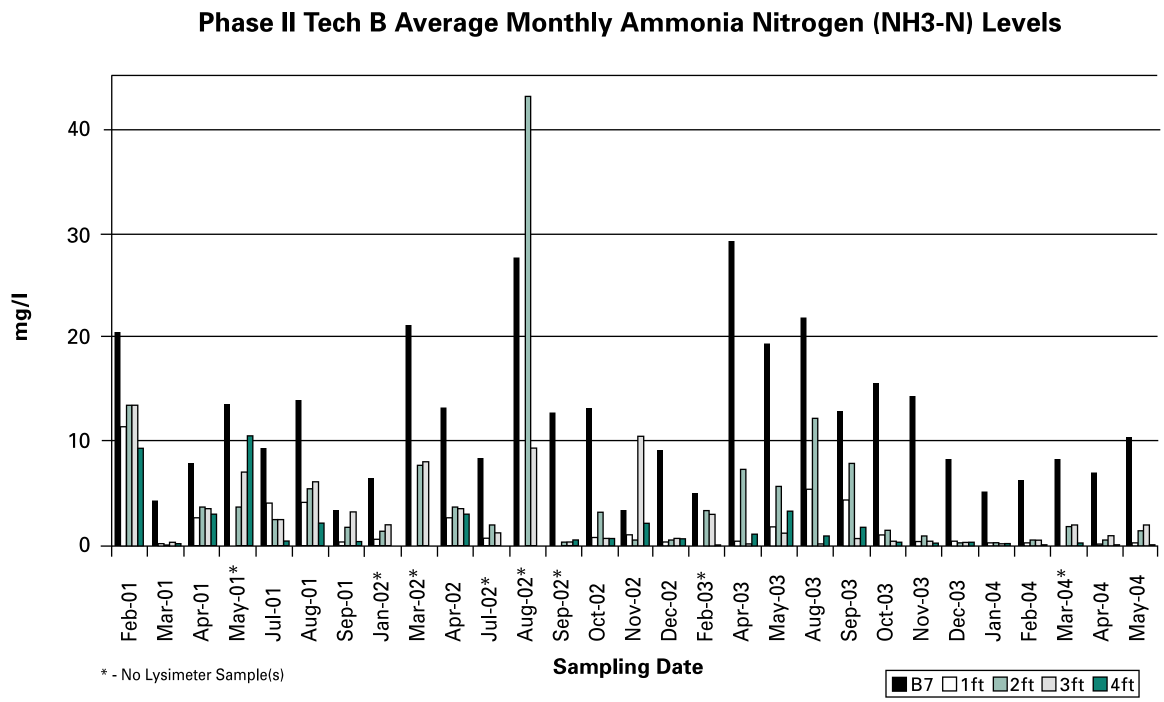
	B7	BL 1ft	BL 2ft	BL 3ft	BL 4ft
N	33	70	89	67	53
Minimum	4	4	4	4	4
1st Quartile	90	4	4	4	4
Median	360	90	90	90	11
3rd Quartile	1650	90	180	91	90
Maximum	9000	30000	300000	40000	1100



FS (fecal strep): The Wilcoxon calculated p-values for the comparison of B7 to 1ft, 2ft, and 3ft depths (p=.9303, p=.6410, p=.6870) indicated no significant difference between the effluent quality of the compared sites. When comparing B7 to the 4ft depth, the calculated p-value (p=.0117) indicated a significant difference between the two sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated a significant difference among the four depths (p=.0457). The Pairwise Comparison Test indicated no significant difference was found between any two sites, due to the experimentwise error rate. FS counts were higher overall throughout 2001 than any other year with dosing tank levels lower than lysimeter levels. The median or measure of center is the same for the dosing tank through the 3ft depth then decreases slight to the 4ft depth. The lysimeter depths show a wider variability than the dosing tank. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech B FS (colonies/100ml)

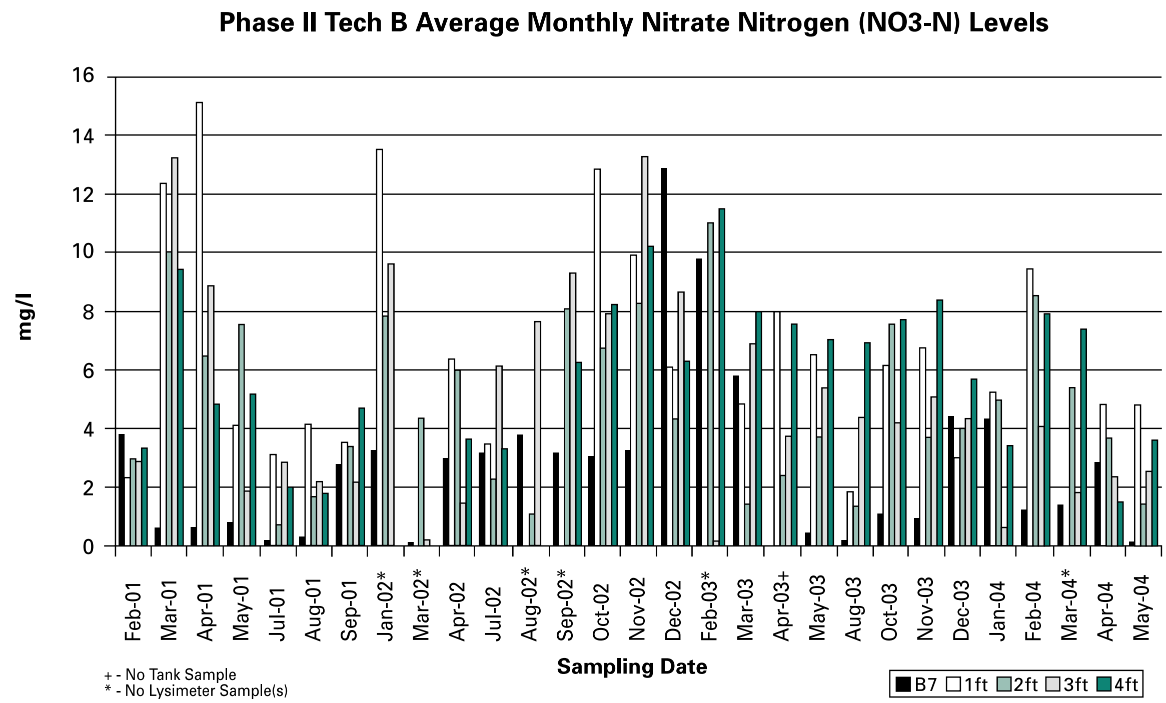
	B7	BL 1ft	BL 2ft	BL 3ft	BL 4ft
N	32	73	85	66	48
Minimum	4	4	4	4	4
1st Quartile	63	8	11	16	4
Median	91	91	90	91	21
3rd Quartile	503	2100	1200	1450	92
Maximum	9000	41000	3.00E+06	590000	98000



NH3-N (ammonia nitrogen): The Wilcoxon calculated p-values for the comparison of B7 to 1ft, 2ft, 3ft, and 4ft depths ($p=.0000$, $p=.0000$, $p=.0000$, $p=.0000$) indicated a significant difference between the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated no significant difference among the four depths ($p=.0561$). Overall, tank NH3-N levels were higher than lysimeter NH3-N levels. The maximum values were recorded in Feb 2001 for 3ft and 4ft, in Aug 2002 for 2ft, and in Aug 2003 for 1ft. The median or measure of center decreased from the dosing tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech B NH3-N (mg/l)

	B7	BL 1ft	BL 2ft	BL 3ft	BL 4ft
N	29	58	79	56	44
Minimum	3.20	0.03	0.02	0.04	0.04
1st Quartile	6.75	0.21	0.24	0.24	0.12
Median	10.41	0.48	1.08	0.73	0.34
3rd Quartile	15.00	2.37	5.03	3.92	1.21
Maximum	29.16	15.00	43.20	17.39	11.08

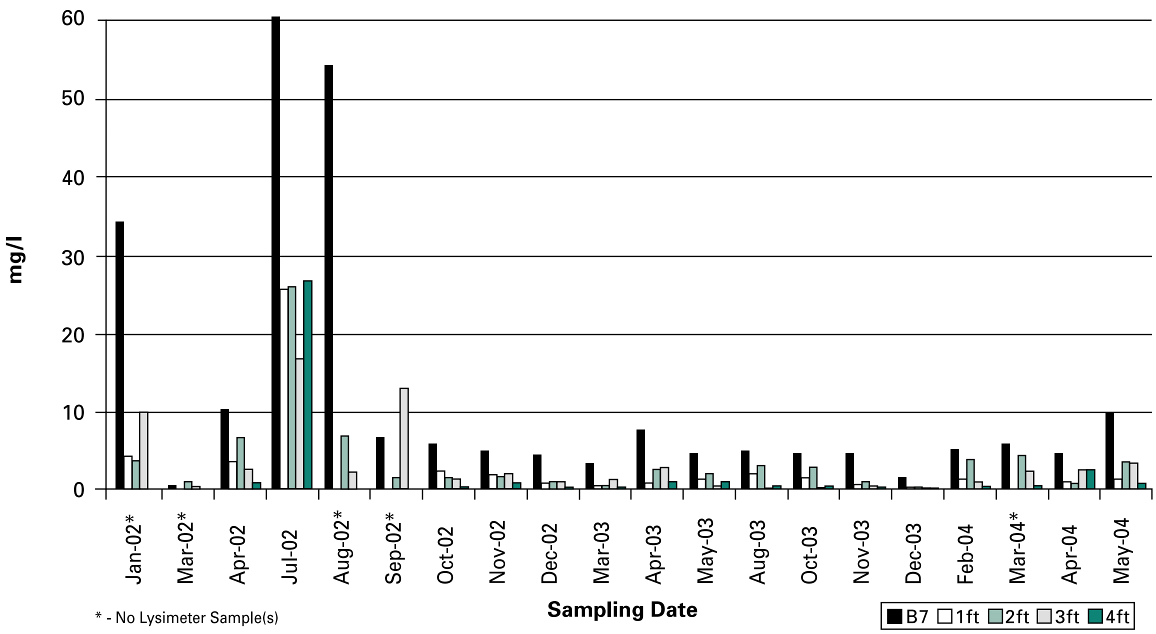


NO3-N (nitrate nitrogen): The Wilcoxon calculated p-values for the comparison of B7 to 1ft, 2ft, 3ft, and 4ft depths (p=.0022, p=.0085, p=.0042, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated no significant difference among the four depths (p=.1558). The maximum NO3-N levels at 1ft, 2ft, and 3ft were recorded in Apr 2001, for B7 in Dec 2002, and for 4ft in Feb 2003. NO3-N levels exceeded the PA water quality criterion of 10mg/l (Pa Code, Ch93) 1:28 times (4%) for B7, 14:57 times (25%) for 1ft depth, 7:77 times (9%) for 2ft depth, 8:60 times (13%) for 3ft depth, and 10:43 times (23%) for 4ft depth. The median or measure of center increased from the dosing tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech B NO3-N (mg/l)

	B7	BL 1ft	BL 2ft	BL 3ft	BL 4ft
N	28	57	77	60	43
Minimum	0.08	0.58	0.2	0.06	0.34
1st Quartile	0.64	1.92	1.46	2.29	3.4
Median	2.83	4.41	3.94	4.25	4.66
3rd Quartile	3.61	9.25	7.08	7.73	9.5
Maximum	12.86	17.91	14.97	17.59	19.00

Phase II Tech B Average Monthly Soluble Phosphorus (SP) Levels



SP (soluble phosphorus): The Wilcoxon calculated p-values for the comparison of B7 to 1ft, 2ft, 3ft, and 4ft depths (p=.0000, p=.0001, p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated a significant difference among the four depths (p=.0008). The Pairwise Comparison Test indicated a significant difference was found between the 4ft and the 1ft, 2ft, and 3ft depths. All sampling sites experienced higher than usual SP levels in July 2002 (maximum levels). A majority of the SP levels were below 5mg/l for all sampling sites. The median or measure of center decreased from the dosing tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech B SP (mg/l)

	B7	BL 1ft	BL 2ft	BL 3ft	BL 4ft
N	20	38	52	40	33
Minimum	0.53	0.11	0.08	0.02	0.02
1st Quartile	4.50	0.42	0.46	0.22	0.07
Median	4.97	0.71	1.17	0.68	0.40
3rd Quartile	9.12	2.44	4.11	3.38	0.83
Maximum	63.86	30.72	29.60	16.65	27.56

Technology D:

The Intermittent Sand Filter System with time dosed surface drip irrigation received effluent from the campus sewer system. Raw effluent was passed through one of two 3000-gallon single compartment septic tanks hooked in parallel and through one of 9 single pass intermittent sand filters with uniform (coefficient of uniformity <2) 2mm sand. Effluent was then dosed on the at-grade soil absorption area using drip tubing.

- 1200 lineal feet of drip tubing was laid on the soil surface.
- 6ft of spacing was left between drip tube lines.
- Total absorption area was approximately 7200 sq ft.
- Dosing cycle: Dosed 4 times each day at 100 gallons per dose to equal 400gpd.

Soil absorption bed with lysimeters

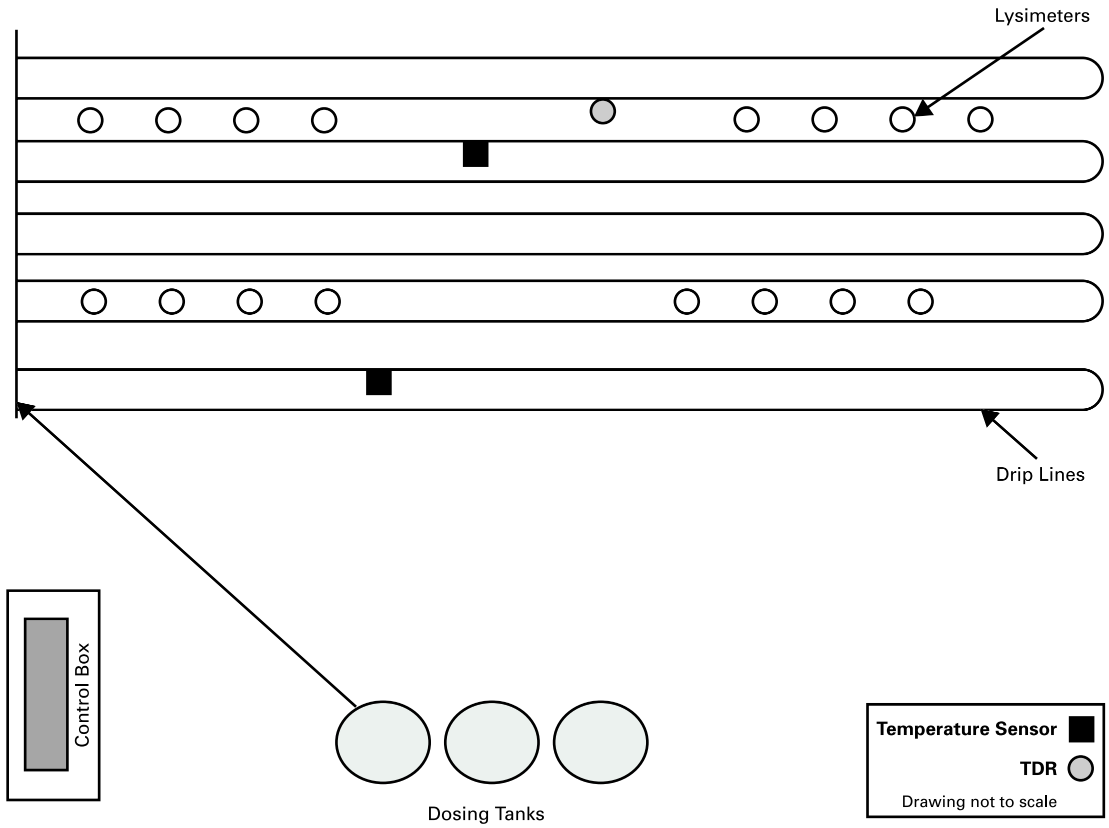
Technology D: Soil and Site Conditions

Chalfont series, somewhat poorly drained. Common faint mottles at 8 inches, common distinct mottles at 13 inches, and a fragipan at 21 inches beneath the surface.

- Limiting zone depth: 13 inches beneath the surface
- Slope: 3.7 to 3.9%
- Percolation rate: Average 70 to 197 minutes per inch. Range was 10.4 to 240 minutes per inch.
- Hydraulic conductivity: 0.4 to 5.8 cm/day.
- Dosing cycle: At-grade beds were demand dosed.

Site preparation

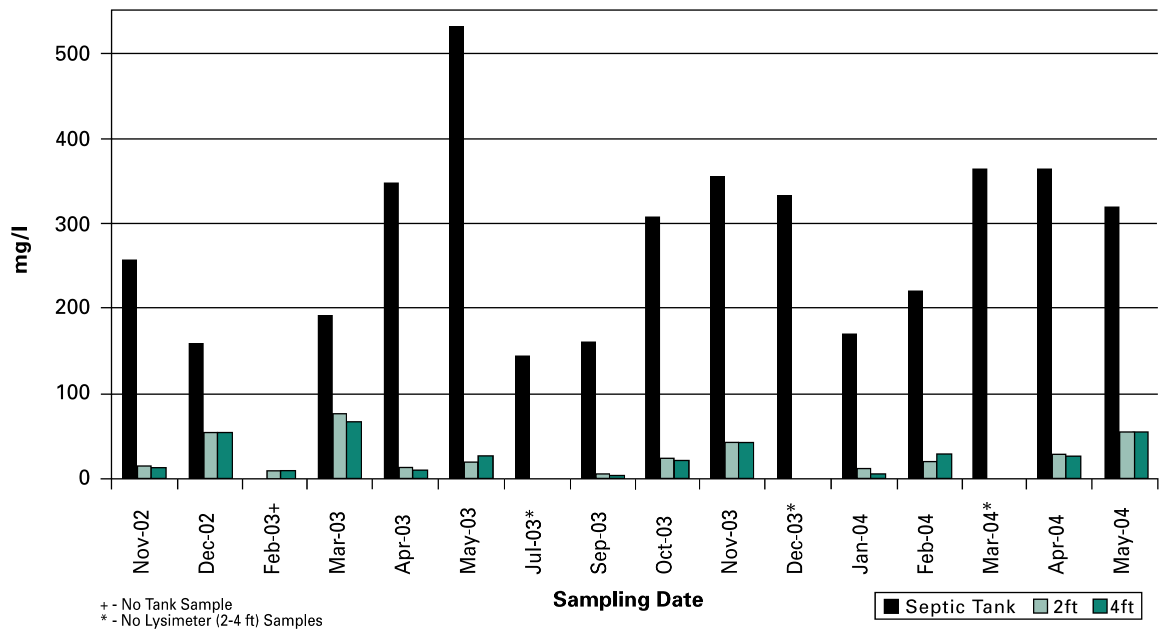
Technology D: Surface Drip Irrigation System in Wooded Area



Technology D: Test Results

Lab results for wastewater samples collected monthly from the septic tank and the soil absorption beds at 2ft and 4ft depths were examined using graphs, descriptive statistics, and hypothesis testing. Non-parametric tests were used and the preset alpha of .05 determined whether the null hypothesis of no significant difference was accepted or rejected. See Statistical Analysis of Alternative Systems, page 5, for more detailed information.

Phase II Tech D Average Monthly Biological Oxygen Demand (BOD) Levels

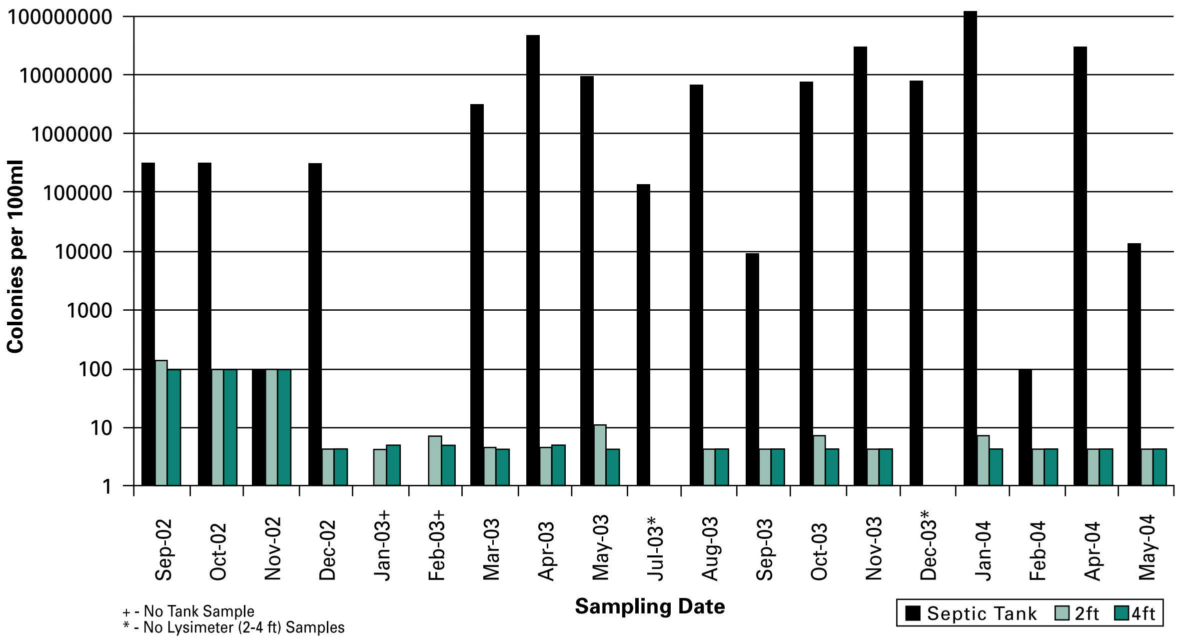


BOD (biological oxygen demand): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to Tech D 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.9037) indicated no significant difference between the two depths. Mar 2003 saw higher than usual BOD levels at the 2ft and 4ft levels (maximums). The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech D BOD (mg/l)

	Tank	DL 2ft	DL 4 ft
N	18	96	70
Minimum	61.0	0.0	0.0
1st Quartile	160.7	8.7	9.3
Median	255.4	22.8	24.9
3rd Quartile	349.4	45.0	44.3
Maximum	531.6	77.4	73.8

