Small-Scale Permeameter Test to Determine Compatibility of Pipe Wall Perforations, Geotextile Socks, and Sand/Gravel Envelopes

Dam Safety Office

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By J. Jay Swihart
Materials Engineering and Research Laboratory

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Executive Summary

Previous studies using a full-scale pipe box test have shown that a geotextile sock can significantly improve performance of perforated drain pipe by simultaneously increasing inflow rates and decreasing soil loss (table ES-1). Unfortunately, these full-scale tests are time-consuming and expensive. This study looks at a small-scale permeameter test (Modified Gradient Ratio) as a possible replacement for the full-scale pipe box test.

Table ES-1.—Previous test results with full-scale pipe box (Lake Alice)

Test configuration	Flow rate (gpm/linear ft)	Envelope loss (grams/linear ft)	Test duration and comments
1/8-inch slots	1.74 – Not stable	200 – Stable	8 days – Not stable
1/4-inch holes	6.3 – Not stable	850 – Not stable	24 days – Not stable
Geotextile sock	21.3 – Stable	50 – Stable	31 days – Stable
Improvement with geotextile	300 to 1,100%	300 to 1,600%	

The Gradient Ratio Test (ASTM D-5101) is used in the geosynthetic industry to determine compatibility between a geotextile and a soil. For this study, the Gradient Ratio Test was modified to determine compatibility between perforated High-Density Polyethylene (HDPE) pipe (with and without a geotextile sock) and various sand/gravel envelope materials. Primary modifications included:

- Use of perforated HDPE geomembrane to simulate perforated HDPE pipe wall
- Use of geonet under geotextile to simulate air void in corrugated pipe valley
- Increased CO_2 purge
- Recycling of de-aired water
- Addition of Biocide (bleach) on day 2 to prevent biological clogging
- Measurement of soil loss at end of test

Results from the modified permeameter test (table ES-2) show good agreement with the previous full scale tests. However, the 24-hour test interval at multiple gradients appears insufficient to allow plugging of the pipe perforations. Future tests should be run at a single gradient (i = 10) for 30 days.

Table ES-2.—Summary of small-scale permeameter tests (Lake Alice and “A” Zone envelope)

Test configuration	Flow rate (cc/sec)	Permeability (meters/sec)	Envelope loss (grams)	Test interval
No geotextile	5 to 11	0.005 to 0.010	0.7 to 8.3	24 hours
With geotextile	20 to 30	0.017 to 0.027	< 0.1 to 0.4	24 hours
Improvement with geotextile	200 to 300%	200 to 300%	600 to 2,000%	

Introduction

The Bureau of Reclamation (Reclamation) has a long history of success with agricultural drains buried 6 to 10 feet deep using perforated HDPE pipe with sand/gravel envelopes. The same perforated HDPE pipe is also used in toe drains and finger drains in dams. Drains in dams are a more critical application because (1) they relieve hydrostatic pressure within the dam and (2) they are buried much deeper (10 to 20 feet for toe drains and up to 60 feet for finger drains) and therefore are much more difficult to replace if they should fail.

Background

In 1997, perforated HDPE pipe was used in the toe drain with a sand envelope at Lake Alice Dam (near Scottsbluff, Nebraska). The sand envelope was used to retain the fine silty native soil. HDPE pipe (12-inch and larger) is normally perforated with 3/8-inch holes. For Lake Alice, the pipe was specially perforated with 1/8-inch holes to retain the sand envelope (keep the sand from washing into the pipe). Unfortunately, this installation did not work very well because the sand particles plugged the 1/8-inch perforations. Plugging was aggravated by a "tunnel effect" where the pipe wall thickness (approximately 0.25 inch for double walled pipe) was greater than the perforation diameter. This tunnel effect appears to increase the likelihood of a sand particle becoming lodged in the pipe perforation. Full-scale laboratory testing on sections of 15-inch toe drain showed that a geotextile sock placed around the toe drain dramatically improved performance by simultaneously increasing inflow and decreasing soil loss into the pipe (Swihart, 1997, 1999, 1999). Typical results from those full-scale tests are summarized in table 1.

Table 1.—Previous test results with full-scale pipe box (Lake Alice)

Test configuration	Flow rate (gpm/linear ft)	Envelope loss (grams/linear ft)	Test duration and comments
1/8-inch slots	1.74 – Not stable	200 – Stable	8 days – Not stable
1/4-inch holes	6.3 – Not stable	850 – Not stable	24 days – Not stable
Geotextile sock	21.3 – Stable	50 – Stable	31 days – Stable
Improvement with geotextile	300 to 1,100%	300 to 1,600%	

This study explores a small-scale (bench top) Gradient Ratio Test (ASTM D-5101) as a simpler, lower-cost alternative to the full-scale pipe box test. Gradient Ratio is the geosynthetic industry standard to determine compatibility between a geotextile and a soil. For this study, the Gradient Ratio Test was modified to also include a perforated HDPE pipe wall. The modified Gradient Ratio Test was then used to determine compatibility between various sand/gravel envelope materials and various perforated pipe walls (with and without geotextile socks).

Test Apparatus

The Gradient Ratio Test apparatus (ASTM D5101) is shown in figures 1, 2, and 3. Soil is placed in a 4-inch-diameter, rigid-wall permeameter. ASTM D-5101 specifies that soil particles should be no larger than 10 percent of the permeameter diameter. Therefore, soil particles up to 0.4 inch can be used in the 4-inch test apparatus. Field soil samples are scalped with a 3/8-inch screen (0.375 inch) and only the smaller fraction is used in the test apparatus. The larger fraction is discarded. A 6-inch permeameter is also allowed, with soil particles up 0.6 inch in diameter.

The Gradient Ratio Test is intended to determine compatibility of geotextile with soil. Incompatibility is demonstrated by excessive soil loss or by clogging of the geotextile. For this study, the Gradient Ratio Test was modified to determine compatibility between various envelope materials and perforated HDPE pipe (with and without geotextile).

Modifications

The following modifications were made to the ASTM D-5101 test method:

1. The perforated HDPE pipe wall was simulated with perforated HDPE geomembrane (figure 4) or acrylic (figure 5). Perforations included slots and holes. The number of perforations was adjusted to yield a 1-percent nominal open area. A geonet was placed between the geotextile and the HDPE pipe wall to simulate the void space in corrugated pipe valleys (figures 6 and 7).