Phase II Tech D Monthly Geomean Fecal Coliform (FC) Levels

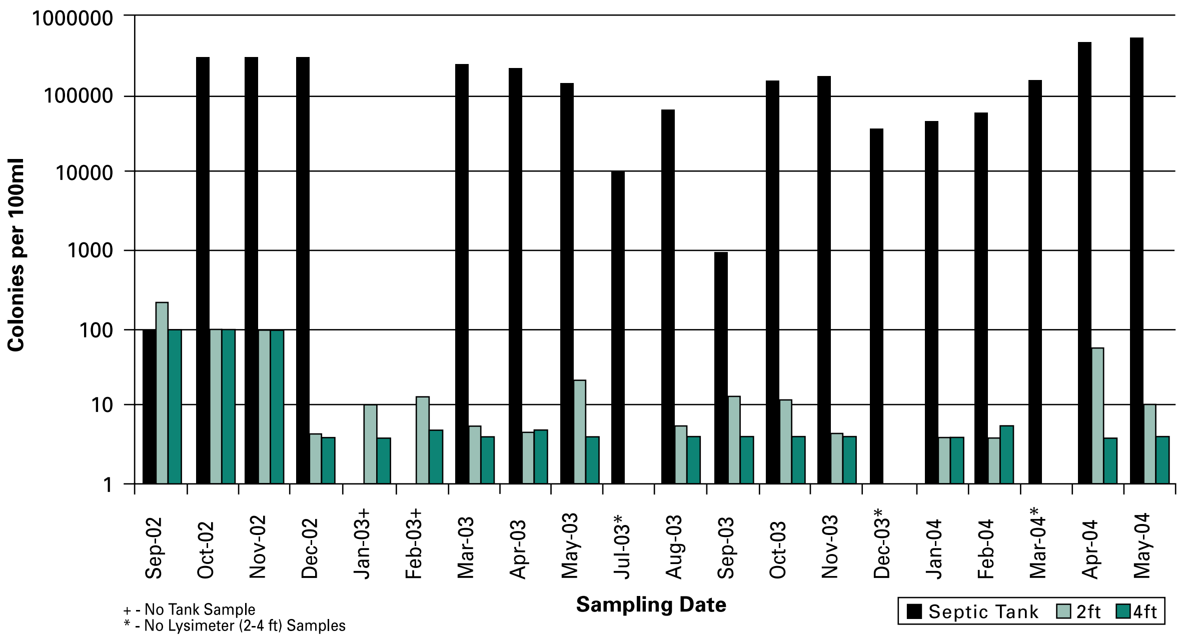


FC (fecal coliform): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to Tech D 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.1932) indicated no significant difference between the two depths. There were higher than usual FC counts Sept 2002 and May 2003 at the 2ft depth (1300, 11000 col/100ml) and Jan 2004 at the septic tank (maximum). The septic tank had lower than usual FC level Nov 2002 and Feb 2004 (90 col/100ml). The PA water quality criterion of 200 col/100ml was exceeded 4:130 times (3%) at 2ft and 0:92 times (0%) at 4ft depths (PA Code, Ch93, and Ch72.42). The 2ft and 4ft mode or most frequent value was four col/100ml. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech D FC (colonies/100ml)

	Tank	DL 2ft	DL 4 ft
N	20	130	92
Minimum	90	4	4
1st Quartile	1.7E+05	4	4
Median	2.7E+06	4	4
3rd Quartile	9.1E+06	4	4
Maximum	1.2E+08	11000	91

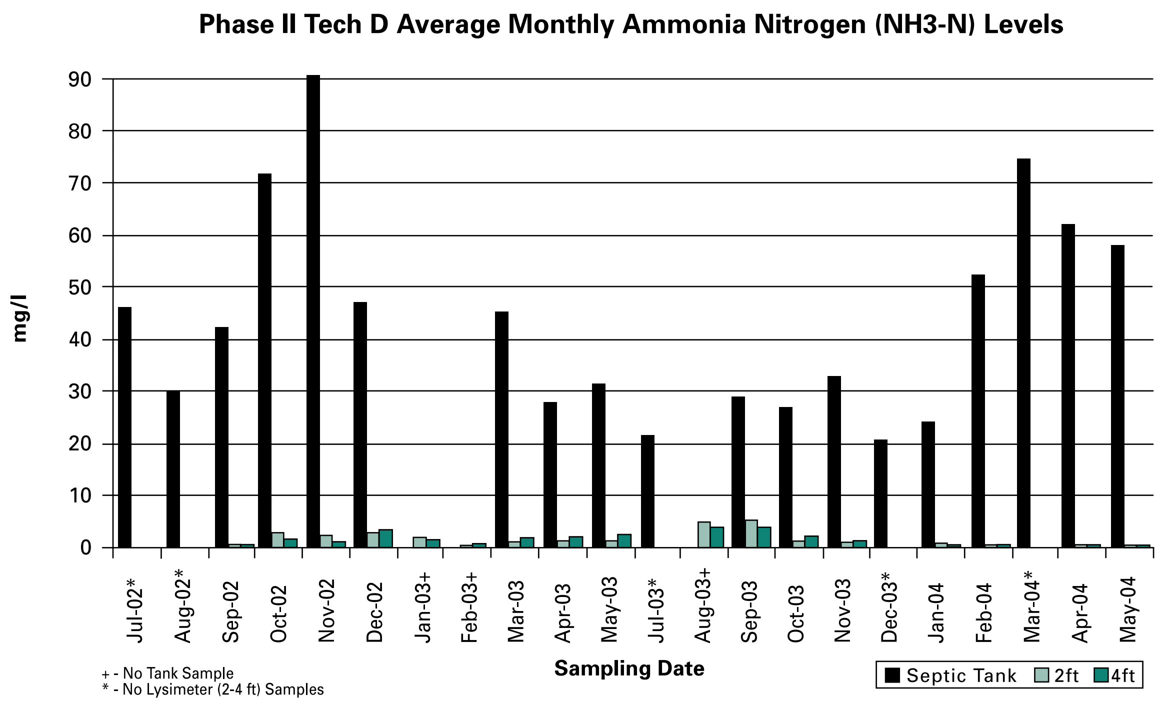
Phase II Tech D Monthly Geomean Fecal Strep (FS) Levels



FS (fecal strep): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to Tech D 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value indicated a significant difference between the two depths (p=.0001). The 2ft and 4ft mode or most frequent value was four col/100ml. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech D FS (colonies/100ml)

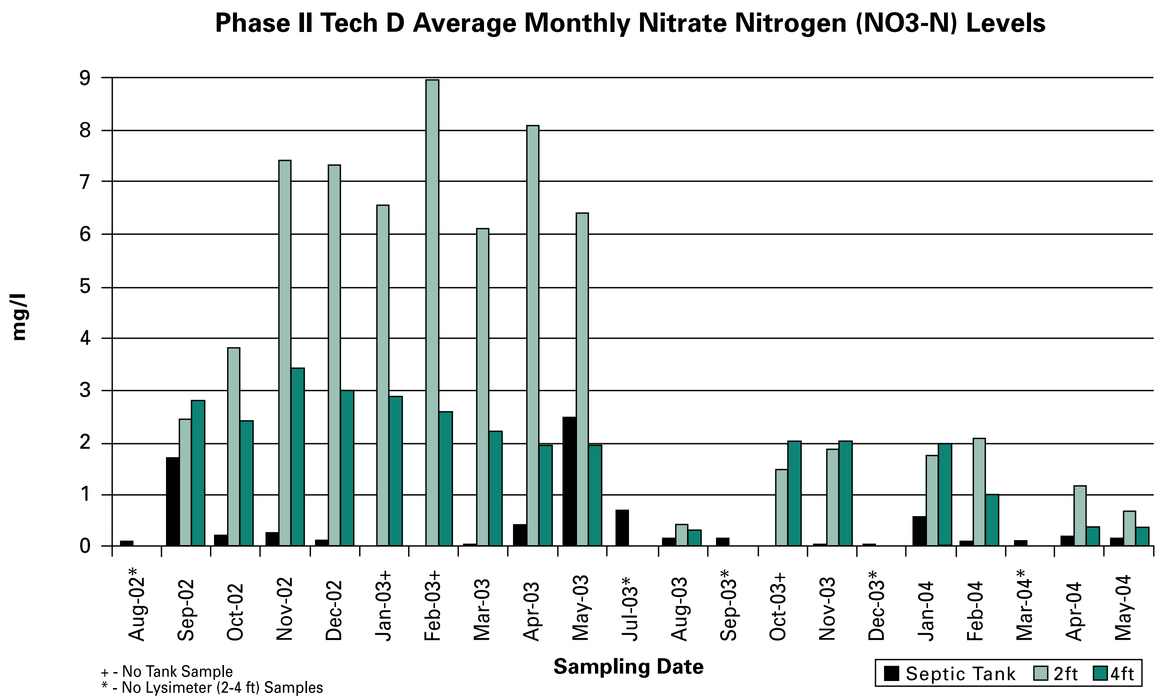
	Tank	DL 2ft	DL 4 ft
N	20	122	94
Minimum	90	4	4
1st Quartile	38250	4	4
Median	130000	4	4
3rd Quartile	285000	91	4
Maximum	540000	7200	91



NH3-N (ammonia nitrogen): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to Tech D 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.2498) indicated no significant difference between the two depths. The maximum NH3-N levels were recorded in Nov 2002 for the septic tank and in Sept 2003 for the 2ft and 4ft depths. The majority of 2ft and 4ft NH3-N levels were below 3mg/l. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech D NH3-N (mg/l)

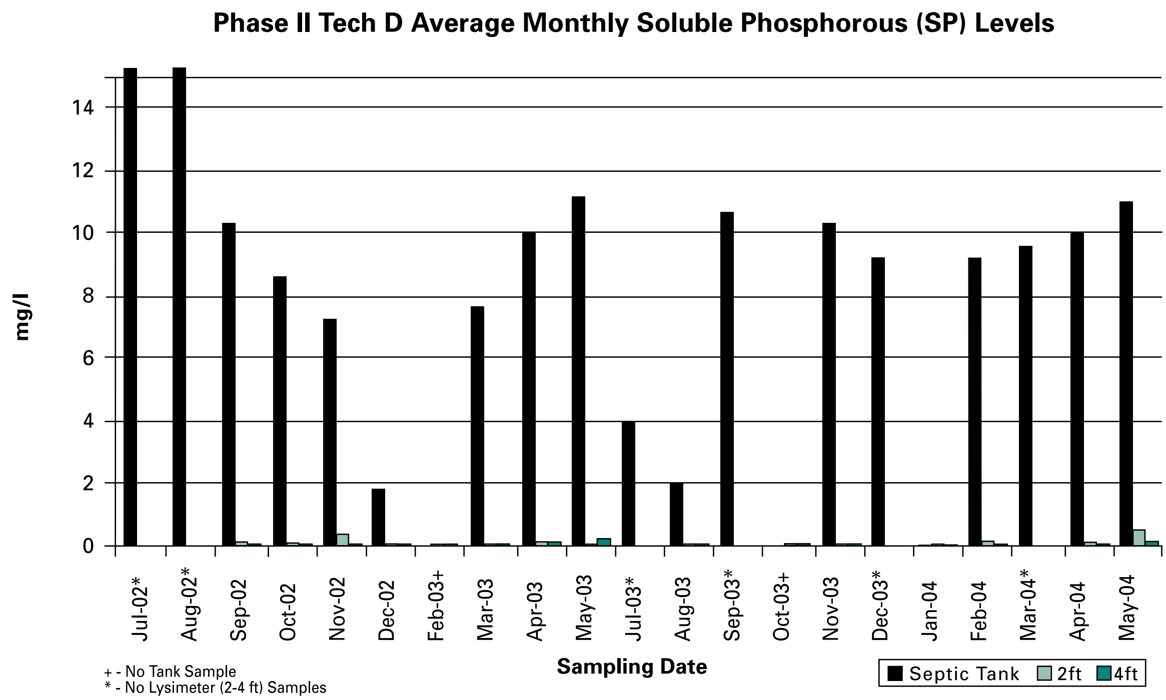
	Tank	DL 2ft	DL 4 ft
N	19	128	93
Minimum	20.16	0.00	0.02
1st Quartile	27.84	0.36	0.49
Median	42.34	1.03	1.10
3rd Quartile	57.77	2.26	2.22
Maximum	90.38	11.04	10.56



NO3-N (nitrate nitrogen): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to Tech D 2ft and 4ft lysimeter depths (p=.0000, p=.0024) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value indicated a significant difference between the two depths (p=.0012). There were higher than usual NO3-N levels for the septic tank in Sept 2002 (1.67mg/l) and in May 2003 (2.51mg/l). The majority of tank NO3-N levels were below .7mg/l. There were higher than usual NO3-N levels at the 2ft depth in May 2003 and at the 4ft depth in Mar 2003 (maximums). NO3-N levels exceeded the PA water quality criterion of 10mg/l (Pa Code, Ch93) 18:121 times (15%) at the 2ft depth and 2:88 times (2%) at the 4ft depth. The median or measure of center increased from the septic tank to the 2ft depth then a decrease at the 4ft depth. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech D NO3-N (mg/l)

	Tank	DL 2ft	DL 4 ft
N	18	121	88
Minimum	0.01	0.07	0.09
1st Quartile	0.10	0.26	0.18
Median	0.16	1.67	0.51
3rd Quartile	0.48	7.17	2.18
Maximum	2.51	18.62	10.88



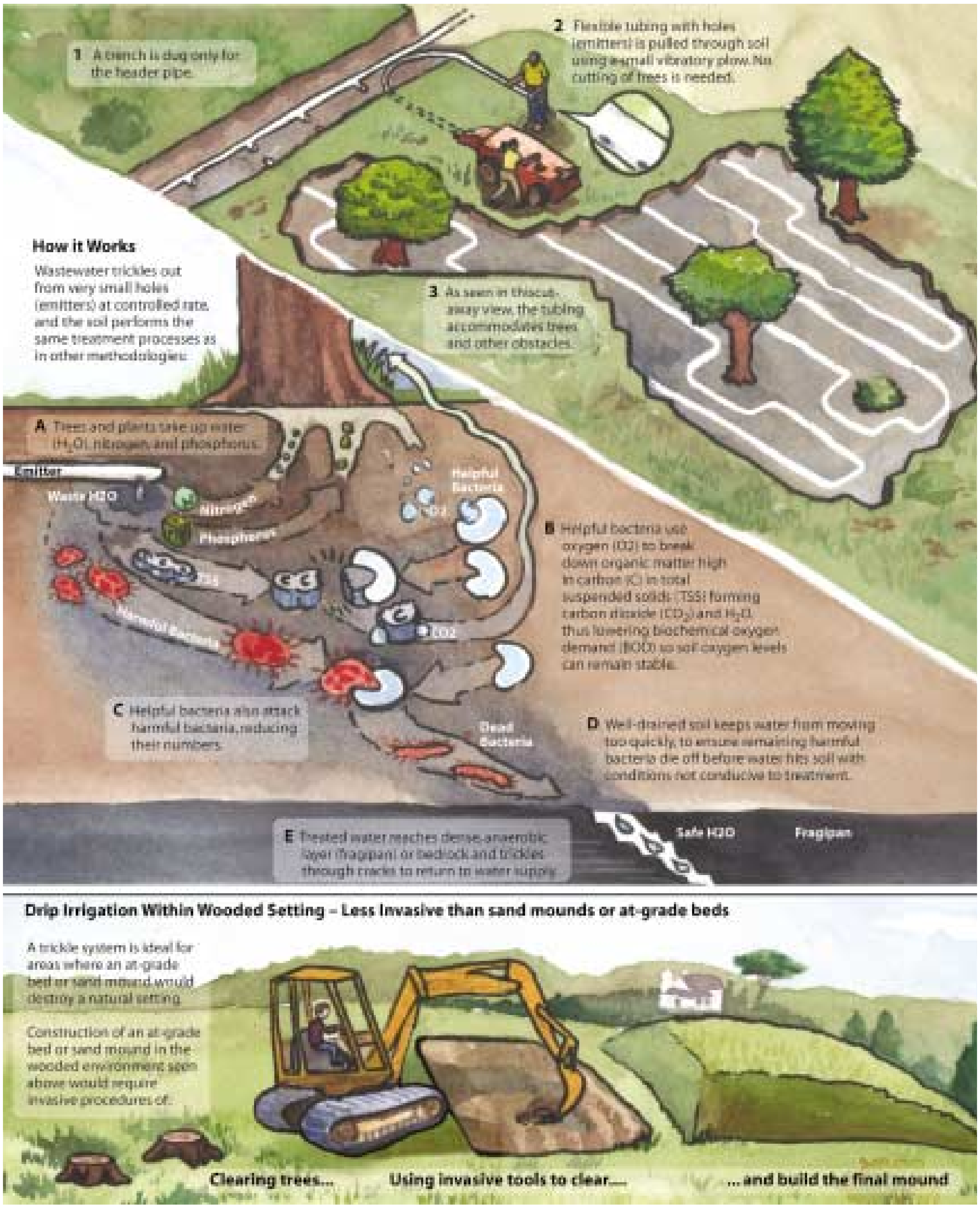
SP (soluble phosphorus): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to the 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.0766) indicated no significant difference between the two depths. A higher than usual SP level was recorded in Nov 2002 at the 2ft depth and in May 2004 at the 4ft depth. The majority of lysimeter SP readings are below .07mg/l with a mode of .03mg/l. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech D SP (mg/l)

	Tank	DL 2ft	DL 4 ft
N	17	113	82
Minimum	0.00	0.00	0.00
1st Quartile	5.63	0.01	0.01
Median	9.21	0.03	0.03
3rd Quartile	10.29	0.06	0.03
Maximum	11.10	2.28	0.46

Drip Irrigation in a Wooded Setting

While not able to be used in dense woods, drip irrigation can be used in areas where several trees are present. This system introduces a smaller amount of water to a larger surface area over a longer period of time, creating a more controlled environment in which to maintain oxygen levels in soil to increase effectiveness of treatment.



Technology E:

This **subsurface drip irrigation system** received effluent from the campus sewer system. Septic tank effluent was dosed via drip tubing onto the soil absorption areas of the trickle irrigation system. Prior to each dose, the disc filters were backwashed. The drip lines were automatically flushed after 20 doses.

- Two systems containing two 600 lineal foot zones.
- Drip tube depth: 8-10 inches below the surface.
- Dosing cycle: Each zone is dosed five times per day; each system received approximately 400 gallons per day.

Drip tube installation

Ends of installed drip tubing

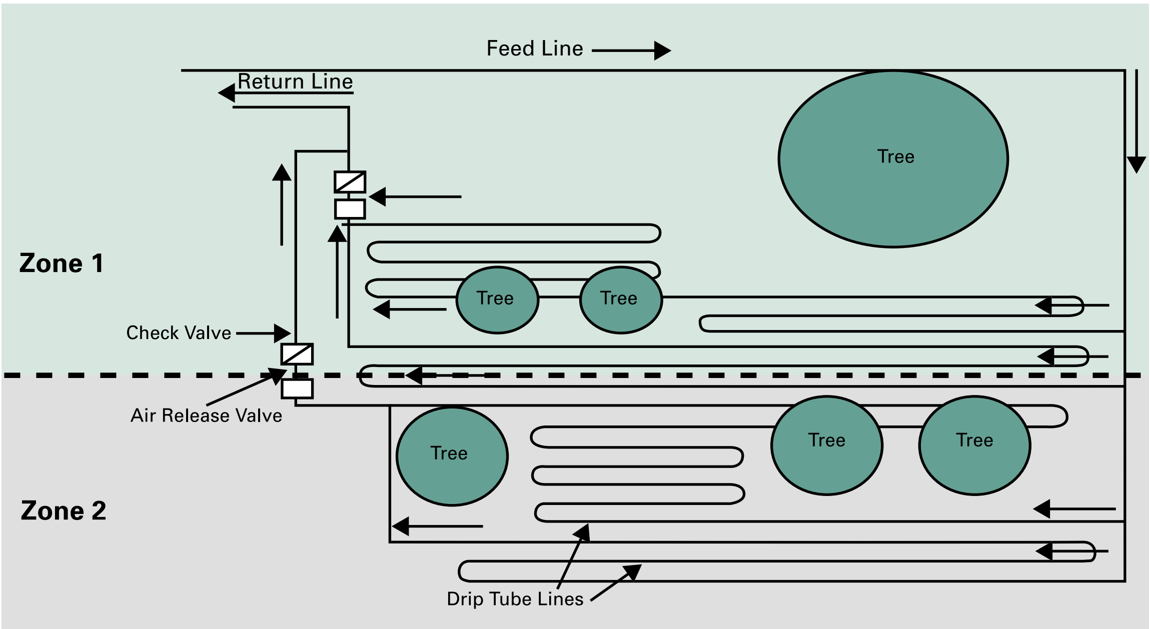
Technology E: Soil and Site Conditions

Readington series, moderately well drained. Common distinct mottles and a fragipan at 25" beneath the surface.

- Limiting zone: 25 inches.
- Slope: 18.4 to 24.3%
- Percolation rate: Average 20.1 to 58.4 minutes per inch. Range was 2.8 minutes per inch to 120 minutes per inch.
- Hydraulic conductivity: 9.9 to 17.6 cm/day.

Drip irrigation on a 24% slope

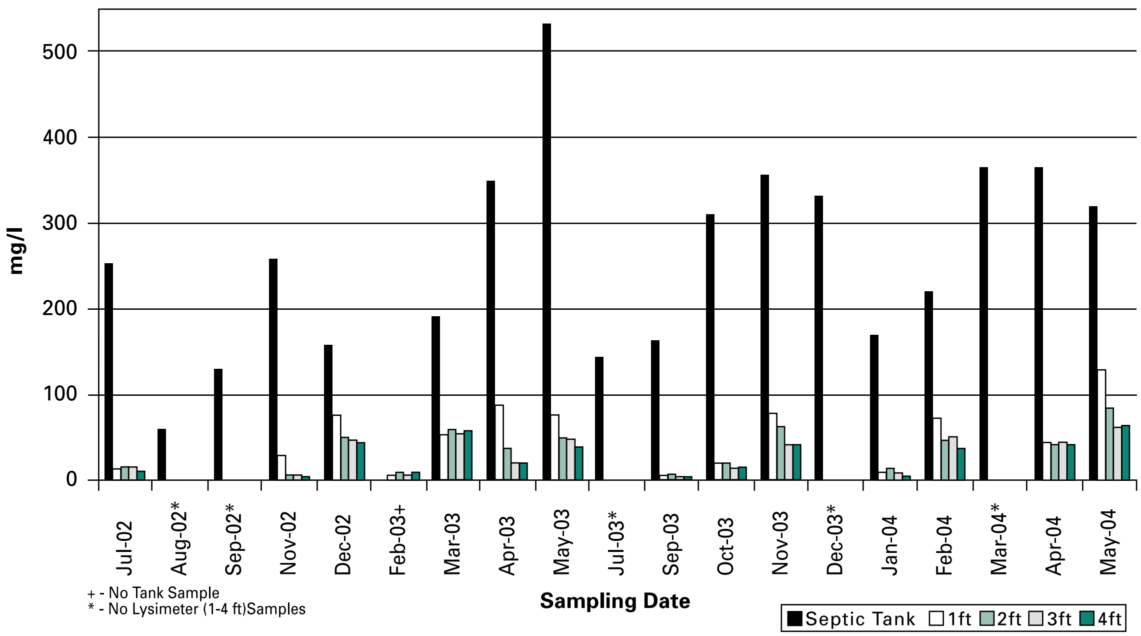
Technology E: Subsurface Drip Irrigation System



Technology E: Test Results

Lab results for wastewater samples collected monthly from the septic tank and the soil absorption beds at 1ft, 2ft, 3ft and 4ft depths were examined using graphs, descriptive statistics, and hypothesis testing. Non-parametric tests were used and the preset alpha of .05 determined whether the null hypothesis of no significant difference was accepted or rejected. See Statistical Analysis of Alternative Systems, page 5, for more detailed information.

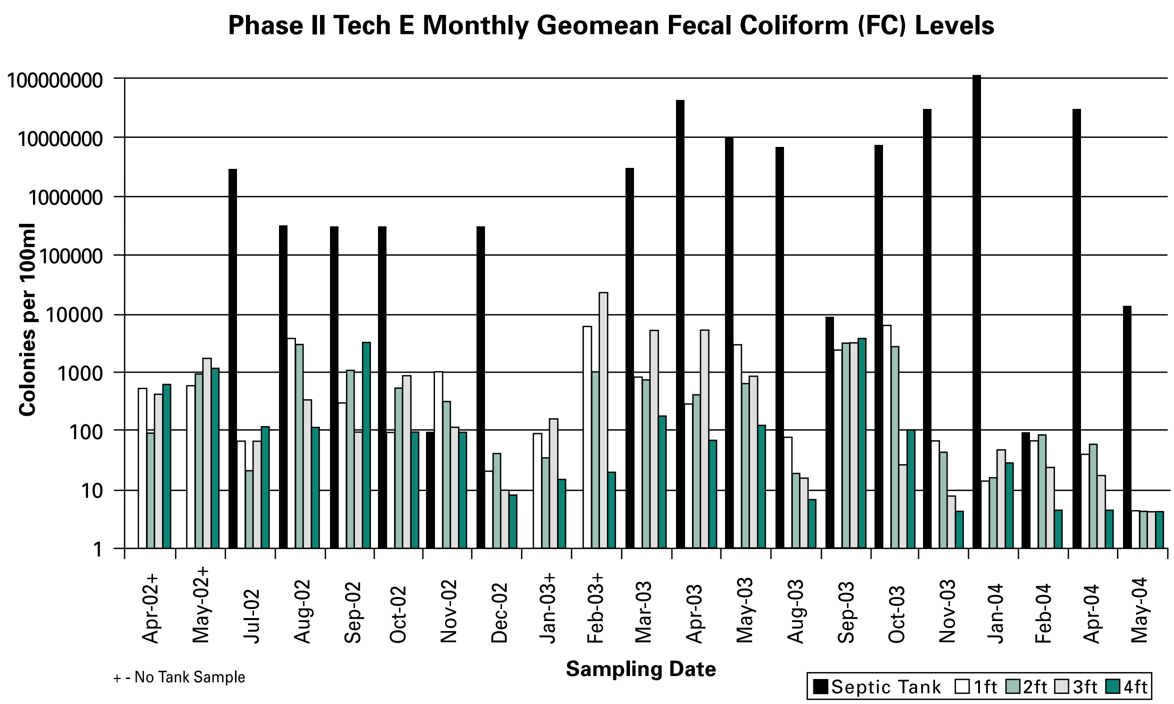
Phase II Tech E Average Monthly Biological Oxygen Demand (BOD) Levels



BOD (biological oxygen demand): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech E 1ft, 2ft, 3ft, and 4ft lysimeter depths (p=.0000, p=.0000, p=.0000, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated no significant difference among the four depths (p=.2483). Of the lysimeter depths, the majority of BOD levels were below 90mg/l only 1ft and 2ft saw BOD levels greater than 90mg/l. There were maximum BOD levels recorded in Dec 2002 for 1ft and in May 2003 for 2ft, 3ft, 4ft, and the septic tank. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech E BOD (mg/l)

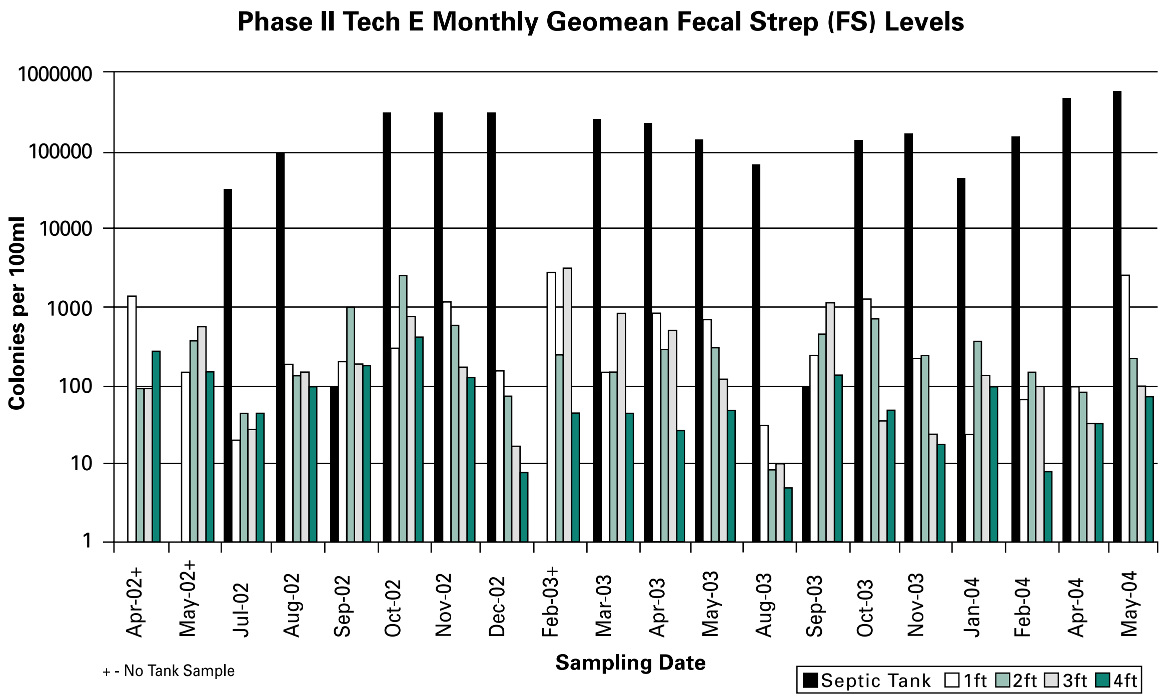
	Tank	EL 1ft	EL 2ft	EL 3ft	EL 4ft
N	18	67	68	59	49
Minimum	61.0	0.6	0.9	1.8	0.0
1st Quartile	160.7	10.8	13.1	8.4	8.8
Median	255.4	36.6	30.3	31.8	27.0
3rd Quartile	349.4	69.6	57.5	47.2	42.6
Maximum	531.6	230.3	151.2	79.2	88.8



FC (fecal coliform): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech E 1ft, 2ft, 3ft, and 4ft lysimeter depths (p=.0000, p=.0000, p=.0000, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated a significant difference among the four depths (p=.0069). The Pairwise Comparison Test indicated a significant difference between the 1ft and 4ft depths, with the 4ft depth being lower in value. FC counts were greater than 200 col/100ml, a PA water quality criterion (PA Code, Ch93 and Ch72.42) 49:108 times (45%) at 1ft, 42:93 times (45%) at 2ft, 35:90 times (39%) at 3ft, and 17:83 times (20%) at 4ft. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech E FC (colonies/100ml)

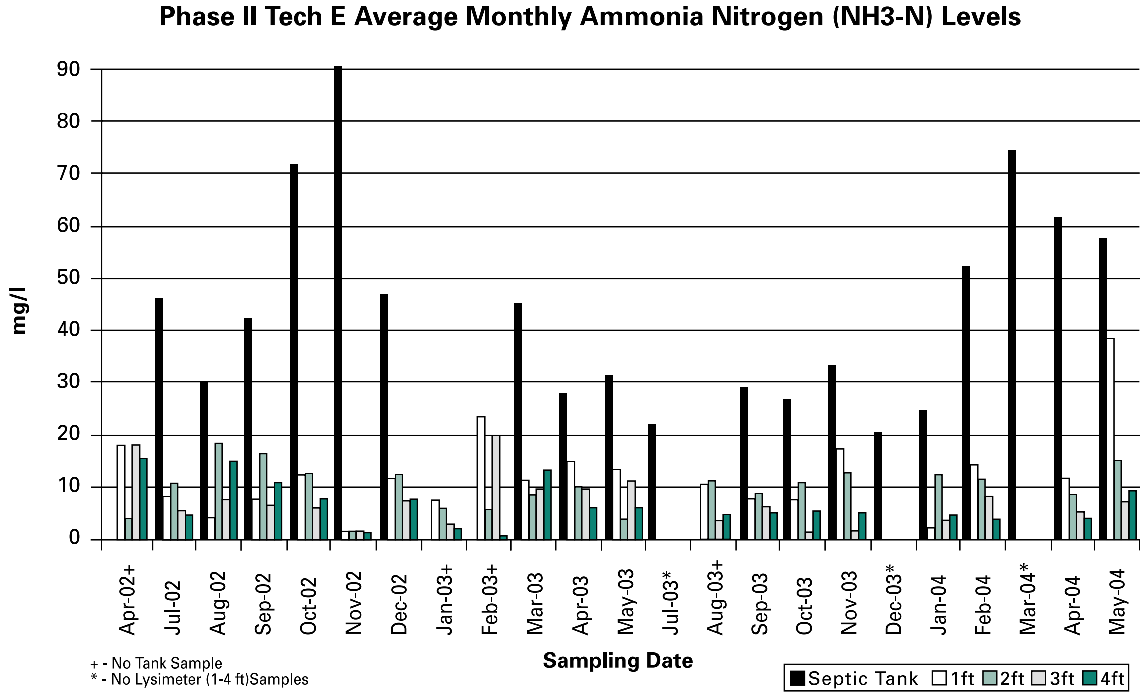
	Tank	EL 1ft	EL 2ft	EL 3ft	EL 4ft
N	20	108	93	90	83
Minimum	90	4	4	4	4
1st Quartile	171750	9	4	4	4
Median	2.7E+06	91	91	91	27
3rd Quartile	9.1E+06	3525	2450	2525	130
Maximum	1.2E+08	300000	220000	35000	30000



FS (fecal strep): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech E 1ft, 2ft, 3ft, and 4ft lysimeter depths (p=.0000, p=.0000, p=.0000, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated a significant difference among the four depths (p=.0001). The Pairwise Comparison Test indicated a significant difference between the 4ft and the 1ft and 2ft depths, with the 4ft depth being lower in value. The septic tank averages 10^5-10^4 colonies/100ml, 1ft, 2ft, and 3ft depths average 10^3-10^2 colonies/100ml and 4ft averages 10^2-10^1 colonies/100ml. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech E FS (colonies/100ml)

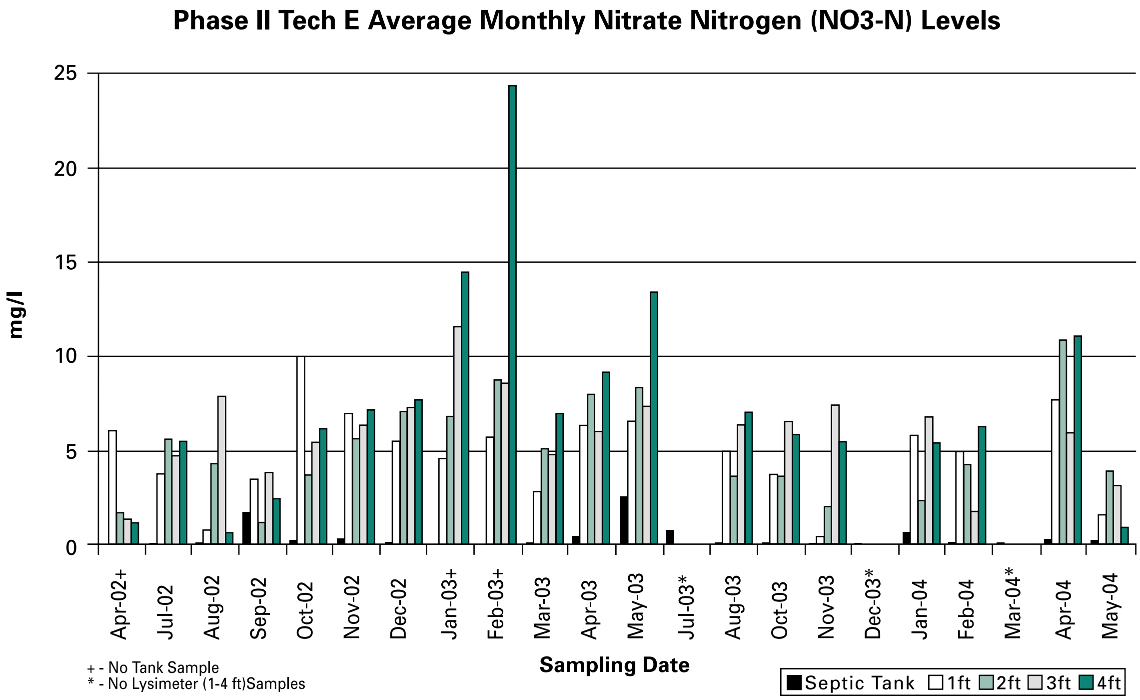
	Tank	EL 1ft	EL 2ft	EL 3ft	EL 4ft
N	20	101	96	85	77
Minimum	90	4	4	4	4
1st Quartile	38250	30	13	9	4
Median	140000	140	175	91	46
3rd Quartile	285000	2600	1975	980	101
Maximum	540000	43000	30000	30000	30000



NH3-N (ammonia nitrogen): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech E 1ft, 2ft, 3ft, and 4ft depths (p=.0000, p=.0000, p=.0000, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated no significant difference among the four depths (p=.1027). Of the lysimeter depths, a majority of the NH3-N levels were between 0-6mg/l. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech E NH3-N (mg/l)

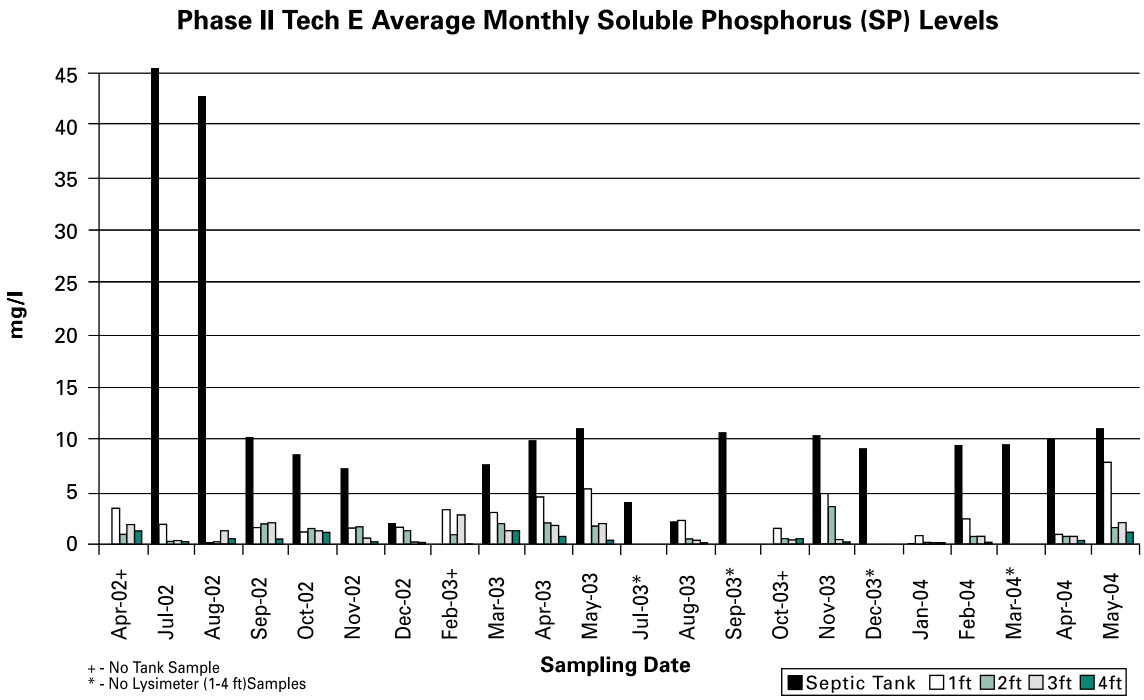
	Tank	EL 1ft	EL 2ft	EL 3ft	EL 4ft
N	19	95	85	76	59
Minimum	20.16	0.05	0.01	0.00	0.00
1st Quartile	27.84	0.72	0.48	0.59	0.59
Median	42.34	3.36	5.84	2.63	1.96
3rd Quartile	57.77	21.84	18.48	11.95	10.96
Maximum	90.38	51.91	42.72	40.71	29.16



NO3-N (nitrate nitrogen): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech E 1ft, 2ft, 3ft, and 4ft depths (p=.0000, p=.0000, p=.0000, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated no significant difference among the four depths (p=.4521). NO3-N levels exceeded the PA water quality criterion of 10mg/l (Pa Code, Ch93) 18:89 times (20%) for 1ft depth, 19:82 times (23%) for 2ft depth, 14:74 times (19%) for 3ft depth, and 20:60 times (33%) for 4ft depth. The median or measure of center increased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech E NO3-N (mg/l)

	Tank	EL 1ft	EL 2ft	EL 3ft	EL 4ft
N	18	89	82	74	60
Minimum	0.00	0.08	0.08	0.04	0.04
1st Quartile	0.09	0.69	0.41	1.02	0.71
Median	0.16	3.21	2.57	2.64	5.55
3rd Quartile	0.48	8.88	9.72	7.90	12.63
Maximum	2.51	26.54	23.98	33.00	31.00



SP (soluble phosphorus): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech E 1ft, 2ft, 3ft, and 4ft depths (p=.0000, p=.0000, p=.0000, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated a significant difference among the four depths (p=.0000). The Pairwise Comparison Test indicated a significant difference between the 4ft depth and the 1ft and 3ft depth. There were unusually high SP levels recorded for the septic tank in Jul 2002 and Aug 2002 (42.61mg/l, 67.31mg/l), all other levels were below 11mg/l. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech E SP (mg/l)

	Tank	EL 1ft	EL 2ft	EL 3ft	EL 4ft
N	19	82	76	69	55
Minimum	0.00	0.00	0.00	0.00	0.00
1st Quartile	7.26	0.07	0.03	0.13	0.03
Median	9.52	0.99	0.31	0.54	0.07
3rd Quartile	10.69	4.65	1.50	1.64	0.46
Maximum	67.31	12.31	7.24	5.26	4.86

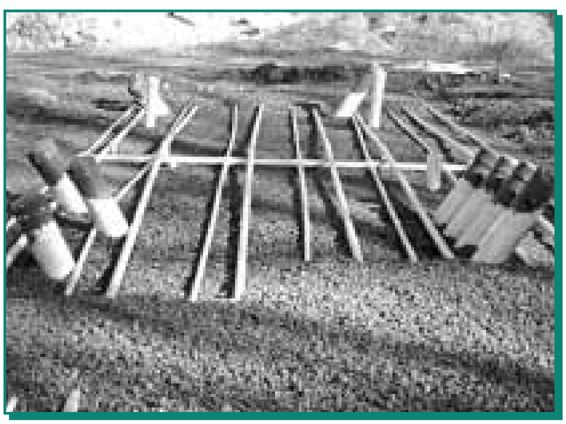
Technology F:

Three **at-grade pressure distribution systems** received septic tank quality effluent. Effluent from the campus sewer system was sent through two parallel 3000-gallon single compartment septic tanks. Effluent was then sent to a common pump chamber and timed dosed on the three at-grade pressure absorption areas four times per day.

- Dosing cycle: 4-75 gallon doses per day per system.
- Loading rate: 300 gallons per day per system.
- Bed size: 15x40 feet

A standard absorption bed design was used with the following changes initiated to improve effluent treatment.

- Additional PVC pipes added with decreased distance between pipes to provide a more even distribution of effluent (6ft spacing decreased to 2ft).
- 7 laterals with 19 holes per lateral = 133 holes total.
- 600 sq ft per 133 holes = 4.51 sq ft per hole.
- 1-inch PVC pipe with 1/8 in holes for dosing with optional switch to 2 inch PVC pipe with 1/4 in holes if clogging occurs.
- If 2-inch PVC pipes used, two lines are dosed at a time.
- Pressure gauges used to indicate clogged lines.



PVC distribution pipes

Tech F construction

Technology F: Soil and Site Conditions

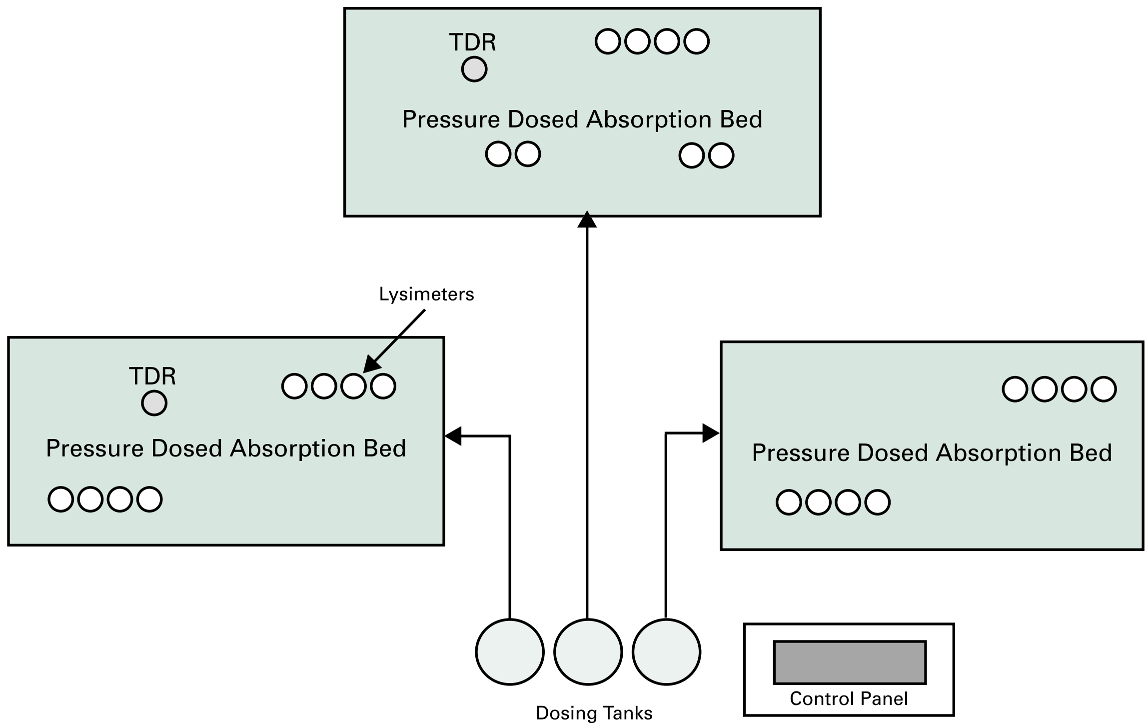
Lansdale series, deep well-drained soil; bedrock greater than 72" beneath the surface.

- Limiting zone: None to 72 inches.
- Slope: 1.6% to 8.5%
- Percolation rate: Average 11.5 to 18.3 minutes per inch.
  Range was 3.3 to 40 minutes per inch.
- Hydraulic conductivity: 26.4 to 103.3 cm/day.