2. Added ball valves between the two constant head devices and the permeameter. These ball valves are closed during CO_2 purging and then opened to begin testing.

3. ASTM D-5101 requires a 5 minute CO2 purge with manometers closed. For this study, purge times were increased to 10 minutes with manometers open, followed by an additional 10 minutes with manometers closed. Increased purge times were used as an added precaution against air bubbles forming in the soil sample.

4. ASTM D-5101 is run with de-aired water to prevent formation of air bubbles within the permeameter during test set-up. A constantly replenished source of de-aired water prevents formation of air bubbles during the 3- to 7-day test duration. Other test methods recirculate without de-airation, such as ASTM D-1987 (Biological Clogging of Geotextile or Soil/Geotextile Filters). For this study, we used de-aired water for the test set-up and then recirculated the de-aired water during the test. This method (combined with increased CO_2 purge times) worked well, and no air bubbles were observed in the soil inside the permeameter.

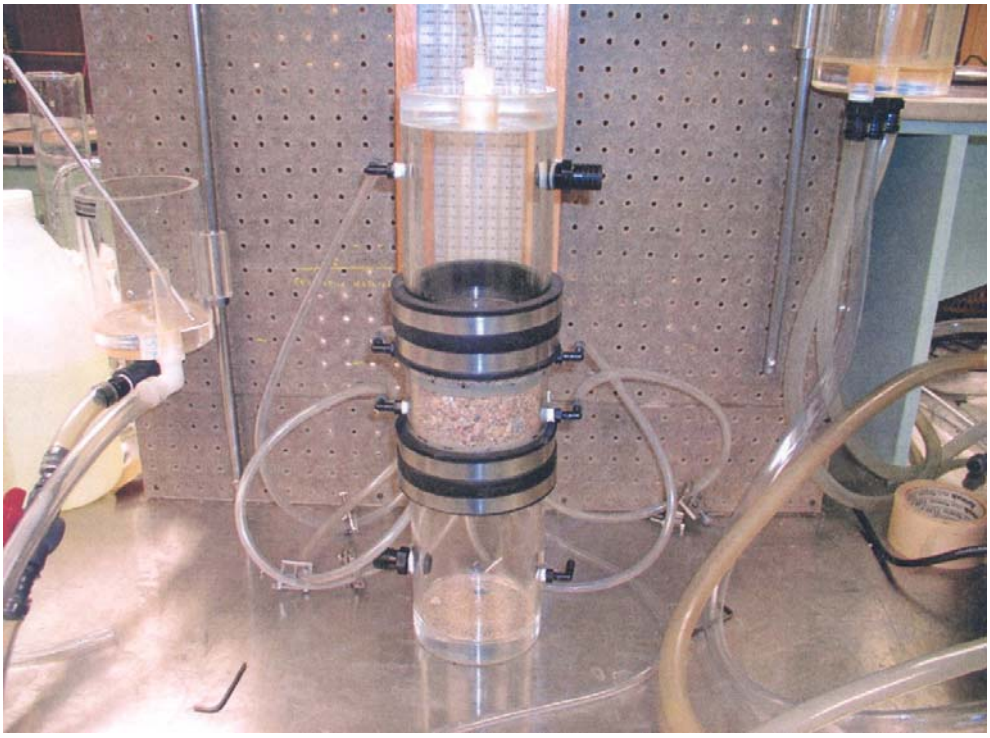

Figure 1.—Permeameter test device (modified Gradient Ratio).

Figure 2.—Close-up of test permeameter with gravel envelope. Clay seals prevent vertical flow along the permeameter wall.

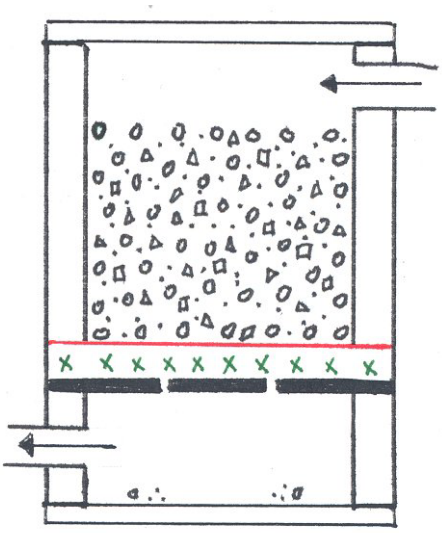

Figure 3.—Schematic of permeameter. Components include (bottom to top) perforated pipe wall, geonet spacer, geotextile, and sand/gravel envelope. Sand particles that pass through the pipe wall collect in bottom of the permeameter.