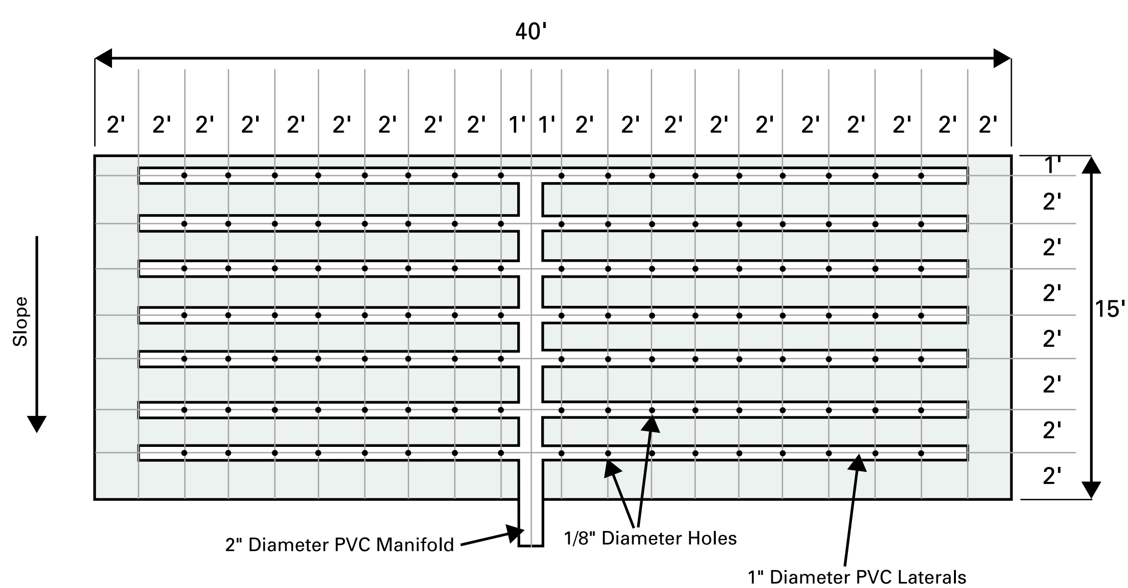
Profile being written for Tech F

At-grade beds after installation

Technology F: Timed Dose System Schematic



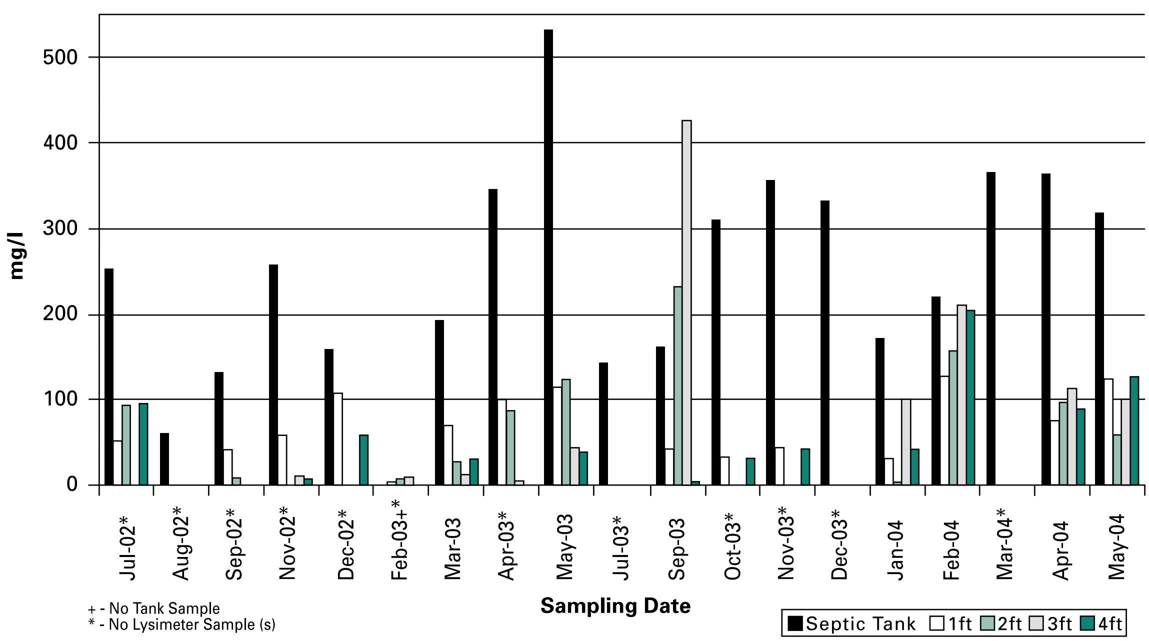
Technology F: Absorption Bed PVC Distribution Pipe Diagram



Technology F: Test Results

Lab results for wastewater samples collected monthly from the septic tank and the soil absorption beds at 1ft, 2ft, 3ft, and 4ft depths were examined using graphs, descriptive statistics, and hypothesis testing. Non-parametric tests were used and the preset alpha of .05 determined whether the null hypothesis of no significant difference was accepted or rejected. See Statistical Analysis of Alternative Systems, page 5, for more detailed information.

Phase II Tech F Average Monthly Biological Oxygen Demand (BOD) Levels

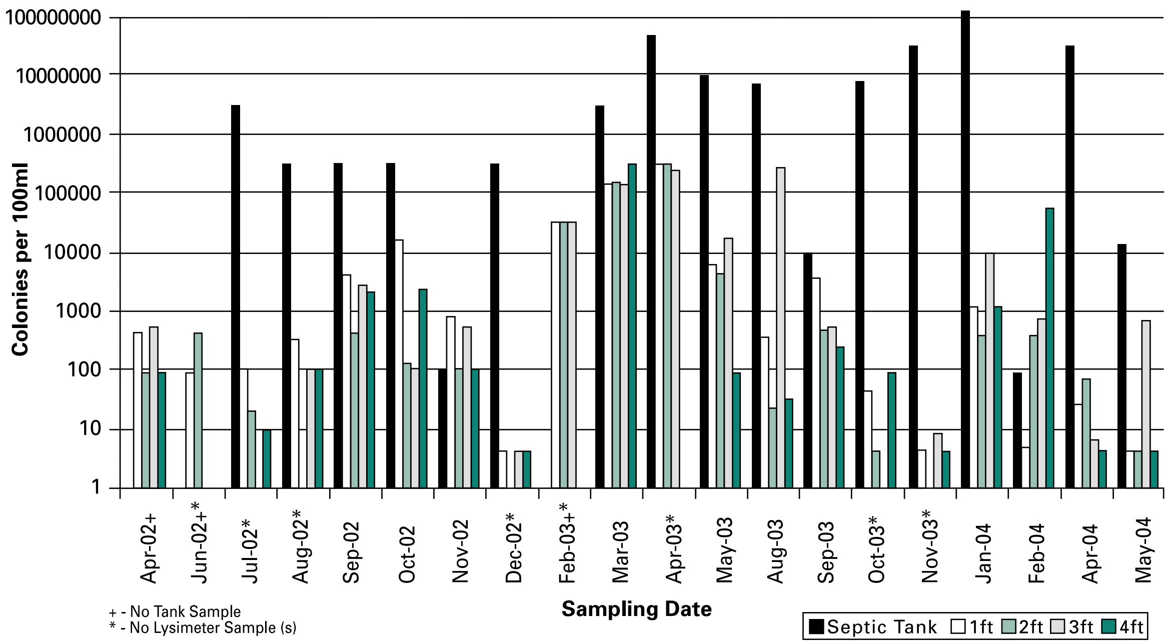


BOD (biological oxygen demand): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech F 1ft, 2ft, 3ft, and 4ft depths (p=.0000, p=.0001, p=.0013, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated no significant difference among the four depths (p=.8038). Higher than usual BOD levels were recorded in Apr 2003 at 1ft, in Sept 2003 at 2ft and 3ft, in Feb 2004 at 4ft, and in May 2003 for the septic tank (maximums). The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech F BOD (mg/l)

	Tank	FL 1ft	FL 2ft	FL 3ft	FL 4ft
N	18	38	18	11	19
Minimum	61.0	0.1	3.0	3.6	1.2
1st Quartile	160.7	33.9	8.1	8.3	9.0
Median	255.4	54.9	48.0	45.6	41.4
3rd Quartile	349.4	95.6	150.5	112.8	93.6
Maximum	531.6	217.8	454.8	426.6	203.4

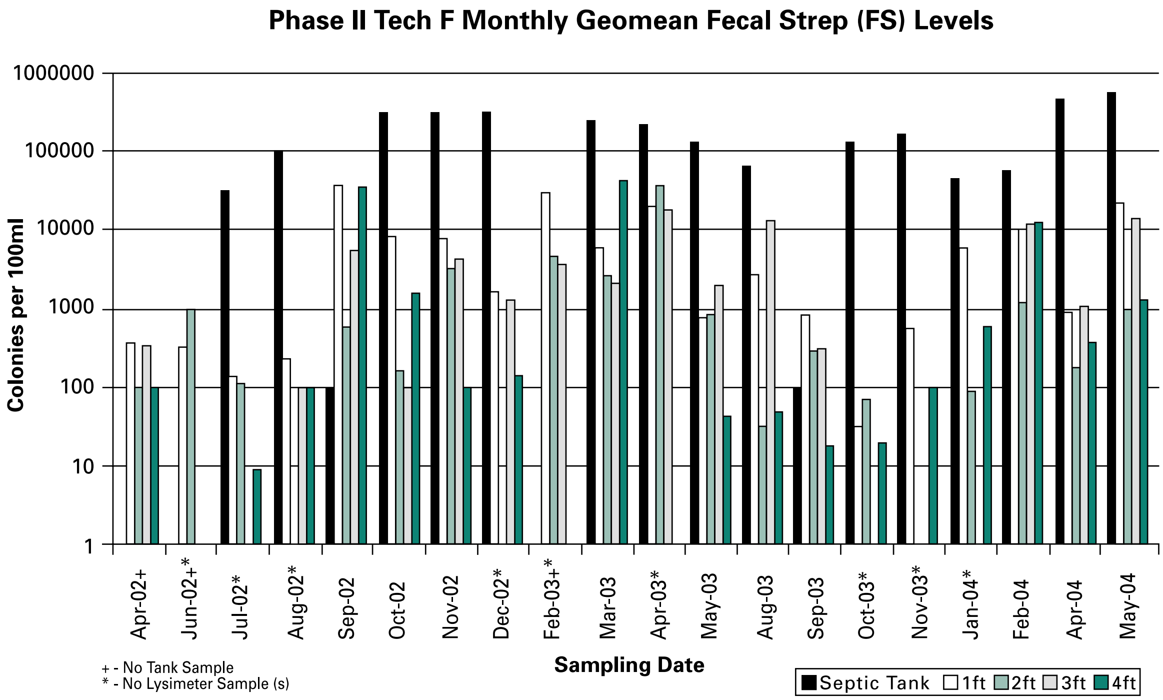
Phase II Tech F Monthly Geomean Fecal Coliform (FC) Levels



FC (fecal coliform): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech F 1ft, 2ft, 3ft, and 4ft depths (p=.0000, p=.0000, p=.0000, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated no significant difference among the four depths (p=.1119). FC counts were greater than 200 col/100ml, a PA water quality criterion (PA Code, Ch93 and Ch72.42) 32:56 times (57%) at 1ft, 14:32 times (44%) at 2ft, 15:25 times (60%) at 3ft, and 9:27 times (33%) at 4ft. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech F FC (colonies/100ml)

	Tank	FL 1ft	FL 2ft	FL 3ft	FL 4ft
N	20	56	32	25	27
Minimum	90	4	4	4	4
1st Quartile	171750	90	90	9	4
Median	2.7E+06	715	145	1200	90
3rd Quartile	9.1E+06	9350	4200	125000	2000
Maximum	1.2E+08	300000	300000	290000	300000

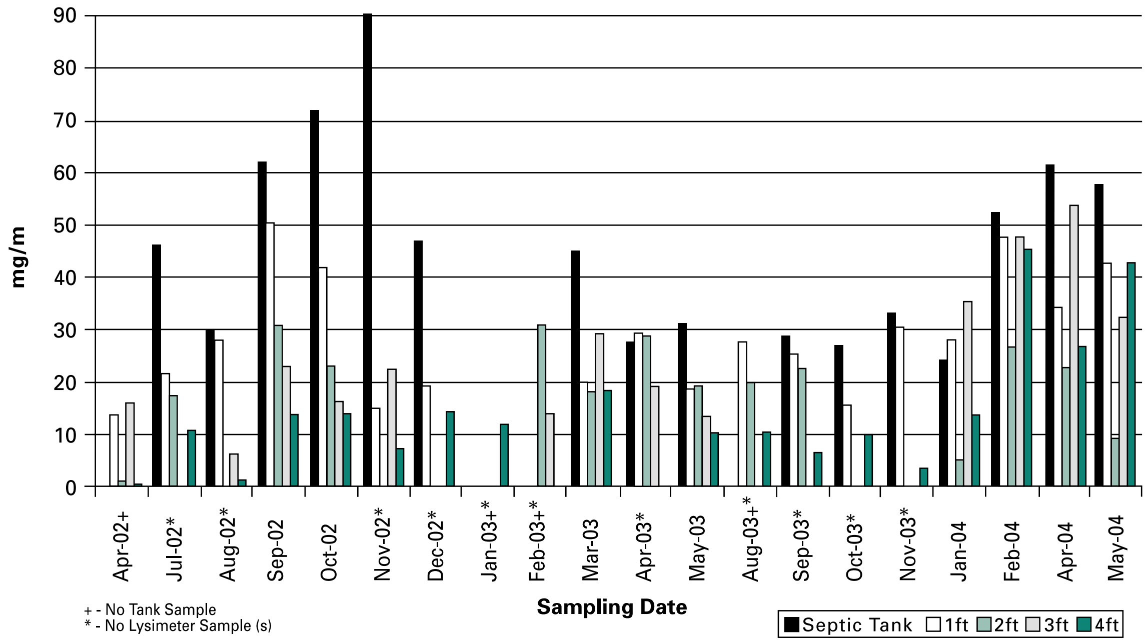


FS (fecal strep): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech F 1ft, 2ft, 3ft, and 4ft depths (p=.0000, p=.0000, p=.0000, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated a significant difference among the four depths (p=.0016). The Pairwise Comparison Test indicated a significant difference between the 1ft and 2ft and 4ft depths. There were higher than usual FS counts recorded at the 1ft depth in Oct 2002 and at the 2ft depth in Apr 2003. The septic tank recorded lower than usual FS counts in Sept 2002 and 2003. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech F FS (colonies/100ml)

	Tank	FL 1ft	FL 2ft	FL 3ft	FL 4ft
N	20	55	32	20	27
Minimum	90	4	9	9	4
1st Quartile	38250	270	90	235	19
Median	130000	2700	235	3800	91
3rd Quartile	285000	20000	2800	12200	4300
Maximum	540000	190000	120000	18000	42000

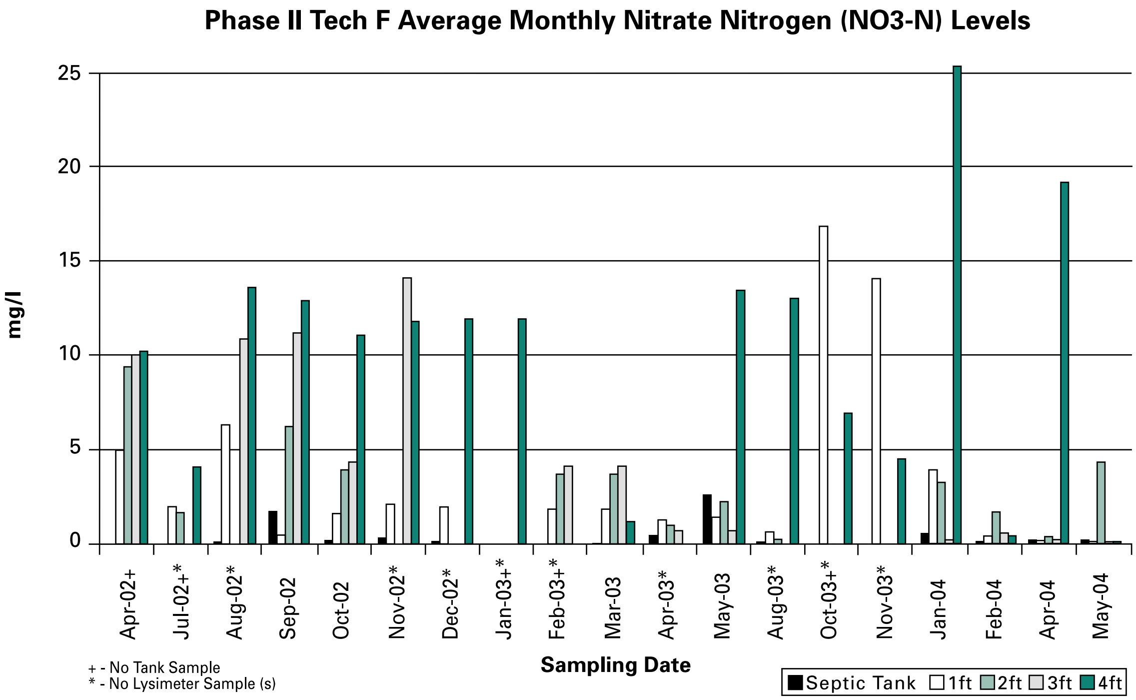
Phase II Tech F Average Monthly Ammonia Nitrogen (NH3-N) Levels



NH3-N (ammonia nitrogen): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech F 1ft, 2ft, 3ft, and 4ft depths (p=.0094, p=.0002, p=.0060, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated a significant difference among the four depths (p=.0017). The Pairwise Comparison Test indicated a significant difference between the 1ft and 4ft depths. The majority of lysimeter NH3-N levels were below 40mg/l. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech F NH3-N (mg/l)

	Tank	FL 1ft	FL 2ft	FL 3ft	FL 4ft
N	19	52	22	16	29
Minimum	20.16	0.02	0.16	0.18	0.00
1st Quartile	27.84	18.00	11.60	13.23	2.16
Median	42.34	29.85	21.35	21.89	9.60
3rd Quartile	57.77	38.43	29.60	34.60	20.81
Maximum	90.38	67.60	42.12	53.99	49.90

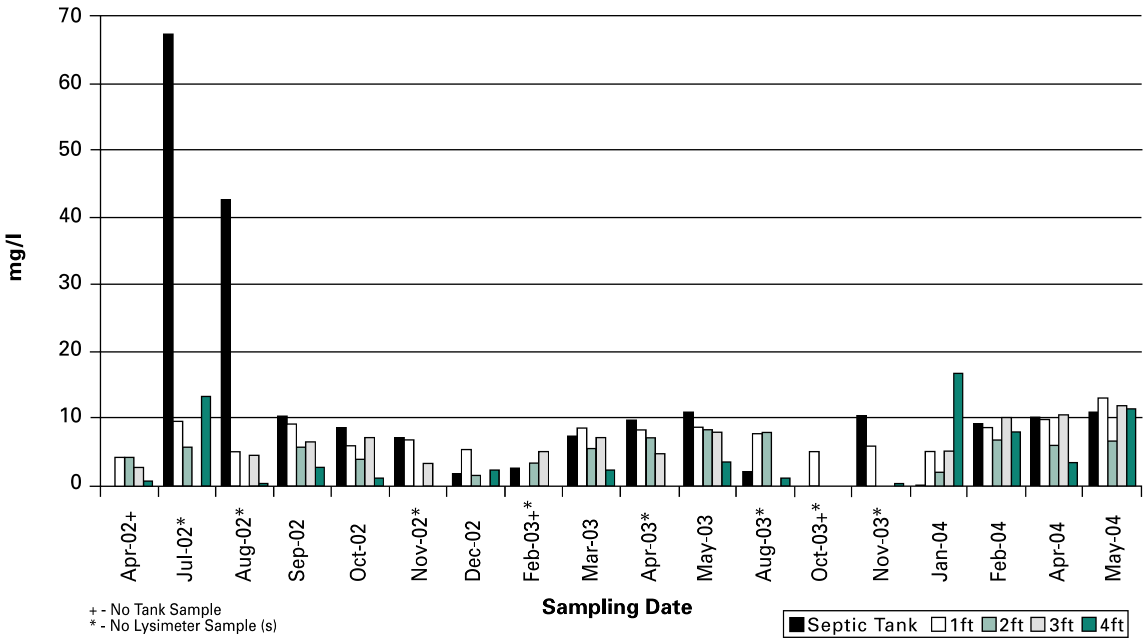


NO3-N (nitrate nitrogen): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech F 1ft, 2ft, 3ft, and 4ft depths (p=.0037, p=.0002, p=.0027, p=.0000) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated a significant difference among the four depths (p=.0021). The Pairwise Comparison Test indicated a significant difference between the 4ft and 1ft depths. NO3-N levels exceeded the PA water quality criterion of 10mg/l (Pa Code, Ch93) 5:49 times (10%) for 1ft depth, 2:21times (10%) for 2ft depth, 5:16 times (31%) for 3ft depth, 12:27 times (44%) for 4ft depth and 0:18 (0%) for the septic tank. There were higher than usual NO3-N levels recorded at the 1ft depth in Oct 2003 and at the 4ft depth in Jan 2004. The median or measure of center increased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech F NO3-N (mg/l)

	Tank	FL 1ft	FL 2ft	FL 3ft	FL 4ft
N	18	49	21	16	27
Minimum	0.01	0.04	0.10	0.10	0.13
1st Quartile	0.10	0.22	0.42	0.32	0.78
Median	0.16	0.56	1.71	2.40	7.69
3rd Quartile	0.48	1.62	3.97	10.65	13.53
Maximum	2.51	34.59	12.93	14.04	54.86

Phase II Tech F Average Monthly Soluble Phosphorus (SP) Levels



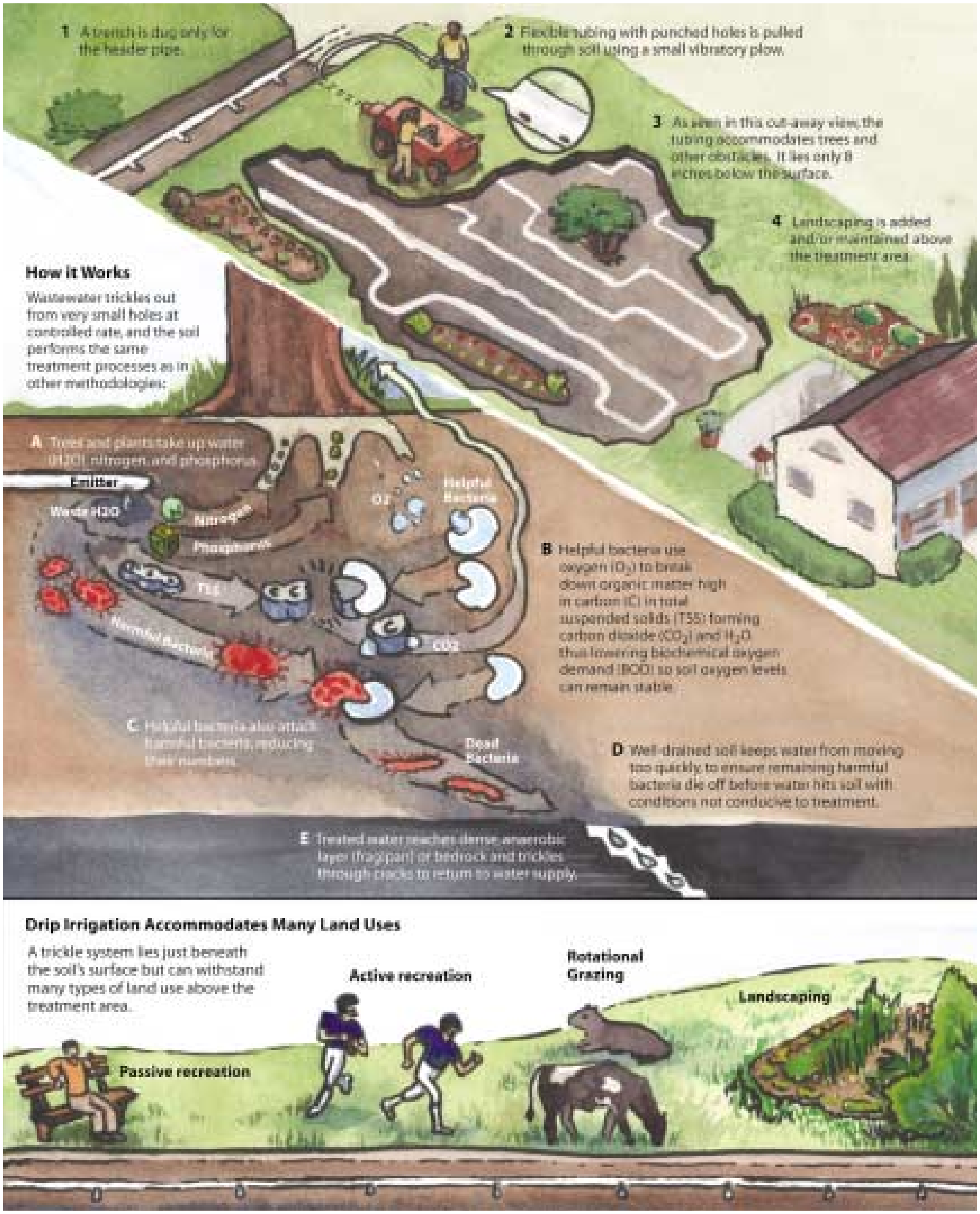
SP (soluble phosphorus): The Wilcoxon calculated p-values for the comparison of the septic tank to Tech F 1ft, 2ft, 3ft, and 4ft depths (p=.0418, p=.0018, p=.0225, p=.0015) indicated a significant difference between the effluent quality of the compared sites. When comparing the lysimeter depths (1ft, 2ft, 3ft, 4ft), the Kruskal-Wallis calculated p-value indicated a significant difference among the four depths (p=.0001). The Pairwise Comparison Test indicated a significant difference between the 1ft and 4ft depths. The majority of SP levels were below 10mg/l. There were higher than usual SP levels recorded at the 4ft level in July 2002 and Apr 2004 (30.86mg/l, 26.79mg/l) and at the septic tank in July 2002 (67.31mg/l). The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for Tech F SP (mg/l)

	Tank	FL 1ft	FL 2ft	FL 3ft	FL 4ft
N	19.00	50	22	17	26
Minimum	0.00	0.07	1.59	0.06	0.01
1st Quartile	7.26	5.39	4.04	2.60	0.09
Median	9.52	7.60	5.98	6.49	1.68
3rd Quartile	10.69	9.31	7.06	7.72	6.24
Maximum	67.31	13.35	9.04	11.92	30.86

Drip Irrigation in a Landscape Setting

Similar to drip irrigation technology used in a wooded setting, a trickle system can be used to maintain the beauty and land use of a home or park.



Community Systems:

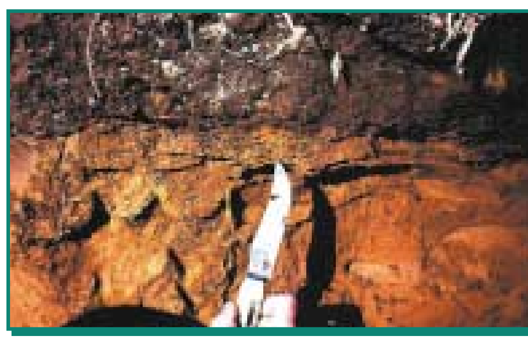
These **subsurface drip irrigation systems** received septic tank effluent that was dosed onto four drip fields each 15000 sq. ft. that represented the following areas: aerated turf, non-aerated turf, pasture, and crops. Installation specifics are as follows:

- Drip tubing installed at a depth of 9-11 inches.
- Drip tube spacing at 2 ft. apart.
- Loading rate: .08gpd/sq. ft. or .9in/wk during months of May-Nov. and .04gpd/sq. ft. during months of Dec.-Apr.
- Dosing rate: each zone was dosed 3 times per day at .026gal/sq. ft. per dose during months of May-Nov. and .013gal/sq. ft. per dose during months of Dec.-Apr.
- The non-aerated turf and pasture systems utilized Netafim drip tubing that was forward flushed every 50 cycles.
- The aerated turf system utilized Rainbird drip tubing that was continually forward flushed.
- To maintain aerated conditions, a constant flow of air was blown through the 8100 ft. of Rainbird tubing at 127cfm.
- The cropland zones utilized Geoflow drip tubing.
- Soil profile: Chalfont soil series with faint redox features at 11 inches, common distinct redox features at 18 inches, and a fragipan at 25 inches.

Community System Construction:

▲ 1. Soils are often compacted and need to be loosened for systems to operate successfully. Compacted soils do not allow air and water to move freely.

2. Typical "plow pan" of compacted soil from many years of agricultural operations: ▼



3. Subsoiling is the first step in breaking up the compaction that has gone deep into the profile. ▶

Community System Construction:

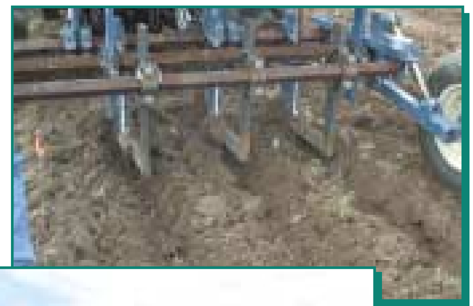
(Continued from Page 55)

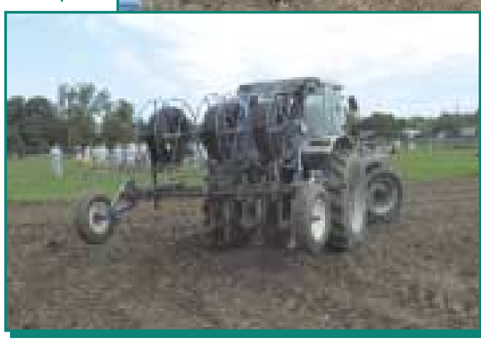
4. After subsoiling, chisel plowing will loosen compaction closer to the surface.

5. After chisel plowing, disking is done to smooth the surface

6. Soil structure now has a nice granular appearance for good air and water movement.

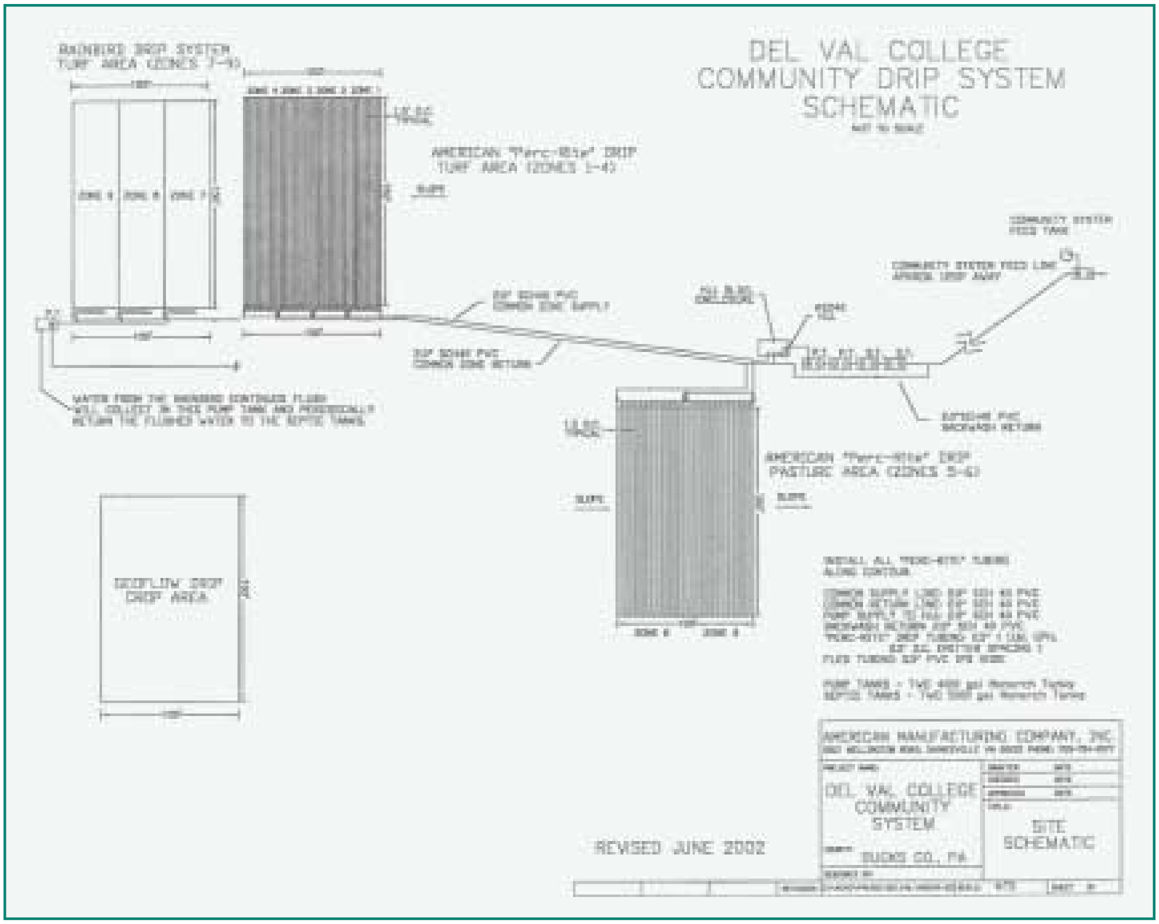
7. The drip tubing is then installed at 9 to 11 inches beneath the surface.





8-9-10. Drip tubing being installed

Community System Schematic:

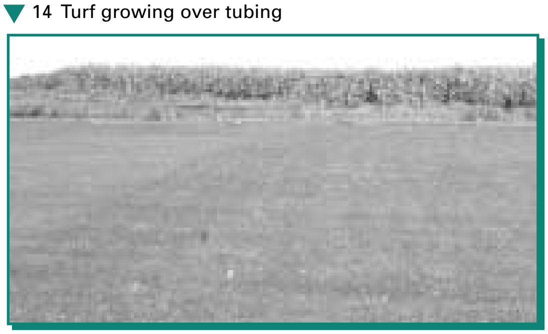


▲ 11. Connecting feed and return lines that supply wastewater to the tubing.

▲ 12. Preparing the soil over the tubing for seeding.

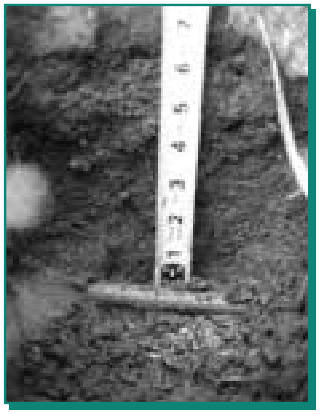
▲ 13. Seed being broadcast over the tubing areas.

▼ 14 Turf growing over tubing



Community System Construction:

(Continued from Page 57)



15. Tubing emitting wastewater

16. Sampling lysimeters over turf areas.

17. Installing tubing in the pasture area.

19. Cows grazing over wastewater area.

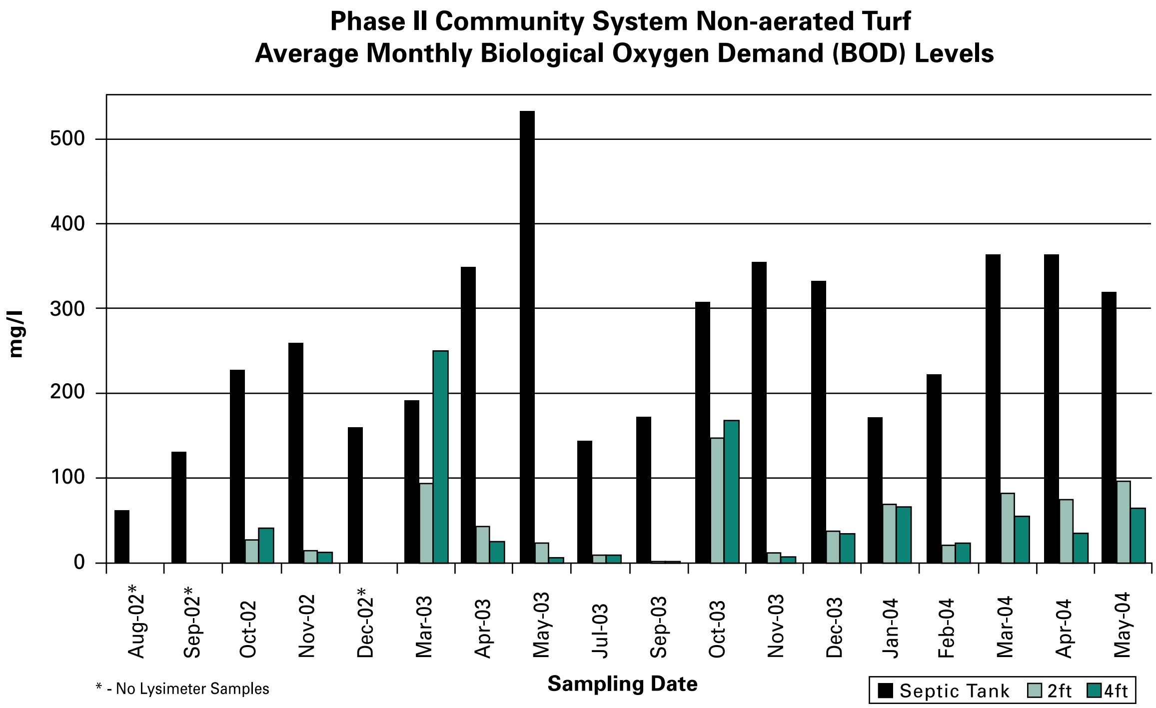
18. Tubing installed in the pasture.

20. Area receiving wastewater is much greener in the summer compared to the rest of the pasture.

21. No-till corn being planted in cropland area over tubing.

Community System Non-Aerated Turf: Test Results

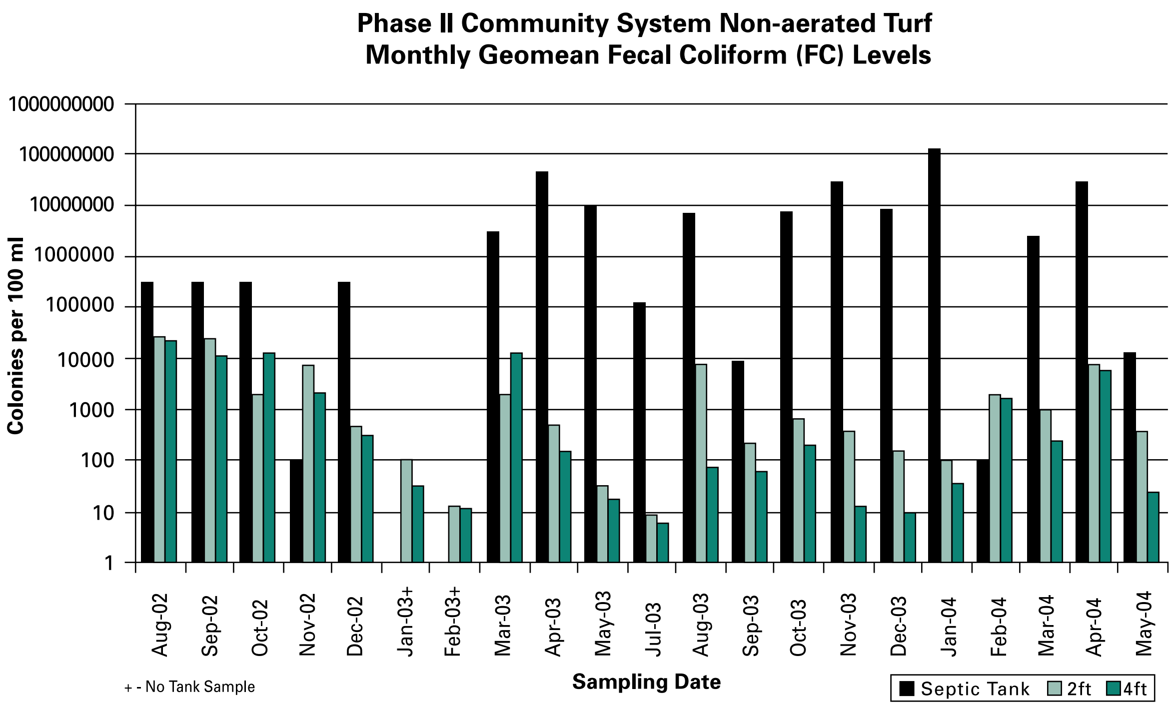
Lab results for wastewater samples collected monthly from the septic tank and the soil absorption beds at 2ft and 4ft depths were examined using graphs, descriptive statistics, and hypothesis testing. Non-parametric tests were used and the preset alpha of .05 determined whether the null hypothesis of no significant difference was accepted or rejected. See Statistical Analysis of Alternative Systems, page 5, for more detailed information.



BOD (biological oxygen demand): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS non-aerated turf 2ft and 4ft depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.3973) indicated no significant difference between the two depths. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Non-aerated Turf BOD (mg/l)

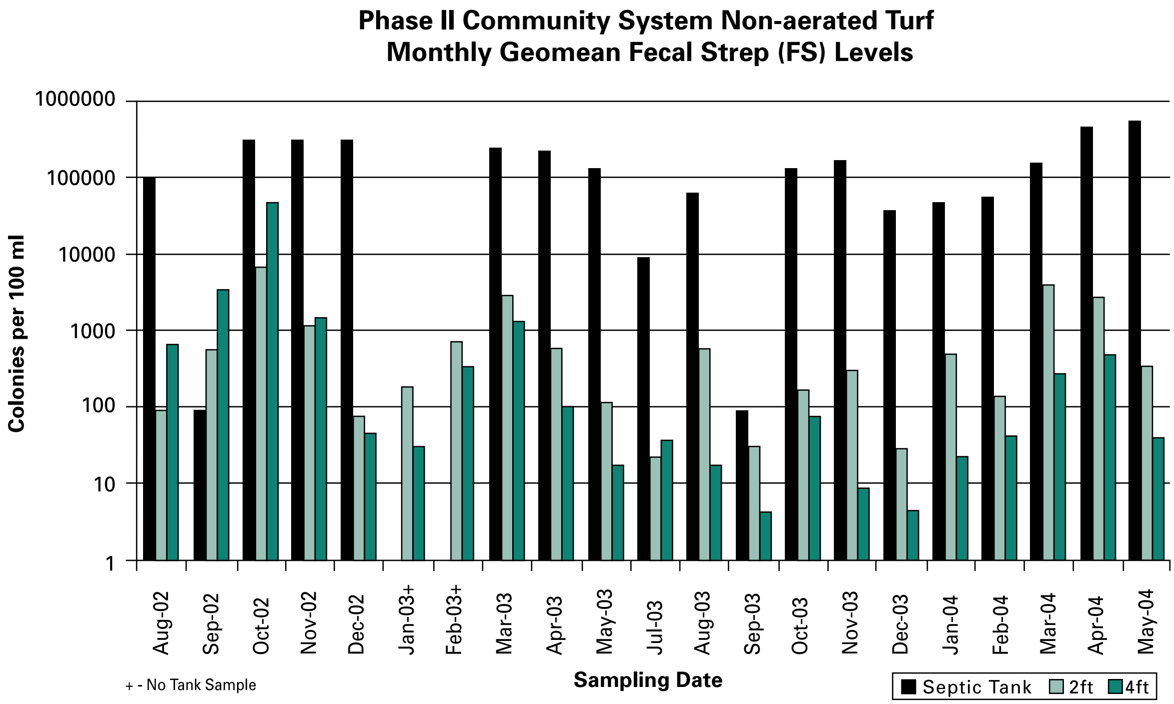
	Tank	AmT 2ft	AmT 4ft
N	19	94	70
Minimum	61	0	0
1st Quartile	170	8	6
Median	253	22	26
3rd Quartile	347	71	60
Maximum	532	471	474



FC (fecal coliform): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS non-aerated turf 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value indicated a significant difference between the two depths (p=.0020). The PA water quality criterion of 200 col/100ml was exceeded 82:137 times (60%) at 2ft and 49:117 times (42%) at 4ft depths (PA Code, Ch93, Ch72.42). The septic tank saw unusually low FC counts in Nov 2002 and in Feb 2004. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Non-aerated Turf FC (colonies/100ml)

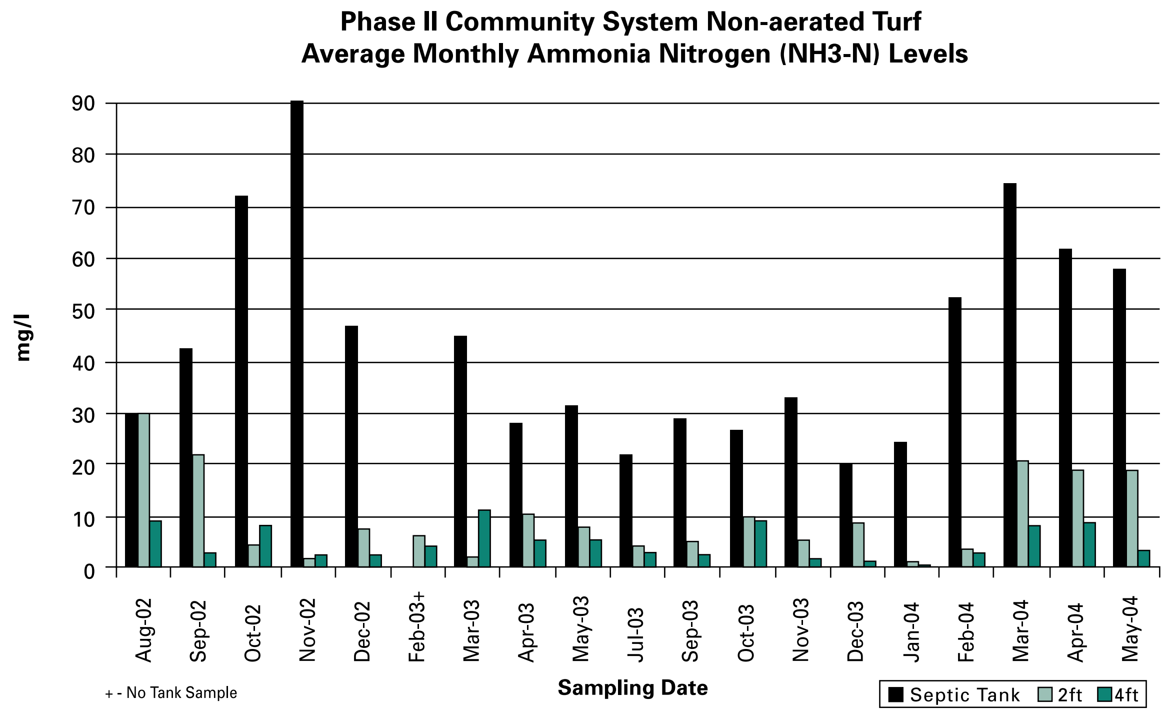
	Tank	AmT 2ft	AmT 4ft
N	19	137	117
Minimum	90	4	4
1st Quartile	129000	58	4
Median	2.4E+06	850	91
3rd Quartile	9.4E+06	15500	3250
Maximum	1.2E+08	300000	300000