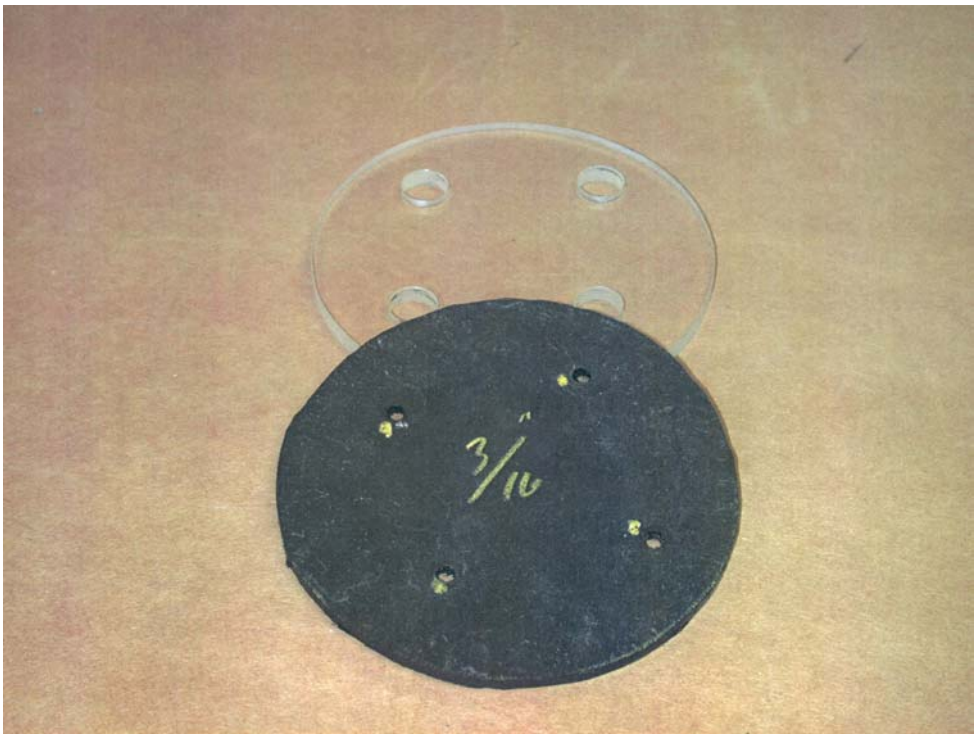

Figure 4.—Single-wall HDPE pipe is modeled by 60-mil HDPE geomembrane with four perforations (3/16-inch diameter), over an acrylic support plate.

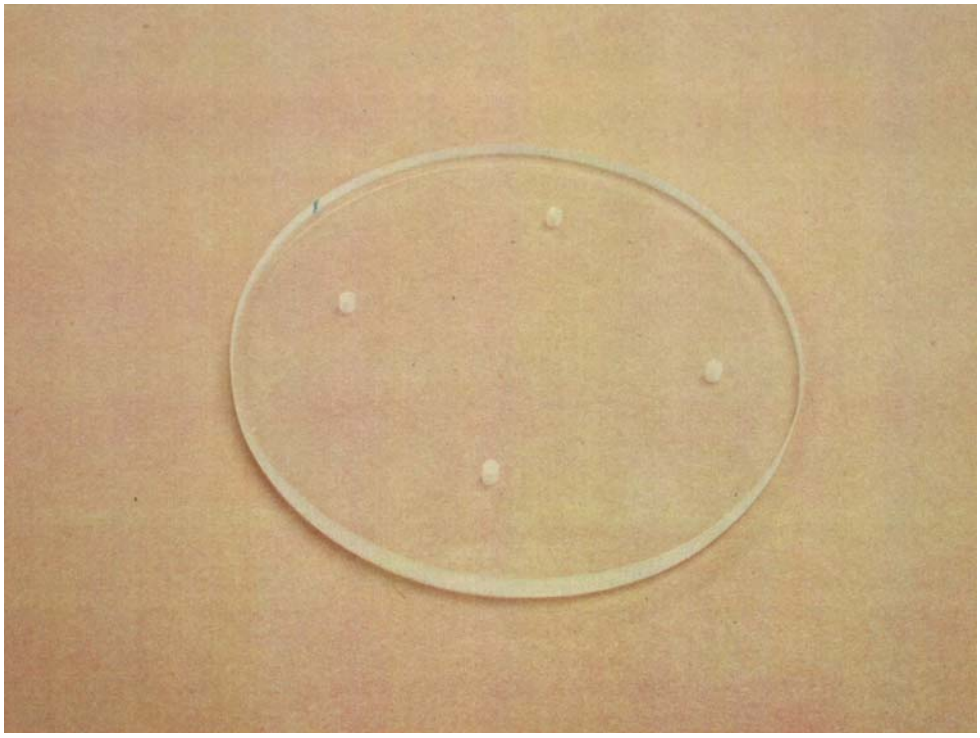

Figure 5 – Double-wall HDPE pipe is modeled by 1/4-inch acrylic plate with 1/8-inch perforations.

Figure 6.—Heat-bonded geotextile with geonet and perforated pipe wall.

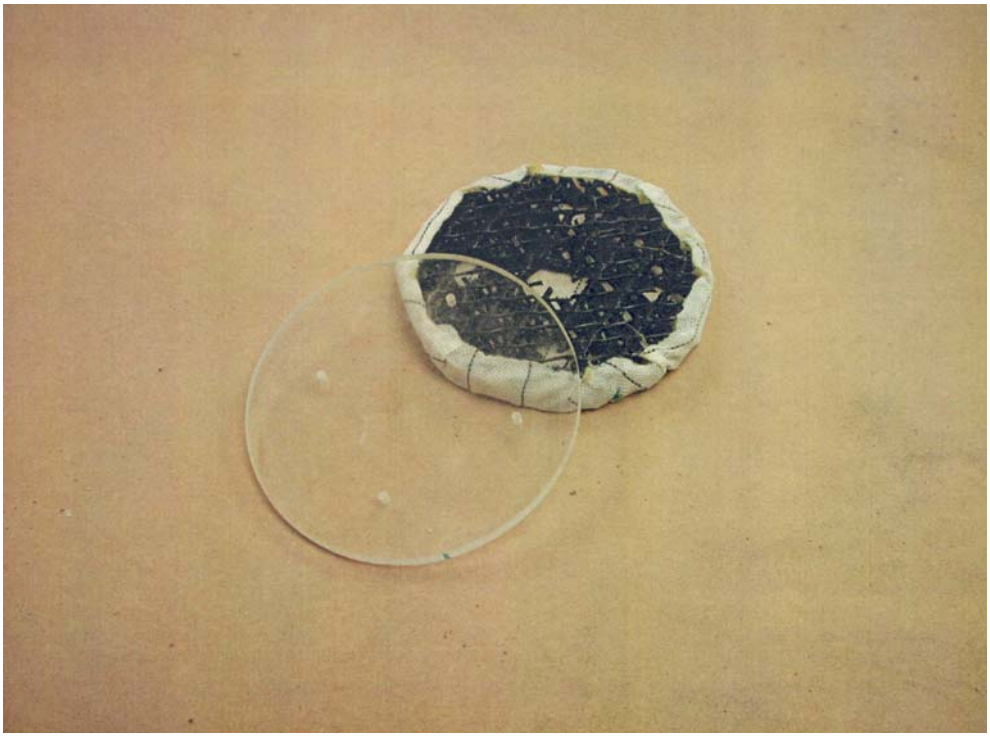

Figure 7.—Knitted geotextile (AOS = #30) with geonet and perforated pipe wall.

5. The following material compatibility and contamination problems were encountered:

   Biocide-aluminum – The biocide reacted with the aluminum support plate in the permeameter. The aluminum support plate was replaced with Plexiglas (acrylic).

   Steel fittings – A couple of steel fittings were initially used in the permeameter connections. The steel corroded and deposited iron-oxide (rust) in the soil sample. Steel fittings were removed and replaced with brass or stainless steel.

6. ASTM D-5101 requires 24-hour hold at test gradients (i) of 1, 5, and 10. Intermediate readings are taken at i = 2.5 and 7.5. To meet these hold times, tests were initiated on Mondays and concluded on the following Monday, according to the schedule on the following page.

7. Biocide (bleach) was added to the test to prevent biological fouling (algae growth) in the permeameter. The biocide (5% solution of sodium hypochlorite) was added according to

Day of week	Test gradient	Hold interval
Monday	Set-up new test	
Tuesday	CO_2 purge for 20 minutes Begin test, i = 1	 Hold for 24 hours
Wednesday	Increase i to 2.5 Increase i to 5	Hold for 1/2 hour Hold for 24 hours
Thursday	Increase i to 7.5 Increase i to 10	Hold for 1/2 hour Hold for 96-1/2 hours
Friday	i = 10	
Saturday	i = 10	
Sunday	i = 10	
Monday	Final reading at i = 10 Tear down old test Set-up new test	

the schedule below. Tests without biocide were not successful. The second dose of biocide had no effect and apparently is not required for 7-day tests. However, longer duration tests may require the second dose of biocide.

Day of week	Test gradient	Amount of biocide	Time added
Monday		—	
Tuesday		—	
Wednesday	i = 5	200 ml	After the 2-hr reading
Thursday		—	
Friday		—	
Saturday		—	
Sunday		—	
Monday	i = 10	100 ml	After the 96-hr reading

8. At the end of each test, the permeameter was disassembled and sediment in the bottom of the permeameter was collected, dried, and weighed. This soil represents envelope material that passed through the geotextile sock or pipe perforations or both.

Testing

This test program looked at a number of different test parameters including type of geotextile, envelope material, and pipe perforations:

Geotextile – Four geotextiles were included in this study. Manufacturer data sheets are included in Appendix A.

Monofilament woven
Carriff # 30 knitted sock
Heat-bonded nonwoven
Trevira 1112 needle-punched nonwoven

Perforation Size – Smaller diameter HDPE pipe (up to about 10 inches) is typically perforated with 1/8-inch slots or 3/16-inch holes. Larger diameter HDPE pipe (12-inch and up) is typically perforated with 3/8-inch holes. The following perforation patterns were included in this study. The number of perforations was based on a nominal 1-percent open area.

4 holes @ 1/8-inch diameter
4 holes @ 3/16-inch diameter
1 hole @ 3/8-inch diameter

Envelope Material – Reclamation specifies sand and gravel envelope gradations (figure8) for four types of base soil (coarse silt loam, very fine sand, medium sand, and Coarse sand). The "A" Zone envelope gradation is the most restrictive and covers "All" soil types. The boundaries for the "A" Zone envelope are 4f (fine limit for envelope 4) and 1c (coarse limit for envelope 1). Figure 9 shows the gradations for the following envelope materials included in this study.

ASTM C778 sand (20-30)
Lake Alice
Many Farms
Reclamation "A" Zone - 4f (4 fine)
Reclamation "A" Zone - 1c (1 coarse)

Twenty-four tests were performed for this study. Each test typically ran for 7 days. Many of the early test results were not used because of various mechanical problems such as air entrapment, contamination, biological clogging, and mechanical failure. The 14 valid tests (9 with geotextile and 5 without) are summarized in table 2. Test data are included in Appendix B.

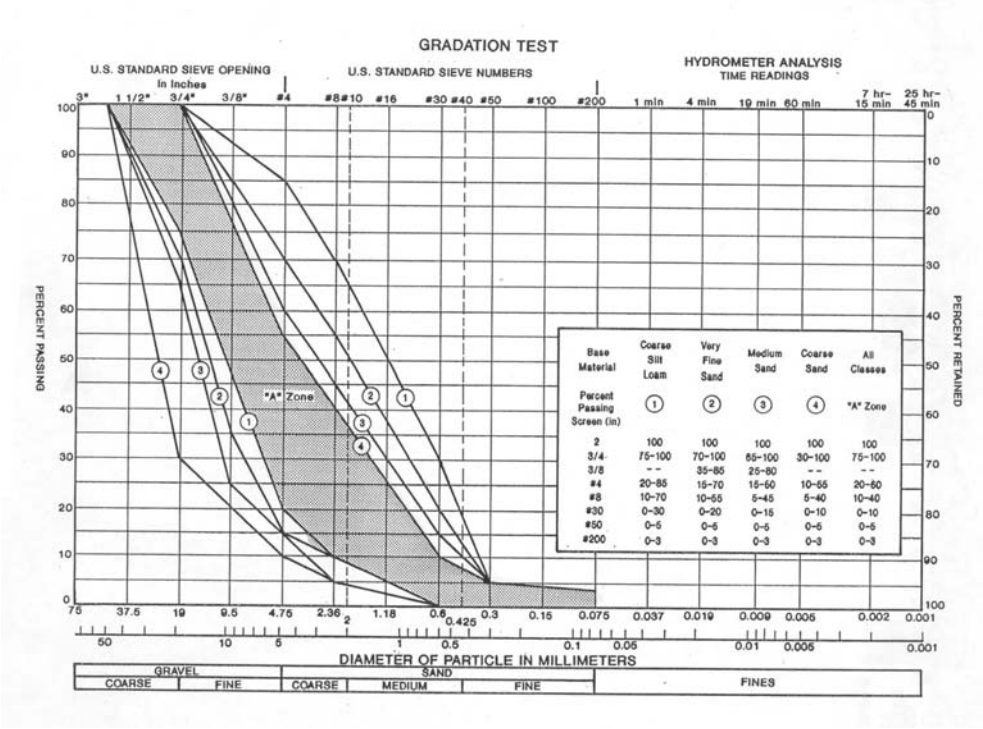

Figure 8.—Reclamation criteria for sand/gravel envelopes around perforated pipe.