FS (fecal strep): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS non-aerated turf 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value indicated a significant difference between the two depths (p=.0004). Lower than usual FS counts were recorded for the septic tank in Sept 2002 and 2003. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Non-aerated Turf FS (colonies/100ml)

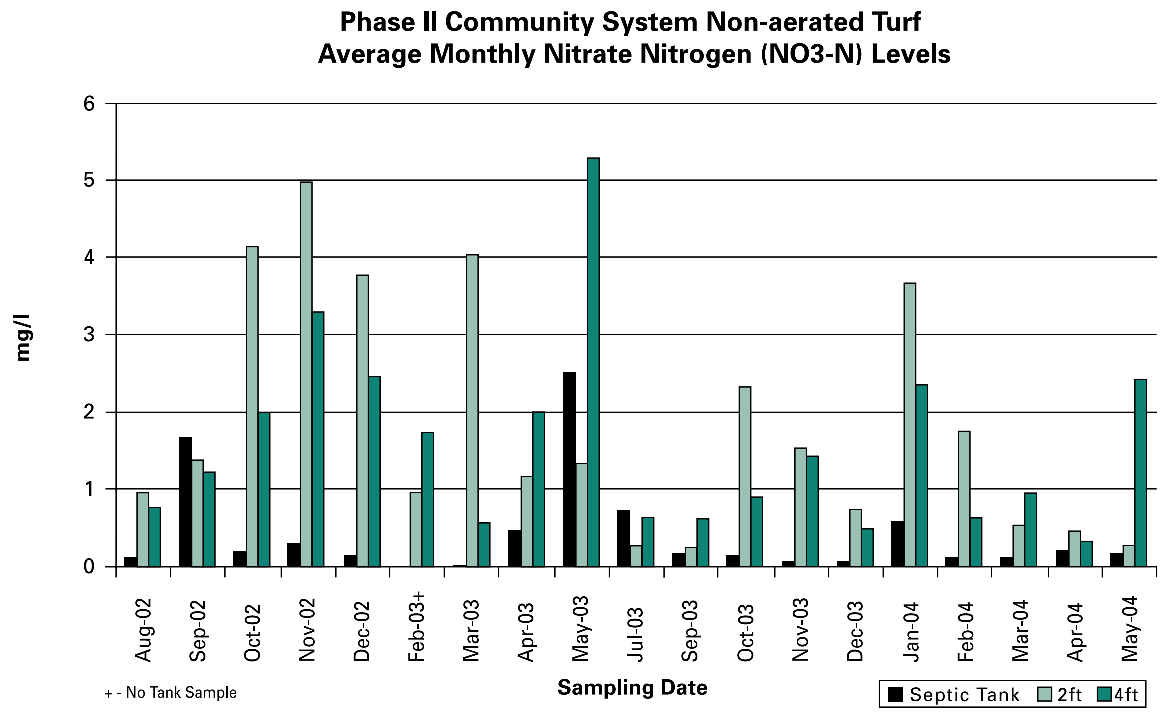
	Tank	AmT 2ft	AmT 4ft
N	19	129	107
Minimum	90	1	1
1st Quartile	45000	50	4
Median	130000	370	54
3rd Quartile	300000	1800	1300
Maximum	540000	160000	300000



NH3-N (ammonia nitrogen): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS non-aerated turf 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.0165) indicated a significant difference between the two depths. In Aug-Sept 2002 and Mar-May 2004, 2ft NH3-N levels were higher than the rest of the sampling period. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Non-aerated Turf NH3-N (mg/l)

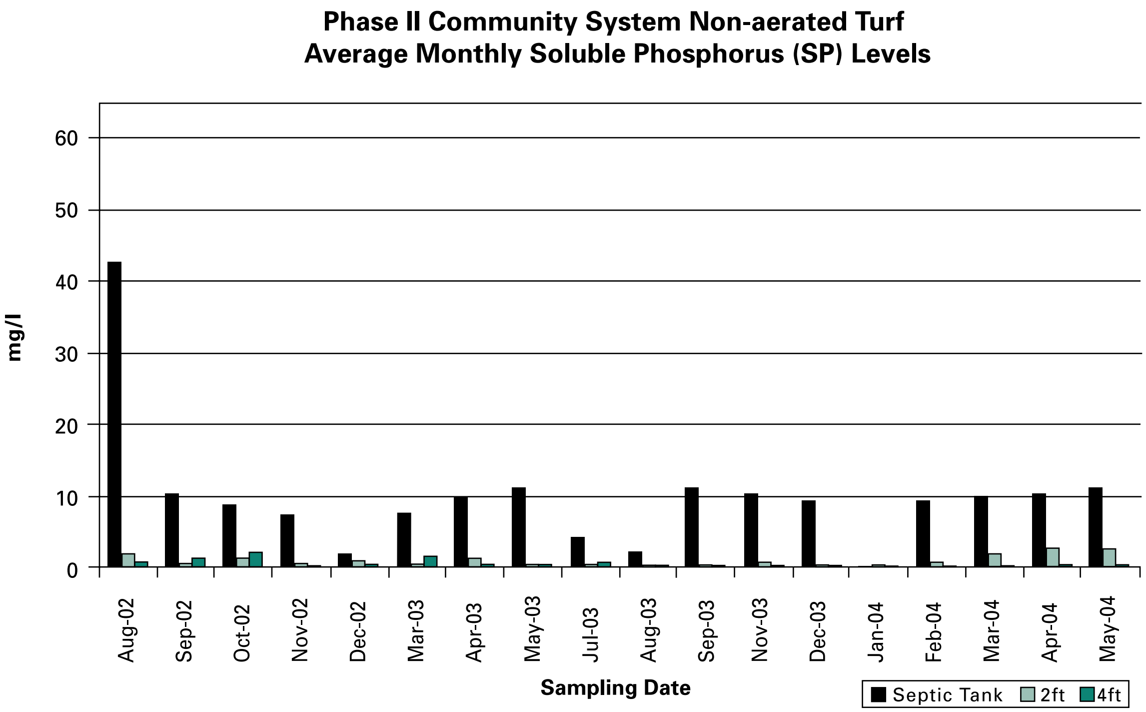
	Tank	AmT 2ft	AmT 4ft
N	19	111	83
Minimum	20.16	0.03	0.05
1st Quartile	27.84	0.84	0.48
Median	42.34	3.24	2.40
3rd Quartile	57.77	12.60	5.19
Maximum	90.38	56.76	33.57



NO3-N (nitrate nitrogen): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS non-aerated turf 2ft and 4ft lysimeter depths (p=.0015, p=.0007) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.6671) indicated no significant difference between the two depths. NO3-N levels exceeded the PA water quality criterion of 10mg/l (Pa Code, Ch93) 0:18 times (0%) for the septic tank, 3:115 times (3%) at the 2ft depth, and 2:85 times (2%) at the 4ft depth. The median or measure of center increased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Non-aerated Turf NO3-N (mg/l)

	Tank	AmT 2ft	AmT 4ft
N	18	115	85
Minimum	0.01	0.00	0.00
1st Quartile	0.10	0.22	0.27
Median	0.16	0.54	0.57
3rd Quartile	0.48	2.08	1.89
Maximum	2.51	15.05	23.72



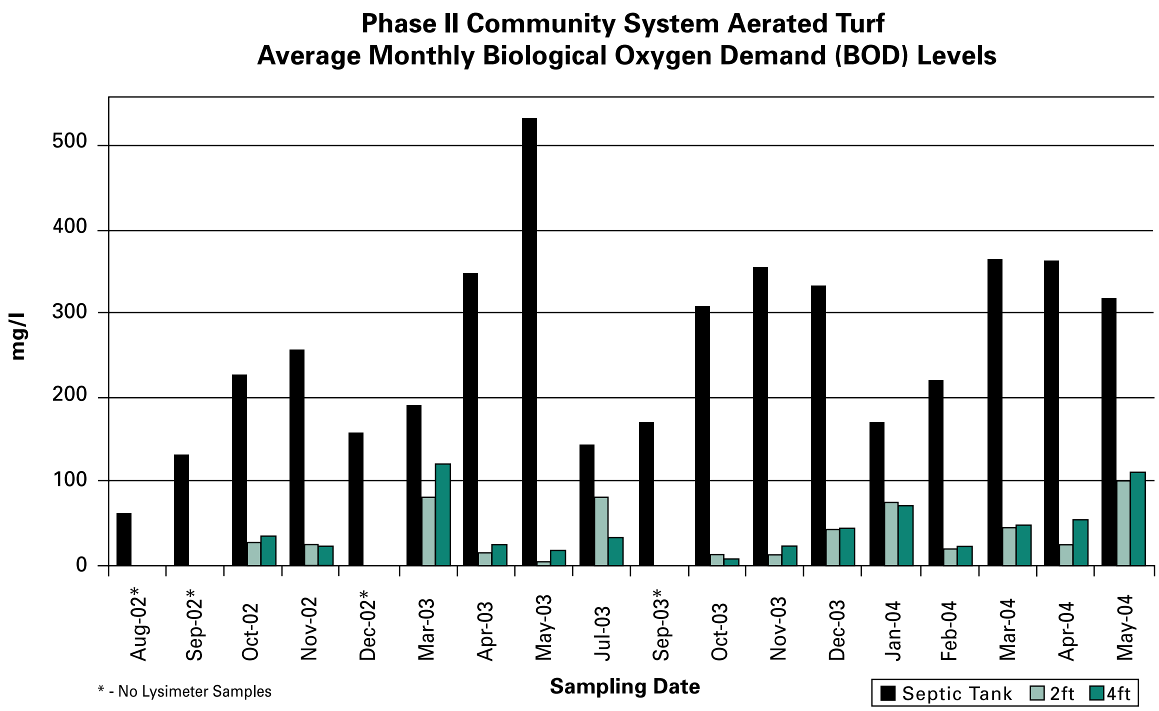
SP (soluble phosphorus): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS non-aerated turf 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value indicated a significant difference between the two depths (p=.0020). The majority of lysimeter SP readings are below 1.0mg/l with a mode of .03mg/l. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Non-aerated Turf SP (mg/l)

	Tank	AmT 2ft	AmT 4ft
N	19	109	79
Minimum	0.00	0.00	0.00
1st Quartile	7.26	0.07	0.03
Median	9.52	0.23	0.11
3rd Quartile	10.92	0.81	0.30
Maximum	67.31	7.93	5.76

Community System Aerated Turf – Test Results:

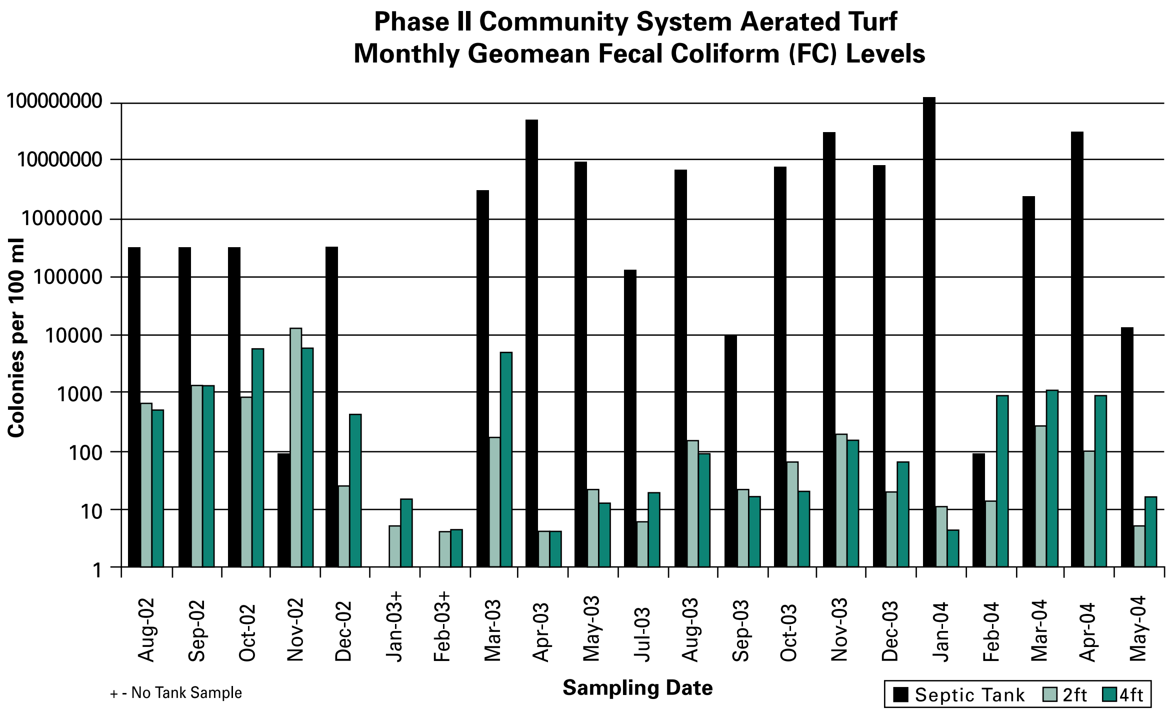
Lab results for wastewater samples collected monthly from the septic tank and the soil absorption beds at 2ft and 4ft depths were examined using graphs, descriptive statistics, and hypothesis testing. Non-parametric tests were used and the preset alpha of .05 determined whether the null hypothesis of no significant difference was accepted or rejected. See Statistical Analysis of Alternative Systems, page 5, for more detailed information.



BOD (biological oxygen demand): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS aerated turf 2ft and 4ft depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft, 4ft), the Wilcoxon calculated p-value (p=.2910) indicated no significant difference between the two depths. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Aerated Turf BOD (mg/l)

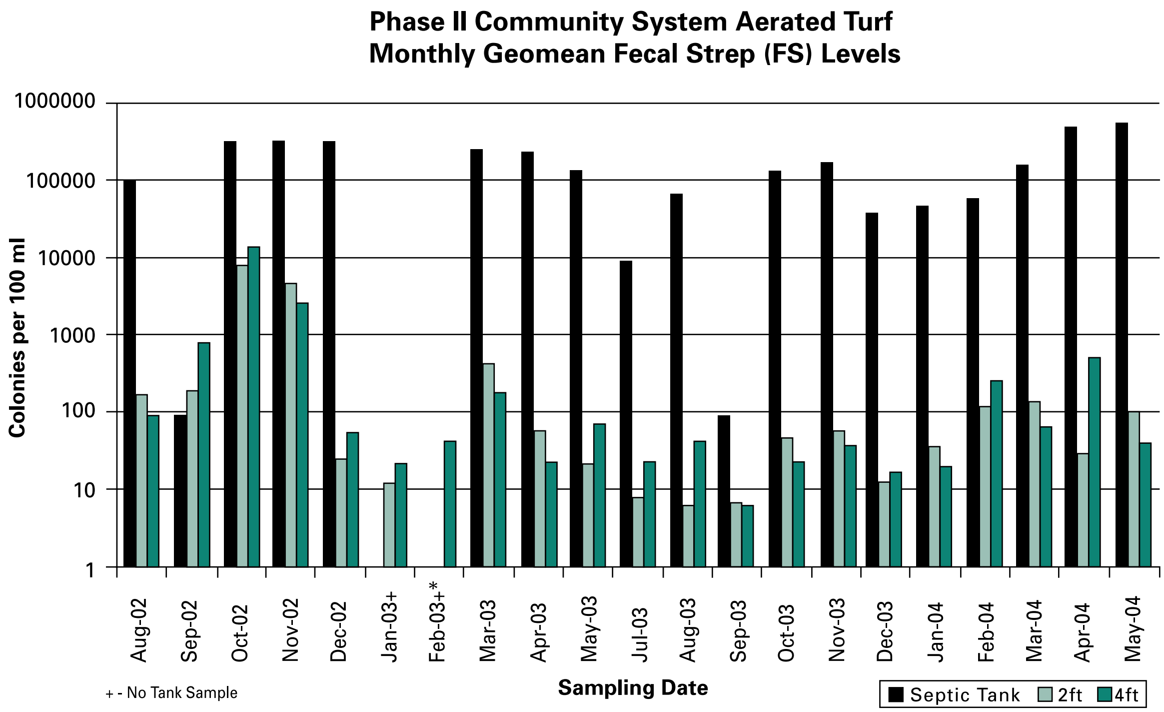
	Tank	RB 2ft	RB 4ft
N	19	92	51
Minimum	61	0	0
1st Quartile	170	9	10
Median	253	17	30
3rd Quartile	347	44	55
Maximum	532	497	134



FC (fecal coliform): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS aerated turf 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.1476) indicated no significant difference between the two depths. The PA water quality criterion of 200 col/100ml was exceeded 40:143 times (28%) at 2ft and 38:101 times (38%) at 4ft depths (PA Code, Ch93, Ch72.42). The septic tank saw unusually low FC counts in Nov 2002 and in Feb 2004. The mode or most frequent lysimeter value was four colonies/100ml. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Aerated Turf FC (colonies/100ml)

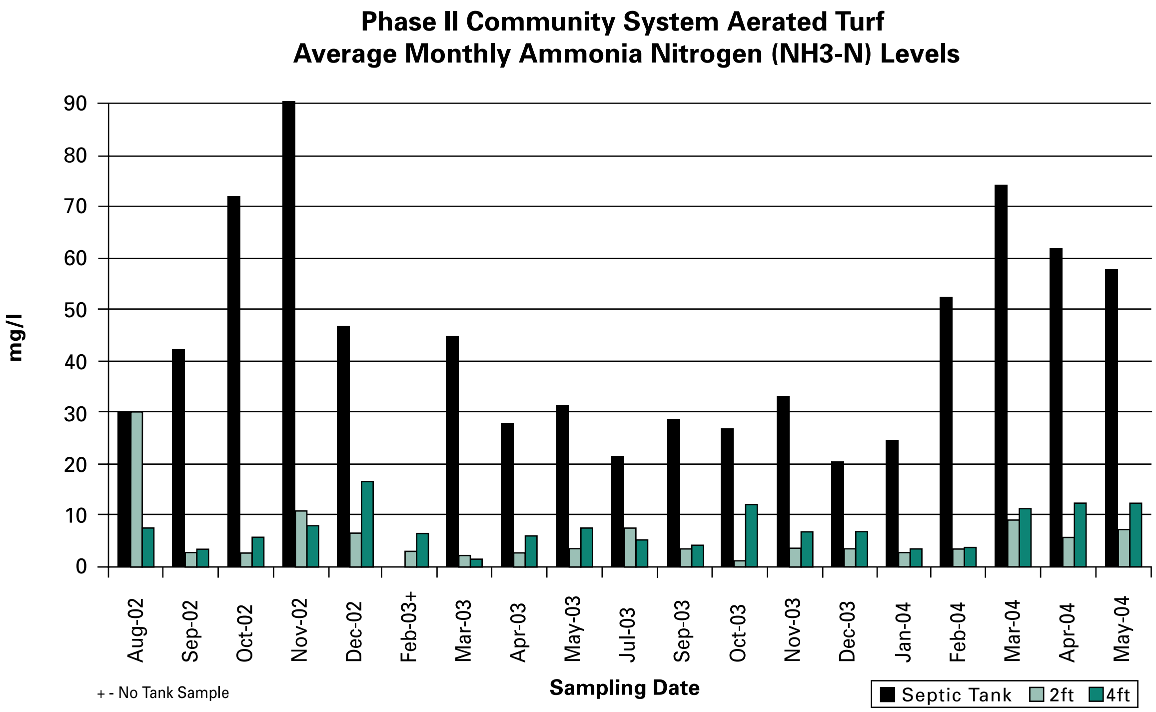
	Tank	RB 2ft	RB 4ft
N	19	143	101
Minimum	90	4	4
1st Quartile	129000	4	4
Median	2.4E+06	12	38
3rd Quartile	9.4E+06	380	1550
Maximum	1.2E+08	300000	300000



FS (fecal strep): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS aerated turf 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.4046) indicated no significant difference between the two depths. The mode or most frequent lysimeter value was four colonies/100ml. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Aerated Turf FS (colonies/100ml)

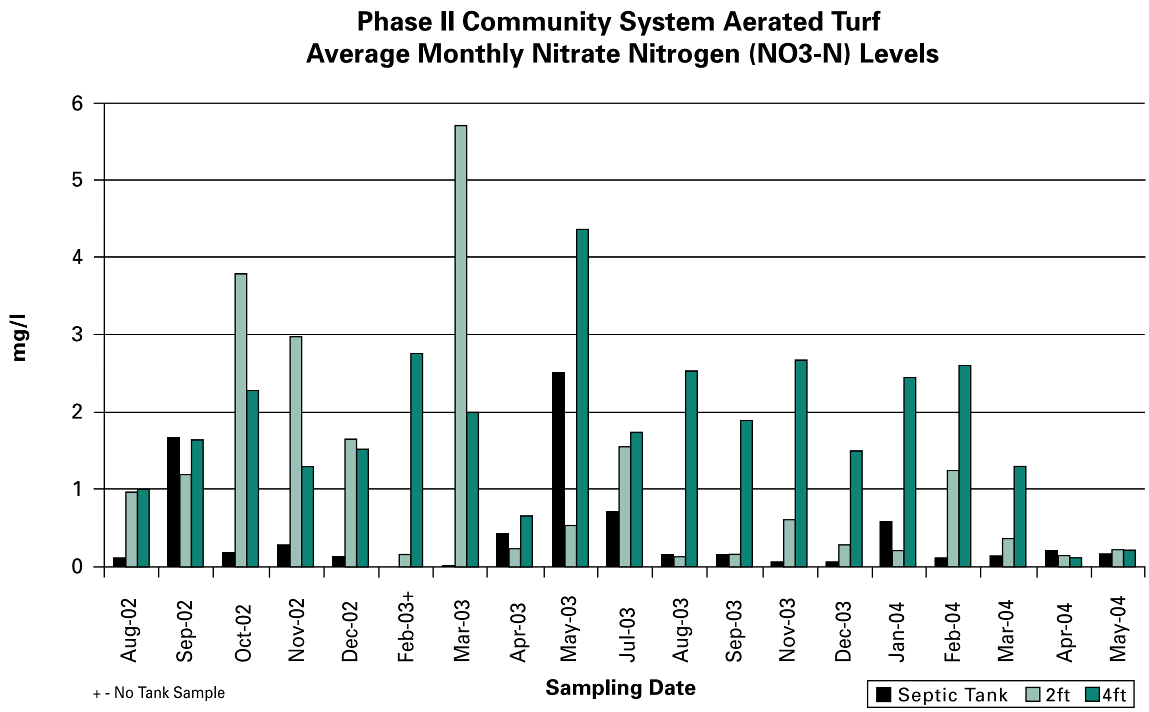
	Tank	RB 2ft	RB 4ft
N	19	131	88
Minimum	90	4	4
1st Quartile	45000	4	4
Median	130000	62	91
3rd Quartile	300000	420	765
Maximum	540000	300000	300000



NH3-N (ammonia nitrogen): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS aerated turf 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.0190) indicated a significant difference between the two depths. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Aerated Turf NH3-N (mg/l)