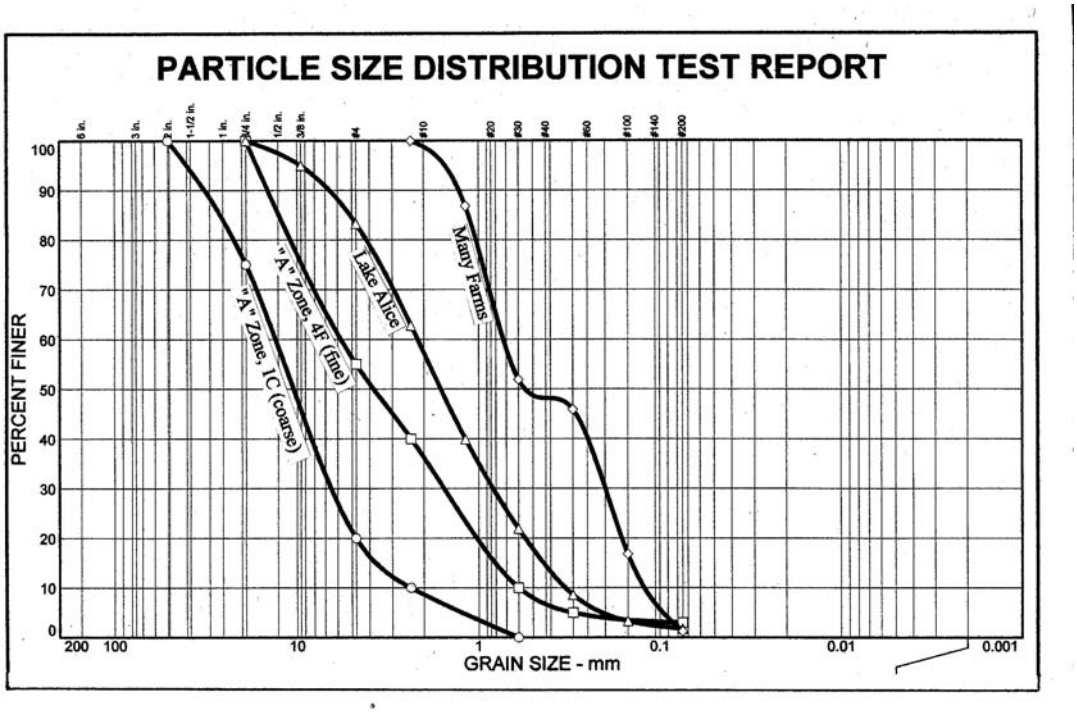

Figure 9.—Gradation of envelope materials used in this study.

Table 2.—Summary of test results

#	Test	Soil	Geotextile	Geonet	Perforations (inches)	Gradient ratio	Permeability (m/sec)	Flow rate (cc/sec)	Soil loss (grams)
3	C-3	ASTM	woven mono			1.6-1.9	.0120-.0170	20-120	
4	C-4	ASTM	woven mono			1.2-1.5	.0120-.0170	20-140	
5	C-5	ASTM	woven mono			1.1-1.6			
6	L Alice #1	Lake Alice	knitted 30	yes		0.9-1.0	.010-.018	20-120	0.413
11	M Farms #3	Many Farms	knitted 30	yes		2.4-2.6	.0017-.0023		3.4189
15	A Zone #3	A Zone-4f			4 @ 3/16	4.5-6.3	.003-.007	8-41	4.8523
16	A Zone #4	A Zone-4f			1 @ 3/8	17-26	.002-.005	5-27	8.2839
18	L Alice #5	Lake Alice			4 @1/8	9-19	.003-.007	8-36	0.7388
19	A Zone #6	A Zone-1c			4 @ 1/8	35-75	.003-.010	11-38	0.8213
20	A Zone #7	A Zone-1c	knitted 30	yes	4 @ 1/8	30-50	.008-.023	28-90	—
21	A Zone #8	A Zone-1c			4 @ 3/16	100-200	.0015-.0045	5-18	2.7338
22	A Zone #9	A Zone-1c	knitted 30	yes	4 @ 3/16	23-40	.008-.027	30-105	—
23	A Zone #10	A Zone-1c	heat bonded	yes	4 @3/16	20-37	.008-.025	30-95	—
24	A Zone #11	A Zone-1c	needle-punch nonwoven	yes	4 @ 3/16	14-22	.008-.022	25-90	—

Discussion – Significance of Test Results

Gradient Ratio (GR) refers to the head loss through 2 inches of soil and geotextile (or pipe wall), divided by the head loss through the next 2 inches of soil.

$$GR = \frac{\text{Head loss through 2 inches of soil + geotextile (or pipe wall)}}{\text{Head loss through 2 inches of soil}}$$

The Gradient Ratio should be stable over time for each test gradient. A Gradient Ratio that increases dramatically over time (at a given test gradient) suggests clogging of the geotextile or pipe perforations. A Gradient Ratio that decreases over time suggests excessive soil loss.

GR stable	=	system stable
GR increasing	=	system clogging
GR decreasing	=	soil loss (piping)

In addition, some studies (Christopher and Holtz, 1985) recommend the Gradient Ratio to be below some threshold value (such as below 3); however, the relevance of this arbitrary value is in debate.

Permeability – Permeability is the permeability of the soil-geotextile-perforation system. Again, permeability should be stable over time at each test gradient. Higher permeability is preferred.

Flow Rate – Flow rate (cc/sec) through the 4-inch permeameter is proportional to permeability. Again, flow rate should be stable over time at each test gradient. Higher flow rates are preferred.

Soil Loss – Amount of soil (envelope material) that washes through the geotextile and pipe perforations during the 7-day test. Only particles larger than about #100 settle out and can be collected with this test. Fine particles remain in suspension and are not collected. Some soil loss may be acceptable, depending on the application.

Tables 3 through 5 compare the results of the eight tests with geotextile to the five tests without geotextile for the Lake Alice and "A" Zone envelope materials. The results are very similar for all three test gradients (i = 1, 5, and 10). In all cases, use of a geotextile with a perforated pipe improved performance compared to a perforated pipe alone.

The single test with the Many Farms envelope (Test #11) used the knitted geotextile (#30 AOS) and had significant soil loss. The openings in the knitted geotextile were perhaps too large to adequately retain the fine-grained Many Farms envelope material.