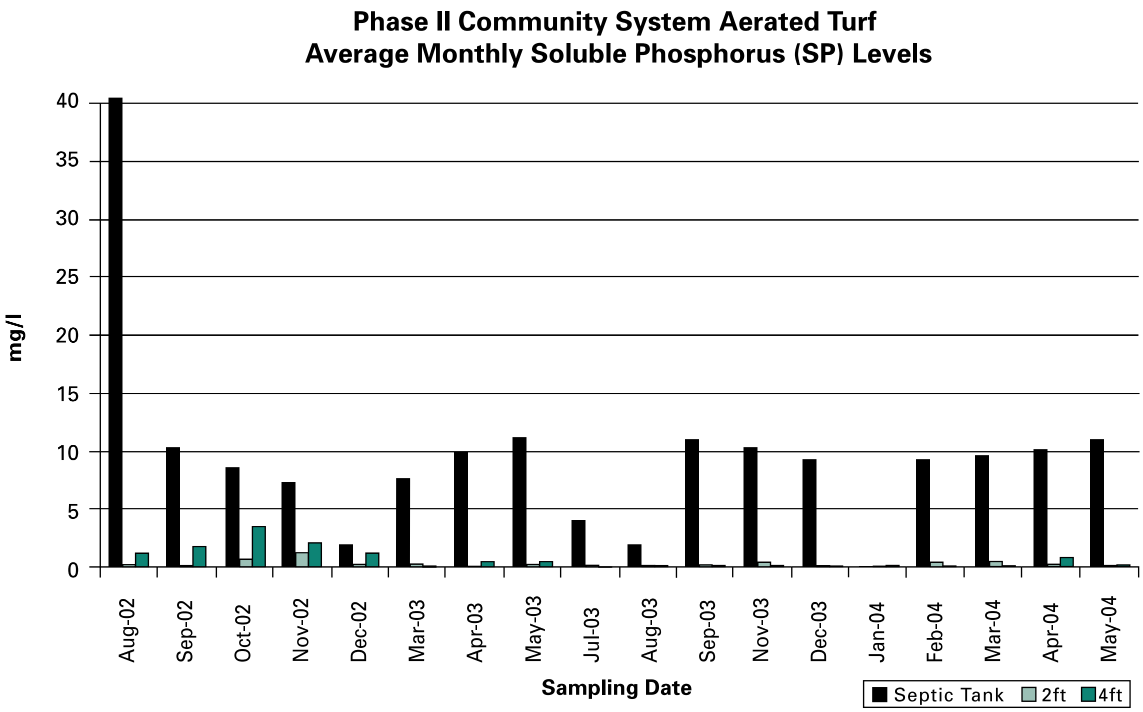
	Tank	RB 2ft	RB 4ft
N	19	123	66
Minimum	20.16	0.00	0.00
1st Quartile	27.84	1.07	0.96
Median	42.34	2.54	3.83
3rd Quartile	57.77	4.56	12.00
Maximum	90.38	47.57	34.97



NO3-N (nitrate nitrogen): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS aerated turf 2ft and 4ft lysimeter depths (p=.0230, p=.0009) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value indicated a significant difference between the two depths (p=.0085). NO3-N levels exceeded the PA water quality criterion of 10mg/l (Pa Code, Ch93) 0:18 times (0%) for the septic tank, 2:118 times (2%) at the 2ft depth, and 0:64 times (0%) at the 4ft depth. There were higher than usual 2ft NO3-N levels in Mar 2003. The median or measure of center increased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Aerated Turf NO3-N (mg/l)

	Tank	RB 2ft	RB 4ft
N	18	118	64
Minimum	0.01	0.05	0.09
1st Quartile	0.10	0.15	0.26
Median	0.16	0.31	0.73
3rd Quartile	0.48	0.95	2.50
Maximum	2.51	16.65	8.86



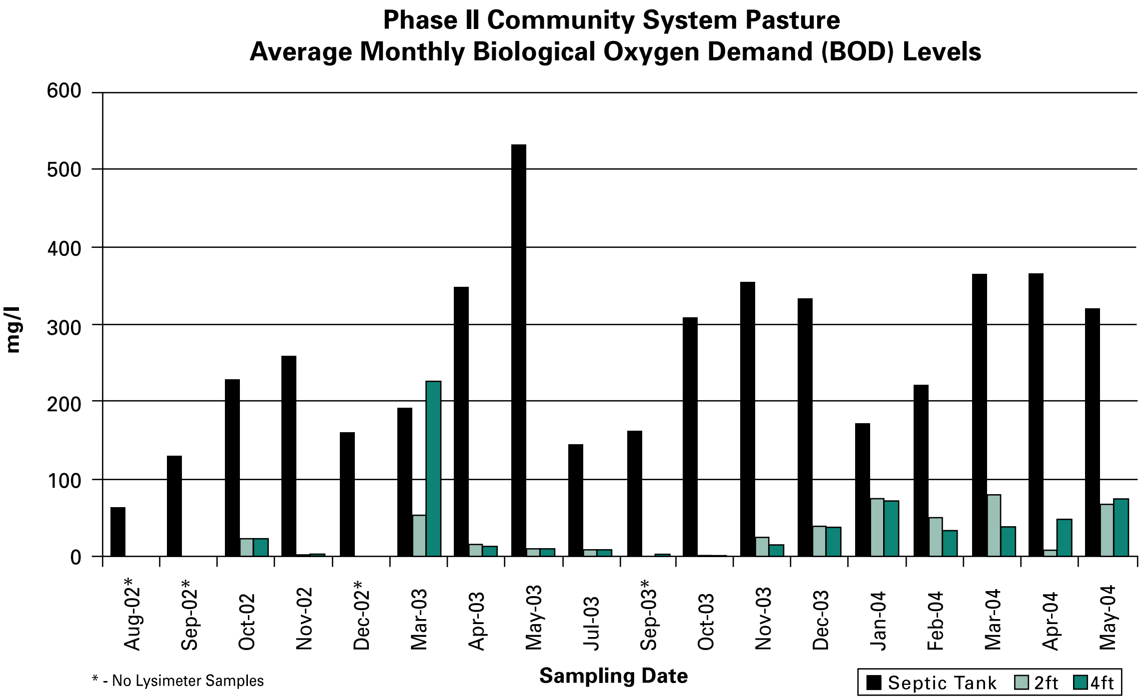
SP (soluble phosphorus): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS aerated turf 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.0582) indicated no significant difference between the two depths. The lysimeter mode or most frequent value was .03mg/l. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Aerated Turf SP (mg/l)

	Tank	RB 2ft	RB 4ft
N	19	118	64
Minimum	0.00	0.00	0.00
1st Quartile	7.26	0.03	0.03
Median	9.52	0.04	0.07
3rd Quartile	10.92	0.17	0.61
Maximum	67.31	4.14	5.44

CS Pasture: Test Results

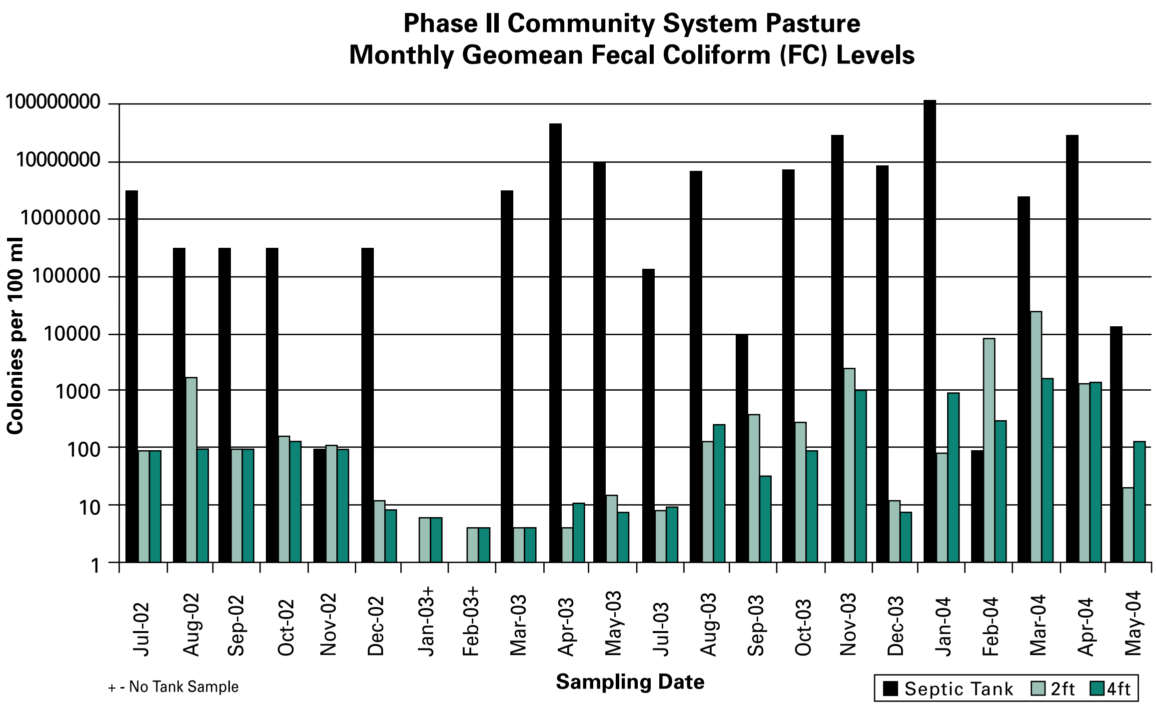
Lab results for wastewater samples collected monthly from the septic tank and the soil absorption beds at 2ft and 4ft depths were examined using graphs, descriptive statistics, and hypothesis testing. Non-parametric tests were used and the preset alpha of .05 determined whether the null hypothesis of no significant difference was accepted or rejected. See Statistical Analysis of Alternative Systems, page 5, for more detailed information.



BOD (biological oxygen demand): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS pasture 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.8013) indicated no significant difference between the two depths. Very low lysimeter BOD levels were recorded in Sept and Oct 2003. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Pasture BOD (mg/l))

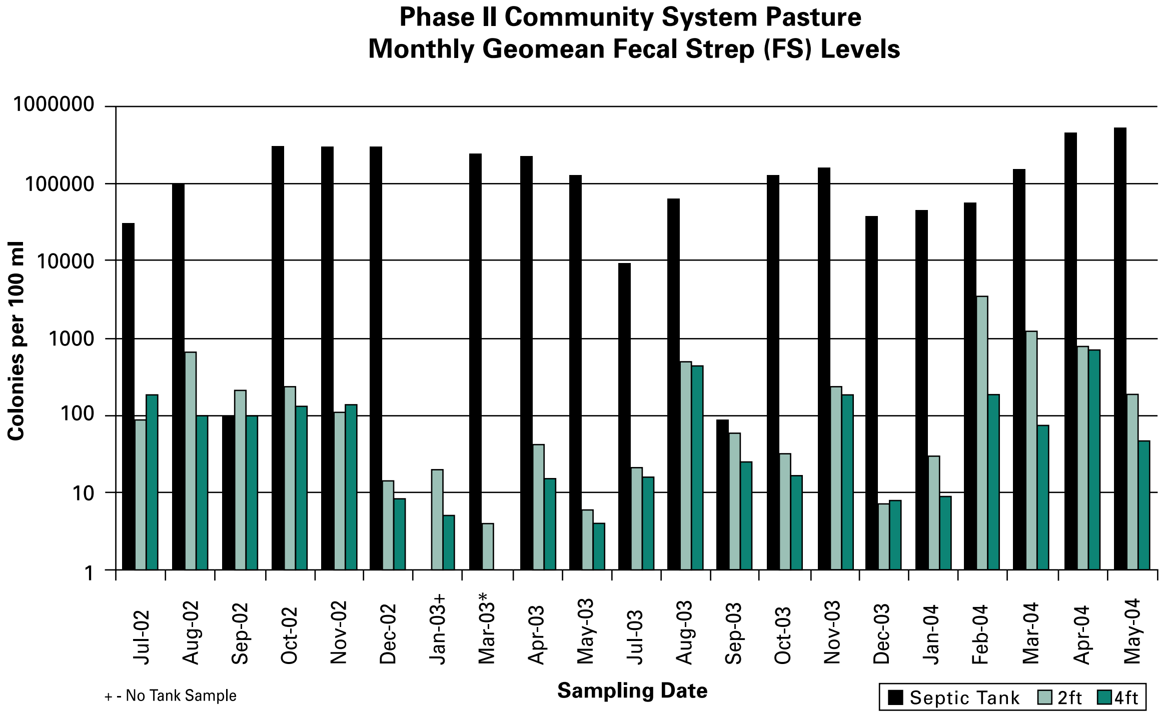
	Tank	PL 2ft	PL 4ft
N	19	78	70
Minimum	61	0	0
1st Quartile	161	5	6
Median	253	18	16
3rd Quartile	347	63	56
Maximum	532	154	227



FC (fecal coliform): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS pasture 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.0545) indicated no significant difference between the two depths. The PA water quality criterion of 200 col/100ml was exceeded 42:127 times (33%) at 2ft and 22:104 times (21%) at 4ft depths (PA Code, Ch93, Ch72.42). The septic tank saw unusually low FC counts in Nov 2002 and in Feb 2004. The mode or most frequent lysimeter value was four colonies/100ml. There was a higher than usual 2ft FC count in Feb 2004. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Pasture FC (colonies/100ml)

	Tank	PL 2ft	PL 4ft
N	20	127	104
Minimum	90	4	4
1st Quartile	171750	4	4
Median	2.7E+06	91	48
3rd Quartile	9.1E+06	480	132.5
Maximum	1.2E+08	140000	30000

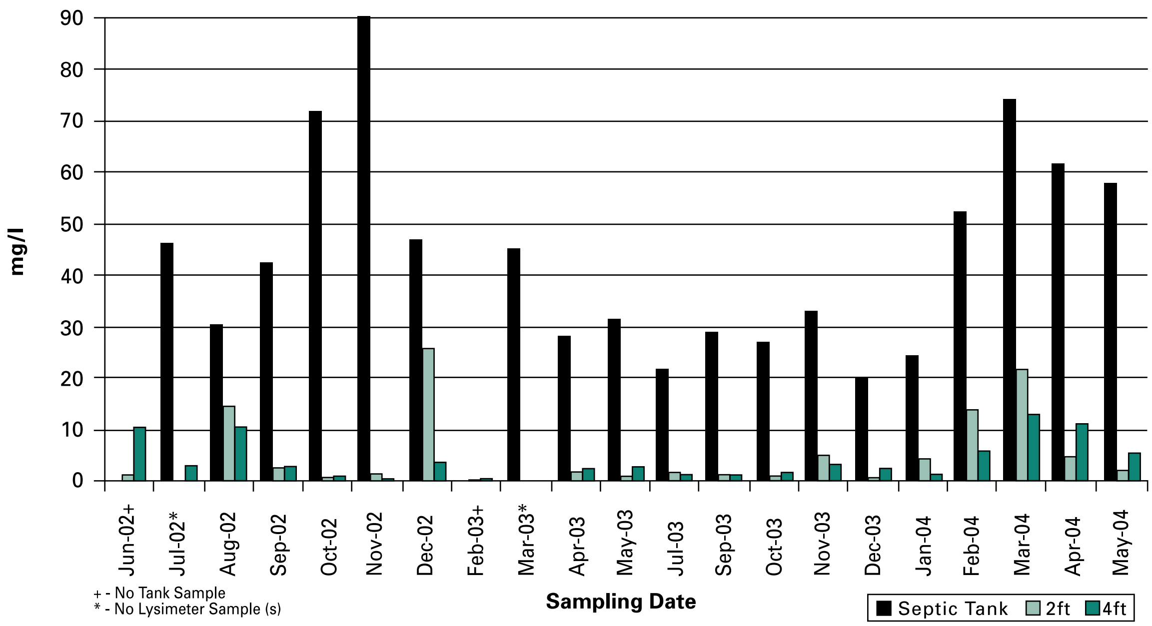


FS (fecal strep): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS pasture 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value indicated a significant difference between the two depths (p=.0075). The mode or most frequent lysimeter value was four colonies/100ml. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Pasture FS (colonies/100ml)

	Tank	PL 2ft	PL 4ft
N	20	121	97
Minimum	90	4	4
1st Quartile	38250	8	4
Median	130000	91	16
3rd Quartile	285000	385	185
Maximum	540000	30000	30000

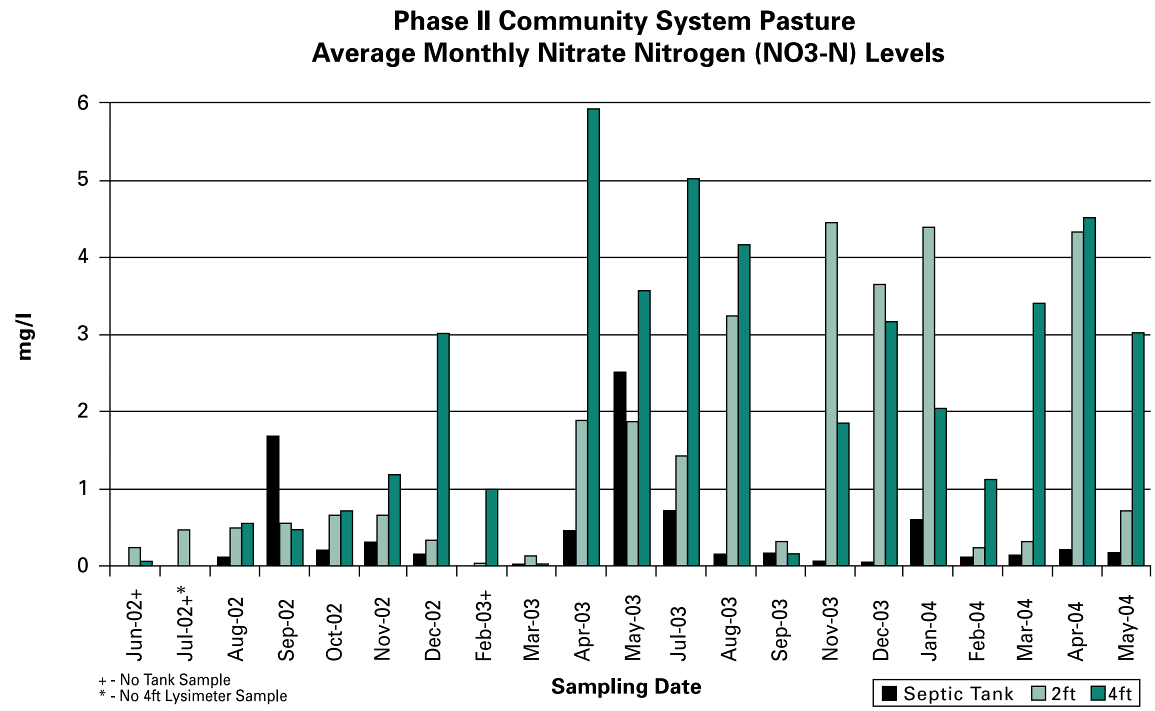
Phase II Community System Pasture
Average Monthly Ammonia Nitrogen (NH3-N) Levels



NH3-N (ammonia nitrogen): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS pasture 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.8055) indicated no significant difference between the two depths. There was a higher than usual NH3-N level in Dec 2002 at 2ft and in Mar 2004 at 4ft. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Pasture NH3-N (mg/l)

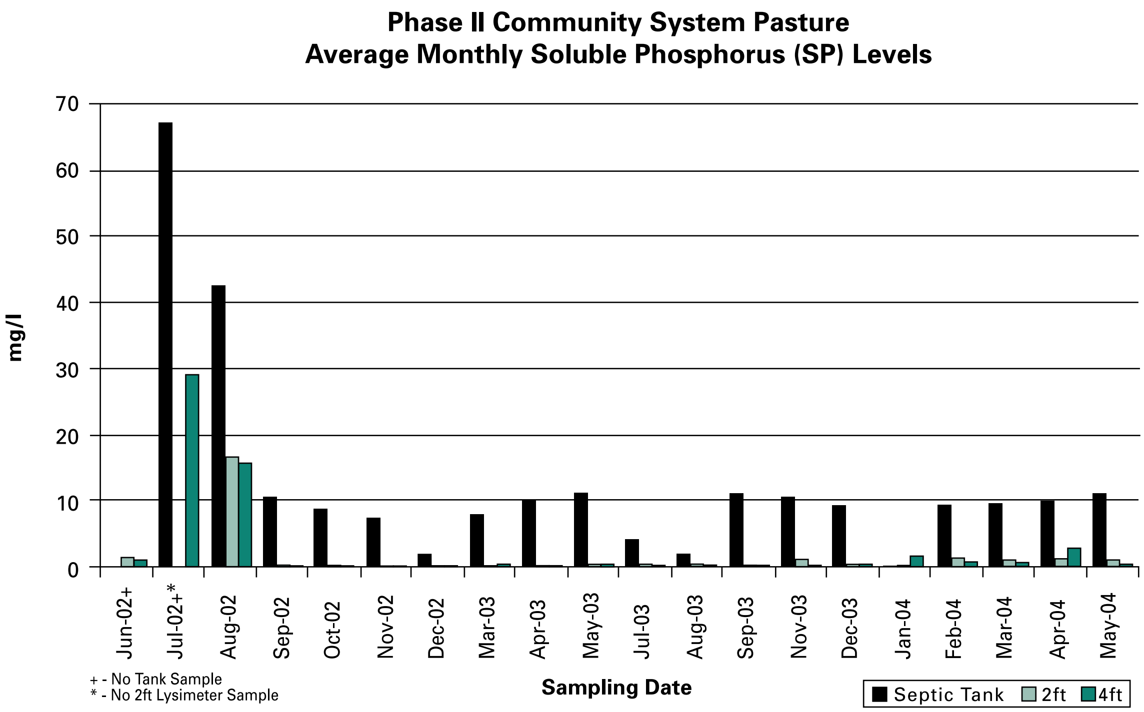
	Tank	PL 2ft	PL 4ft
N	19	98	87
Minimum	20.16	0.03	0.00
1st Quartile	27.84	0.36	0.48
Median	42.34	1.14	1.10
3rd Quartile	57.77	2.65	2.50
Maximum	90.38	143.21	45.56



NO3-N (nitrate nitrogen): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS pasture 2ft and 4ft lysimeter depths (p=.0047, p=.0012) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.1977) indicated no significant difference between the two depths. NO3-N levels exceeded the PA water quality criterion of 10mg/l (Pa Code, Ch93) 0:18 times (0%) for the septic tank, 6:100 times (6%) at the 2ft depth, and 9:88 times (10%) at the 4ft depth. The median or measure of center increased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Pasture NO3-N (mg/l)

	Tank	PL 2ft	PL 4ft
N	18	100	88
Minimum	0.01	0.02	0.01
1st Quartile	0.10	0.17	0.24
Median	0.16	0.47	0.61
3rd Quartile	0.48	1.64	3.35
Maximum	2.51	22.86	17.95