Test Gradient – Toe drains in the field typically do not run completely full and have an air space in the top of the pipe. This leads to high gradients and head loss through the pipe perforations. Therefore, higher test gradients (i = 10) are probably more indicative of field conditions.

Table 3.—Summary of permeameter tests (i = 1)

Test configuration	Gradient ratio	Flow rate (cc/sec)	Permeability (meters/sec)	Envelope loss (grams)
No geotextile	5 to 100	5 to 11	0.005 to 0.010	0.7 to 8.3
With geotextile	1 to 30	20 to 30	0.017 to 0.027	< 0.1 to 0.4
Improvement with geotextile	200 to 400%	200 to 300%	200 to 300%	600 to 2,000%

Table 4.—Summary of permeameter tests (i = 5)

Test configuration	Gradient ratio	Flow rate (cc/sec)	Permeability (meters/sec)	Envelope loss (grams)
No geotextile	5 to 190	12 to 27	0.002 to 0.005	0.7 to 8.3
With geotextile	1 to 43	60 to 80	0.011 to 0.015	< 0.1 to 0.4
Improvement with geotextile	300 to 400%	200 to 400%	200 to 500%	600 to 2,000%

Table 5.—Summary of permeameter tests (i = 10)

Test configuration	Gradient ratio	Flow rate (cc/sec)	Permeability (meters/sec)	Envelope loss (grams)
No geotextile	6 to 200	18 to 41	0.0015 to 0.003	0.7 to 8.3
With geotextile	1 to 50	90 to 140	0.0080 to 0.012	< 0.1 to 0.4
Improvement with geotextile	300 to 500%	200 to 400%	300 to 400%	600 to 2,000%

Table 6 extrapolates the area of the small-scale tests to an equivalent area in a full-size pipe. The results are then compared to actual full-scale tests from earlier studies. The table shows that the observed flow rates are comparable at unit gradient (i = 1), but the soil loss is typically 2 to 10 times less than the full-scale tests. A longer test (30 days) would better simulate the full-scale test.

Table 6.—Comparison of small-scale and full-scale tests (flow rate and soil loss)

	Parameters	Flow rate			Soil loss		
#	Soil Geotextile Perforations	Small scale (cc/min)	Equivalent full scale (gpm/ft)	Actual full scale (gpm/ft)	Small scale (grams)	Equivalent full scale (grams/ft)	Actual full scale (grams/ft)
6	Lake Alice Knitted #30 No perforations	20 to120	14 to 86	21.3	0.413	19	50
11	Many Farms Knitted #30 No perforations	3 to 20	7 to 48	7.3	3.4189	103	1,000
15	A Zone – 4F No geotextile 4 @ 3/16 inch	8 to 41	6 to 30	6.3	4.8523	218	850
16	A Zone – 4F No geotextile 1 @ 3/8 inch	5 to 27	4 to 19	6.3	8.2839	373	850
18	Lake Alice No geotextile 4 @ 1/8 inch	8 to 36	6 to 26	1.7	0.7388	33	200
19	A Zone – 1C No geotextile 4 @ 1/8 inch	11 to 38	8 to 27	1.7	0.8213	37	200
20	A Zone – 1C Knitted #30 4 @ 1/8 inch	28 to 90	13 to 65	21.3	0	0	50
21	A Zone – 1C No geotextile 4 @ 3/16 inch	5 to 18	4 to 13	6.3	2.7338	123	850
22	A Zone – 1C Knitted #30 4 @ 3/16 inch	30 to105	22 to 76	21.3	0	0	50

Conclusions

1. Gradient Ratio Test apparatus (ASTM D5101) was successfully modified to test for compatibility between sand envelope and perforated HDPE pipe (with and without geotextile).

2. This small-scale test can be used for applications where a geotextile sock will be used around a perforated pipe. This test can also be used to evaluate the performance of pipe perforations with various envelope materials.

3. HDPE pipe wall can be simulated with HDPE geomembrane or Plexiglas (acrylic). Geonet was placed between geotextile and pipe wall to simulate void space in corrugated pipe valleys.

4. De-aired water can be recycled if specimen is adequately purged with CO_2.

5. Biocide should be added to the test solution on day 2 to prevent biological clogging. A second biocide treatment may be needed for 30-day tests.

6. Several combinations of envelope material, geotextile, and pipe perforations were identified that work well.

7. All four geotextiles tested in this study (knitted sock, monofilament woven, needle-punched nonwoven, and heat-bonded nonwoven) performed satisfactorily with a wide range of sand/gravel envelopes.

8. The permeameter test (Modified Gradient Ratio) replicated the improvements in flow rate and envelope loss seen in previous full-scale tests.

9. Flow rates from this small-scale test (i = 1) were comparable to previous laboratory tests on full-scale toe drains. However, soil loss was typically 2 to 10 times less than the soil loss seen in previous full-scale tests. A longer test (30 days) is recommended for future testing.

10. Because of the improved performance and low cost, use of a geotextile sock can be considered for applications requiring a two-stage filter around corrugated perforated pipe. Other issues that should be considered include potential tearing and clogging of the geotextile, constructability, verification of construction, and overall criticality of the installation.

11. With solid-wall perforated pipe, a geotextile sock should be used with caution because flow would be concentrated through a very small area of geotextile, increasing the likelihood of geotextile clogging.

Recommendations for Future Studies

1. Run future tests at single gradient (i = 10) for 30 days to better ascertain long-term performance issues such as soil loss and clogging. The modified Gradient Ratio Test did not replicate problems with clogging of 1/8-inch perforations experienced in the field and in the full-scale test. The 24-hour test interval at three different gradients (i = 1, 5, and 10) appears insufficient for clogging to develop.

2. Consider the following tests.

   Soil Loss – Evaluate larger perforations to verify Reclamation perforation criteria (P = ½D85)

   Clogging – Gap-graded silts and clays; slit-film wovens and heat-bonded nonwovens

   Most of the combinations of soil, geotextile, and pipe perforations worked well. Future tests should evaluate situations with unsatisfactory performance (such as clogging or excessive soil loss).

3. Evaluate envelopes with high fines content.

4. Evaluate geotextiles manufactured with time-release biocides to prevent bacterial growth and clogging. These geotextiles may be applicable for installations with iron-reducing bacteria problems.

5. Incorporate an air gap below the pipe perforations to simulate conditions in the pipe crown. The air gap may contribute significantly to soil loss or plugging of pipe perforations with soil particles.

6. Vibrate or disturb the envelope material to reduce arching potential and increase soil loss in the small-scale test.

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Appendix A

Manufacturers Geotextile Data Sheets

Carriff # 30 Knitted Sock
ADS Heat Bonded
Trevira 1112 Needle-punched Nonwoven

TYPAR®/TEKTON® FILTRATION GRADE SPUNBONDED POLYPROPYLENE

Typical Properties*

Style No.	Denier Per Filament	Basis Weight oz/yd²	Basis Weight g/m²	Thickness mils	Grab Tensile lbs MD x XD	Trap Tear lbs MD x XD	Mullen Burst psi	Frazier Air Perm cfm/ft²@ 0.5" H_2O
Low Denier								
3121L	4	1.25	42	9	32 x 28	12 x 9	28	380
3091L	4	0.93	32	8	20 x 15	6 x 5	21	540
3161L	4	1.60	54	10	42 x 22	12 x 10	35	250
3409L	4	4.00	136	15	120 x 80	35 x 20	106	29
3609L	4	6.00	203	20	170 x 110	60 x 35	177	16
Standard								
3121 (N)	8	1.25	42	10	53 x 48	28 x 24	40	650
3141 (N)	8	1.40	48	10	62 x 53	30 x 25	44	590
3151 (N)	10	1.60	54	12	66 x 62	33 x 29	52	530
3201 (N)	10	1.90	64	12	79 x 74	37 x 34	57	400
3251 (N)	10	2.50	85	13	111 x 106	41 x 32	N/A	185
3301	10	3.00	102	14	133 x 135	50 x 50	100	183
3341	20/10	3.40	115	16	130 x 146	48 x 50	N/A	134
3351	10	3.50	119	15	148 x 144	65 x 72	N/A	140
3401	20/10	4.00	136	18	148 x 160	73 x 78	N/A	212
3601	10	6.00	203	21	270 x 275	107 x 123	N/A	38
3801 (N)	10	8.00	271	25	350 x 356	97 x 87	N/A	12
T-515 (LF)	10	6.00	203	20	230 x 230	44 x 53	158	29

All styles designated with an "N" are available in Natural Color.
Note: 3100 Series Round Fiber Diameter = 35µ 3200 Series Round Fiber Diameter = 39 µ 3300 Series Round Fiber Diameter = 39 µ 3400 Series Round Fiber Diameter = 39 µ – 56 µ
3600 Series Round Fiber Diameter = 39 µ 3800 Series Round Fiber Diameter = 39 µ L Series Round Fiber Diameter = 25µ LF Series = Ultra low lint, designated for efficient release

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SEARCH:

Reemay, Synergex, Typar Filtration Media Typical Properties Sheet
PDF: 15kb 2 page document

For more information about available filtration media and services, please follow the links c this page, or e-mail us at info@BBAfiltration.com.

ABOUT BBA - PRODUCT FINDER - PRODUCT DESCRIPTIONS - PRODUCT PROPERTIES - CONTACT INFO

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Carriff Corporation's Drain-Sleeve Specifications

April 1996

Description	2" Regular	3" Regular &Highway	4" Regular	4" Highway	5" Regular	5" Highway	6" Regular	6" Highway	6" Super Highway	8" Regular	10" Regular	12" Regular	15" Regular	18" Regular	24" Regular
Color Stripe	white	white	white	blue	orange	yellow	white	red	black	white	black	blue	orange	white	red
Oz/yd² relaxed	3.20	5.40	3.80	5.40	4.30	5.40	3.30	4.10	4.60	3.50	3.50	3.50	3.50	3.50	3.50
Oz/yd² Applied	2.10	3.50	2.50	3.50	2.80	3.50	2.80	3.50	3.90	3.00	3.00	3.00	3.00	3.00	3.00
Layflat Width															
Inches	5.25	5.50	6.75	6.00	7.00	7.00	10.00	9.75	10.50	14.00	14.00	16.00	25.00	27.50	30.00
mm	133	140	170	152	178	178	255	248	268	355	355	406	635	699	762
Cross Stretch															
Inches	7.5	10	16	14.5	17.5	16.75	20.5	19	19.5	25	30	35	40	42	52
mm	190	254	406	368	445	425	520	483	498	635	762	890	1020	1065	1320
Applied Weight* per 1000'															
lbs	11.0	23.0	25.0	30.0	30.0	36.0	35.0	44.0	53.0	52.0	65.0	81.0	103.0	115.0	150.0
kgs	5.0	10.5	12.0	13.5	13.5	16.3	16.0	20.0	24.0	23.6	30.0	37.0	42.0	52.0	68.0
ft/#	90.0	43.0	40.0	33.0	33.0	27.0	28.0	22.0	19.0	19.0	15.0	12.0	9.0	8.0	6.0

** These weights may vary by application procedure and O.D. of pipe*

SPECIFICATION	Test Method	Regular Sleeve	Highway Sleeve
Fiber		Polyester	Polyester
Weight (Oz/yd²) Applied	ASTM D-3776	2.5-3.5	3.5-3.9
Thickness, in (mm)		.040 (1)	.040 (1)
Mullen Burst, p.s.i. (kpa)	ASTM D-3786	100	135
PunctureStrength	ASTM D-4833	N/A	35
Air Permeabilty ft³/ft²/min(cm³/cm²/sec)	ASTM D-737	700 (335)	700 (335)
Water flow rate (US) gal/ft²/min·3"Head		700	700
Water Permeability by Permittivity s(-1)	ASTM D-4491	2.4	2.9
AOS, US sieve	ASTM D-4751	30	40-50
AOS, (UM)	ASTM D-4751	600	425-300
UV Degradation	ASTM D-4355	70%	70%

Specifications are based on independent laboratory studies and are considered to be true and accurate