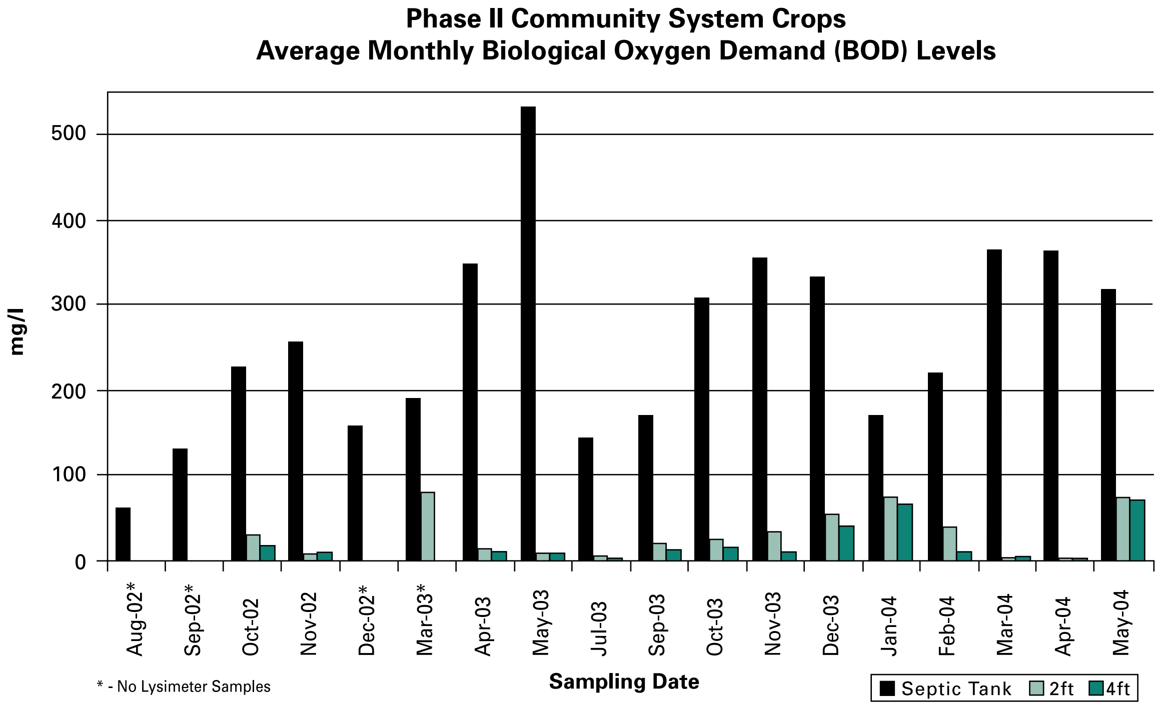
SP (soluble phosphorus): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS pasture 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.1695) indicated no significant difference between the two depths. The lysimeter mode or most frequent value was .03mg/l. There were higher than usual septic tank and lysimeter SP levels in Jul and Aug 2002. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Pasture SP (mg/l)

	Tank	PL 2ft	PL 4ft
N	19	96	81
Minimum	0.00	0.00	0.00
1st Quartile	7.26	0.03	0.03
Median	9.52	0.08	0.05
3rd Quartile	10.69	0.40	0.21
Maximum	67.31	21.94	29.13

CS Crops: Test Results

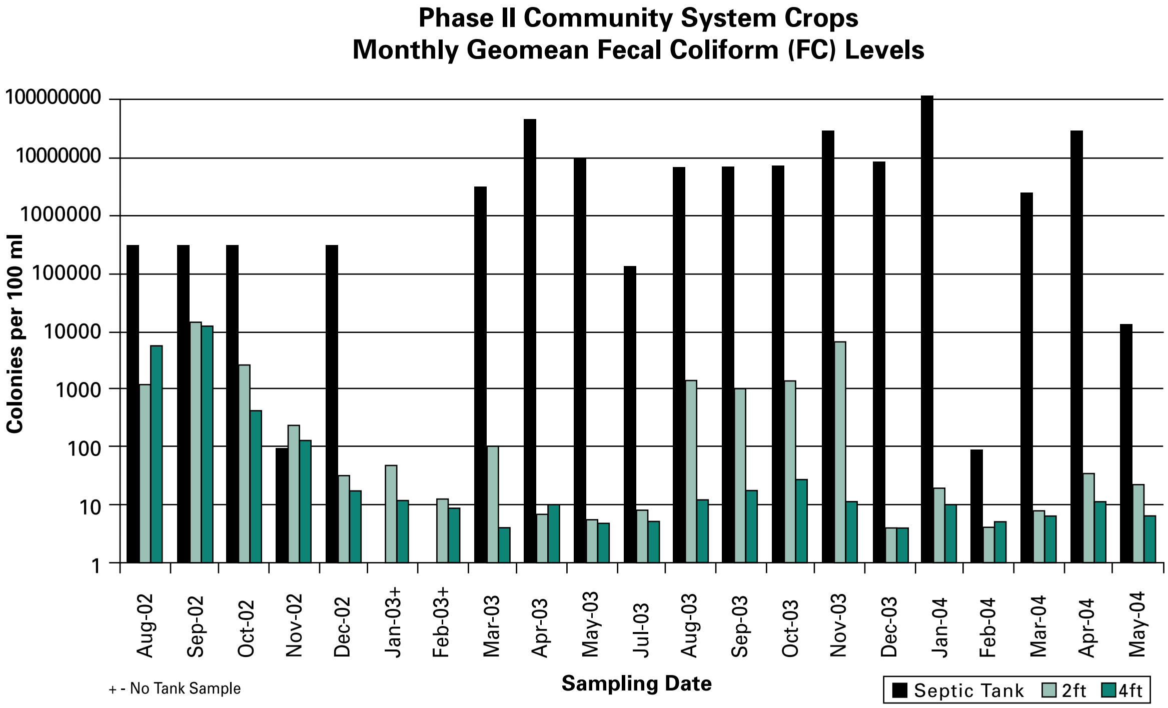
Lab results for wastewater samples collected monthly from the septic tank and the soil absorption beds at 2ft and 4ft depths were examined using graphs, descriptive statistics, and hypothesis testing. Non-parametric tests were used and the preset alpha of .05 determined whether the null hypothesis of no significant difference was accepted or rejected. See Statistical Analysis of Alternative Systems, page 5, for more detailed information.



BOD (biological oxygen demand): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS crops 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.2264) indicated no significant difference between the two depths. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Crops BOD (mg/l)

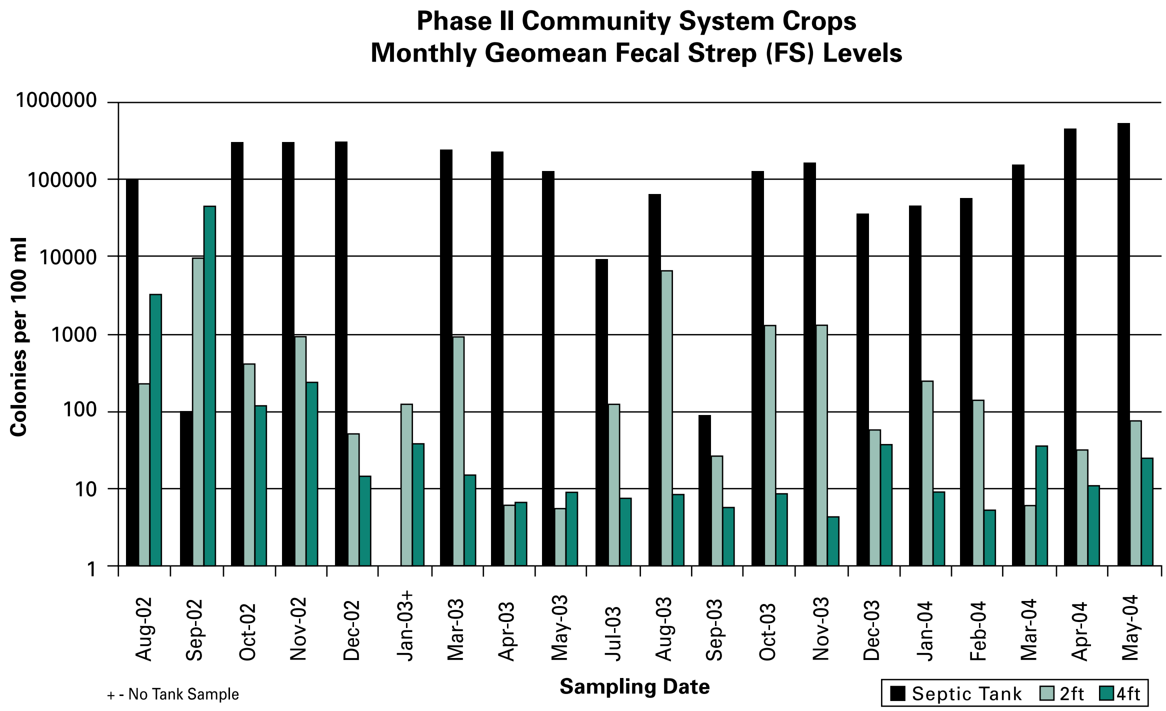
	Tank	GL 2ft	GL 4ft
N	19	103	80
Minimum	61.0	0.0	0.0
1st Quartile	161.4	4.8	2.7
Median	253.4	16.2	11.1
3rd Quartile	347.4	51.6	40.2
Maximum	531.6	112.2	82.8



FC (fecal coliform): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS crops 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.0000) indicated a significant difference between the two depths. The PA water quality criterion of 200 col/100ml was exceeded 54:150 times (36%) at 2ft and 12:127 times (9%) at 4ft depths (PA Code, Ch93, Ch72.42). The septic tank saw unusually low FC counts in Nov 2002 and in Feb 2004. The mode or most frequent lysimeter value was four colonies/100ml. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Crops FC (colonies/100ml)

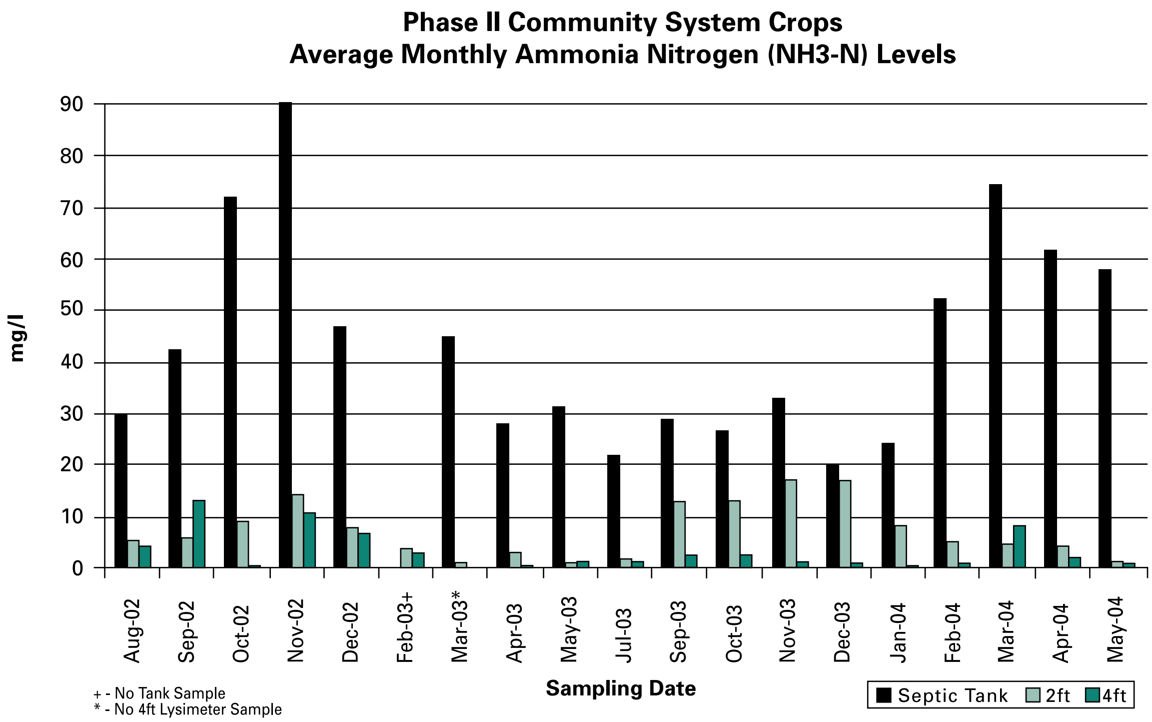
	Tank	GL 2ft	GL 4ft
N	20	150	127
Minimum	90	4	4
1st Quartile	171750	4	4
Median	2.7E+06	75	4
3rd Quartile	9.1E+06	1400	91
Maximum	1.2E+08	300000	300000



FS (fecal strep): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS crops 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value indicated a significant difference between the two depths (p=.0000). Lower than usual FS counts were recorded for the septic tank in Sept 2002 and 2003. Higher than usual 4ft FS counts were recorded in Aug and Sept 2002. The mode or most frequent lysimeter value was four colonies/100ml. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Crops FS (colonies/100ml)

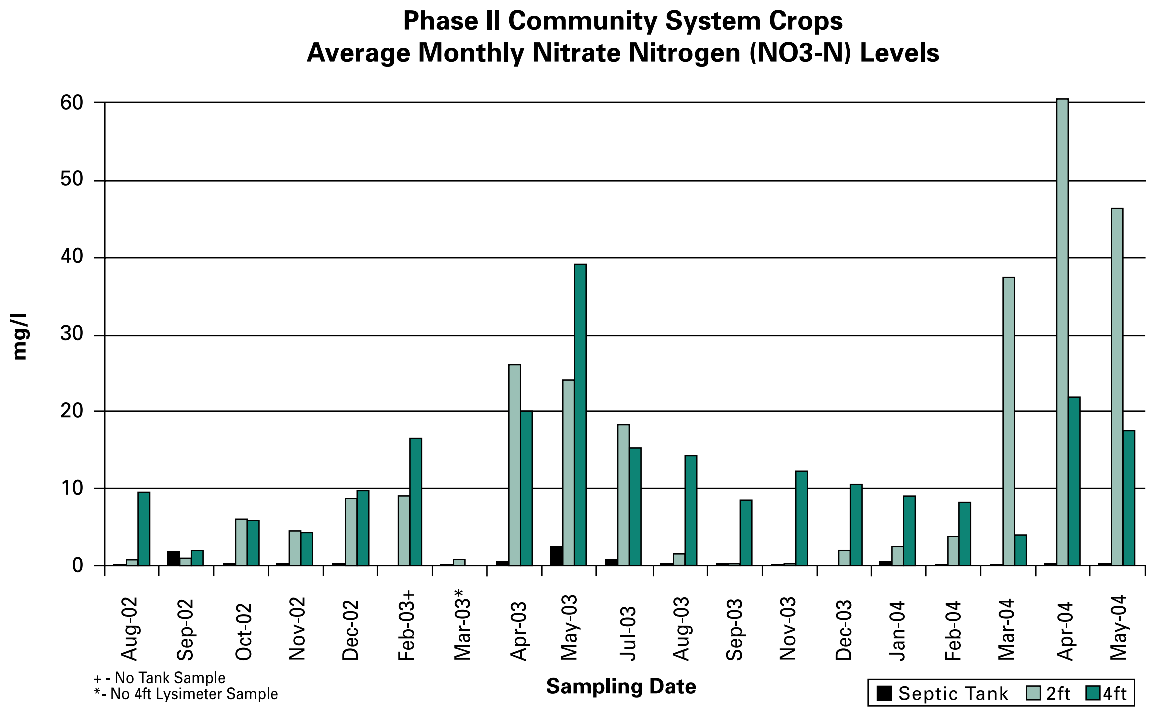
	Tank	GL 2ft	GL 4ft
N	20	138	114
Minimum	90	4	4
1st Quartile	38250	12	4
Median	130000	96	4
3rd Quartile	285000	993	91
Maximum	540000	30000	110000



NH3-N (ammonia nitrogen): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS crops 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.0000) indicated a significant difference between the two depths. The 2ft NH3-N maximum (higher than usual) level was recorded in Oct 2002. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Crops NH3-N (mg/l)

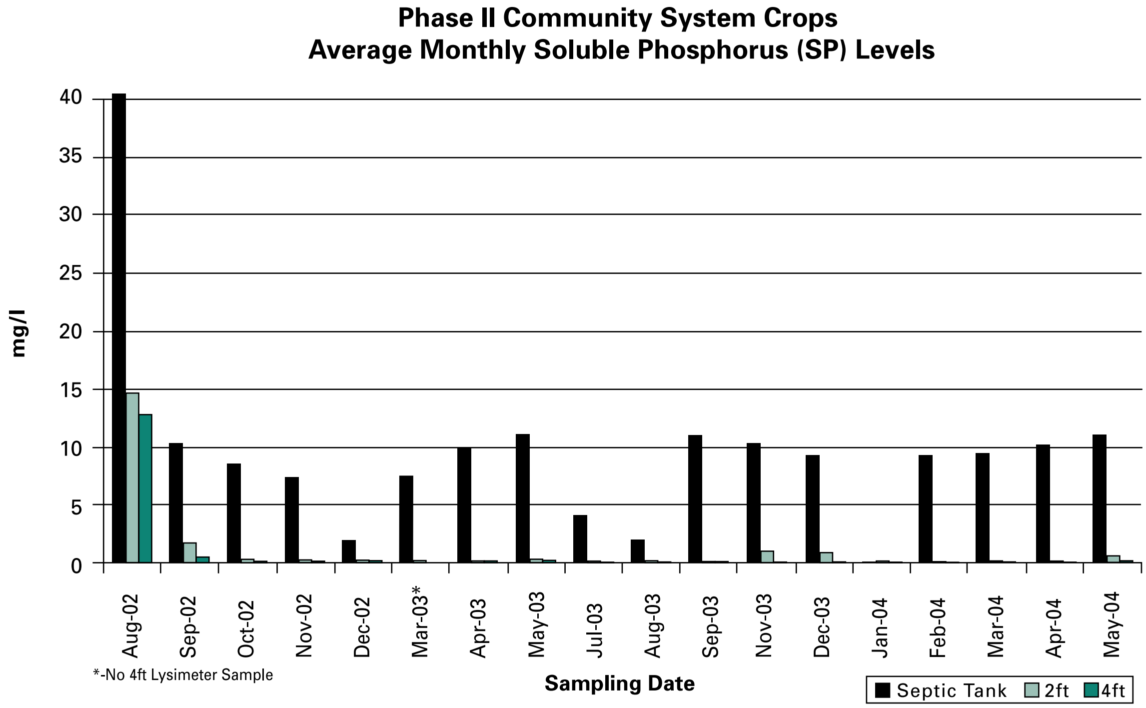
	Tank	GL 2ft	GL 4ft
N	19	128	90
Minimum	20.16	0.13	0.00
1st Quartile	27.84	1.62	0.44
Median	42.34	4.94	0.96
3rd Quartile	57.77	11.12	3.64
Maximum	90.38	51.51	32.67



NO3-N (nitrate nitrogen): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS crops 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value indicated a significant difference between the two depths (p=.0001). NO3-N levels exceeded the PA water quality criterion of 10mg/l (Pa Code, Ch93) 0:18 times (0%) for the septic tank, 42:127 times (33%) at the 2ft depth, and 51:92 times (55%) at the 4ft depth. The median or measure of center increased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Crops NO3-N (mg/l)

	Tank	GL 2ft	GL 4ft
N	18	127	92
Minimum	0.01	0.05	0.17
1st Quartile	0.10	0.52	6.35
Median	0.16	3.78	10.92
3rd Quartile	0.48	13.49	16.19
Maximum	2.51	98.96	85.48



SP (soluble phosphorus): The Wilcoxon calculated p-values for the comparison of campus septic tank effluent to CS crops 2ft and 4ft lysimeter depths (p=.0000, p=.0000) indicated a significant difference between the compared sites. When comparing the lysimeter depths (2ft and 4ft), the Wilcoxon calculated p-value (p=.0001) indicated a significant difference between the two depths. The lysimeter mode or most frequent value was .03mg/l. There were higher than usual lysimeter SP levels in Aug 2002. The median or measure of center decreased from the septic tank through the soil depths. Descriptive statistics for each sampling site, which include the number of samples (N) and the 5-number summary, are found in the table below.

Descriptive Statistics for CS Crops SP (mg/l)

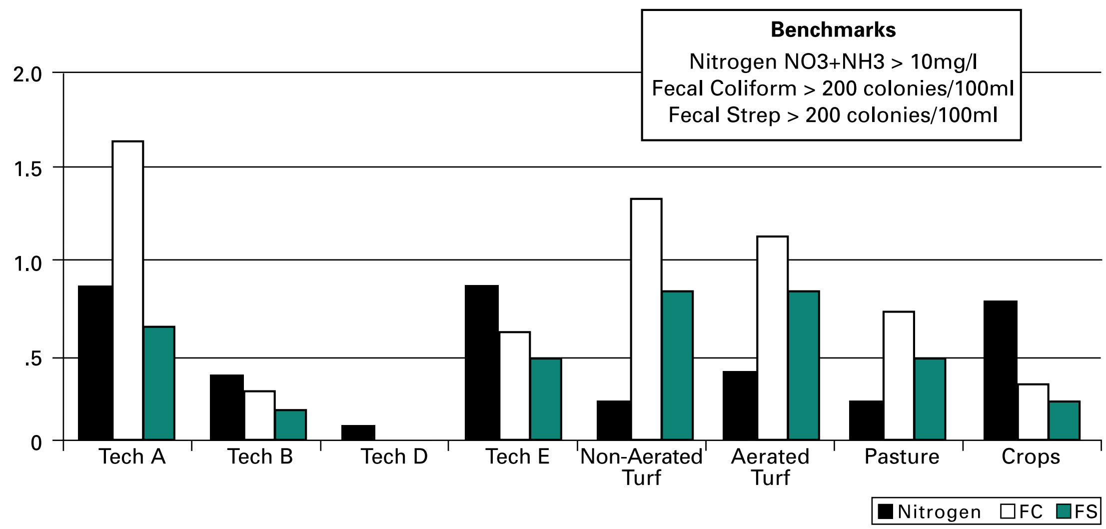
	Tank	GL 2ft	GL 4ft
N	19	119	84
Minimum	0.00	0.00	0.00
1st Quartile	7.26	0.03	0.01
Median	9.52	0.07	0.03
3rd Quartile	10.69	0.31	0.06
Maximum	67.31	15.60	12.83

Risk Comparison of Technologies:

A relative hazard ratio for comparative risk evaluation of the DVC alternative on-lot septic treatment systems was computed. In order to calculate the relative hazard ratio, excedence frequencies were computed for each technology. Nitrogen (NO3-N+NH3-N), FC, and FS data collected from Tech A infiltration cell and the 4-foot lysimeter depths of the other technologies was used in the calculations. Baseline values used for computing the excedence frequencies were taken from EPA water quality criteria.

Excedence frequencies were calculated by computing the number of times the baseline (200 bacteria or 10mg/l N) was exceeded and dividing by the total number of parameter data values. The excedence frequencies of the alternative technologies were then divided by the excedence frequency of Technology F to calculate a relative hazard ratio.

Phase II Relative Hazard Ratios for Biological and Chemical Parameters
Technologies A, B, D, E, & Community Systems



- If the ratio is less than one, the alternative technology (< 4ft of aerobic soil) provided more effective treatment compared to Technology F (4ft of aerobic soil).

- If the ratio is greater than one, the alternative technology provided less effective treatment compared to Technology F.

- If the ratio equals one, the treatment efficiency associated with the alternative technology and Technology F were the same.

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