ECONOMICAL
VERSATILE
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CARRIFF CORPORATION INC

2890 Highway 49 North
Concord, NC USA 28025
1-800-845-5184
704 [illegible] 3917
Fa [illegible] 38-8514

TREVIRA Engineering Fabric

Technical Support

TYPICAL PHYSICAL PROPERTIES OF TREVIRA® TYPE 11 PRODUCTS

Fabric Property	Unit	Test Method	1112	1114	1120	1125	1135	1145	1155
Fabric Weight	oz/yd^2	ASTM D-3376	3.5	4.2	6.0	7.5	10.5	13.5	16.5
Thickness. t	mils	ASTM D-1777	60	70	90	110	140	170	210
Grab strength (MD/CD)[1)]	lbs	ASTM D-4632	120/95	150/115	230/180	300/235	420/350	540/450	650/570
Grab Elongation (MD/CD)[1)]	%	ASTM D-4632	65/75	75/85	75/85	75/85	765/80	80/80	85/85
Trapezoid Tear Strength (MD/CD)[1)]	lbs	ASTM D-4553	50/40	55/50	80/75	105/95	140/125	180/165	225/200
Puncture Resistance	lbs	ASTM D-4833	55	65	95	115	155	185	225
Mullen Burst Strength	psi	ASTM D-3786	195	225	320	400	560	700	855
Water Flow Rate	gpm/ft^2	ASTM D-4491	195	190	170	150	120	100	80
Permittivity Ψ	sec	ASTM D-4491	2.61	2.54	2.27	2.01	1.60	1.34	1.07
Permeability, k = Ψ t	cm/sec	ASTM D-4491	40	.45	.52	.56	.57	.58	.57
AOS	Sieve Size mm	ASTM D-4751	70-100 210-149	70-100 210-149	70-100 210-149	70-100 210-149	100-120 149-125	120-140 125-106	104-170 106-088
Standard Roll Widths	ft		12.5 AND 15.0						
Standard Roll Length	ft		400	400	300	300	300	300	300

[1)]MD = Machine Direction, CD = Cross Machine Direction.

[2)]Other width and length rolls are available upon request.

MINIMUM† PHYSICAL PROPERTIES OF TREVIRA® TYPE 11 PRODUCTS

Fabric Property	Unit	Test Method	1112	1114	1120	1125	1135	1145	1155
Fabric Weight	oz/yd^2	ASTM D-3376	3.3	4.0	5.7	7.1	10.0	13.0	16.0
Thickness. t	mils	ASTM D-1777	50	55	75	95	125	150	185
Grab strength (MD/CD)[1)]	lbs	ASTM D-4632	80	100	160	210	305	390	500
Grab Elongation (MD/CD)[1)]	%	ASTM D-4632	60	60	60	60	60	65	75
Trapezoid Tear Strength (MD/CD)[1)]	lbs	ASTM D-4553	30	40	60	75	100	130	150
Puncture Resistance	lbs	ASTM D-4833	40	50	80	95	130	155	195
Mullen Burst Strength	psi	ASTM D-3786	170	190	275	360	510	640	780
Water Flow Rate	gpm/ft^2	ASTM D-4491	155	150	130	110	80	60	40
Permittivity Ψ	sec	ASTM D-4491	2.07	2.01	1.74	1.47	1.07	0.80	0.53
Permeability, k = Ψt	cm/sec	ASTM D-4491	.26	.28	.33	.35	.34	.31	.25
AOS	Sieve Size mm	ASTM D-4751	50 300	50 300	70 210	70 210	70 210	100 149	100 149

†These minimum values represent minimum test values determined from Q.C. testing on all lots produced in 1989. Certified "Minimum Average Roll Values" representing the industry standard of a 95 percent confidence level (i.e. mean less two standard deviations) may be higher than these values and are determined for each production lot. Please contact your Trevira® Distributor or Hoechst Celanese Corporation for additional information.

Trevira® Spunbond products are 100% polyester (polyethylene terephthalate), nonwoven fabrics mechanically bonded by needling.

TREVIRA® SPUNBOND

Spunbond Business Group
Hoechst Celanese Corporation
P.O. Box 5887
Spartanburg, SC 29304-9880 U.S.A.
1 (800) 845-7597
1 (803) 579-5007
Telex: 9102404053

Hoechst Celanese

Hoechst

Also see our Asphalt Paving System Catalog in Sweet's Section 02550

Appendix B

Test Results

Small-Scale Permeameter Test
(Modified Gradient Ratio)

Geotextile I.D. Woven Monofilament **TEST #3** C-3

Soil I.D. ASTM C778 (20-30 mix)

Geotextile Thickness: 60 mils

Weight of soil used: 3.04 lb Soil Loss: _____

Unit Weight of Dry Soil in Permeamet 17.28 kN/m^3

Volume of Soil: 47.78 in^3

Target Gradient: 1

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
7-Jun	8:00	0	10.0	13.8	12.1	11.8	7.7	7.8	3.8	1	4.2	3.95	1.881	590	30	19.6667	21	0.0167
	8:30	0.5	10.1	13.9	12.1	11.8	7.8	7.9	3.8	1.01	4.1	4.05	1.9756	590	30	19.6667	21	0.0166
	9:00	1	10.1	13.9	12.0	11.8	7.7	7.8	3.8	1.01	4.15	3.95	1.9036	595	30	19.8333	22	0.0171
	10:00	2	10.1	13.9	12.0	11.8	7.8	7.8	3.8	1.01	4.1	4	1.9512	590	30	19.6667	22	0.017
	12:00	4	10.1	13.9	12.0	11.8	7.8	7.8	3.8	1.01	4.1	4	1.9512	575	30	19.1667	23	0.017
	2:00	6	10.1	13.9	12.0	11.8	7.8	7.8	3.8	1.01	4.1	4	1.9512	575	30	19.1667	23	0.017
8-Jun	8:00	24	10.2	13.9	11.9	11.7	7.6	7.7	3.7	1.02	4.15	3.95	1.9036	1150	60	19.1667	24	0.0173

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
8-Jun	8:35	0	25	31	26	25.4	14.6	14.8	6	2.5	11	8.7	1.5818	2727	60	45.45	24	0.0167

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
8-Jun	8:50	0	50	61.8	51.8	50.5	29	29.6	11.8	5	21.85	17.5	1.6018	2560	30	85.3333	24	0.0157
	9:20	0.5	50.1	61.9	51.8	50.6	29.1	29.6	11.8	5.01	21.85	17.55	1.6064	2550	30	85	24	0.0156
	9:50	1.00	50.3	62	51.8	50.6	29.2	29.7	11.7	5.03	21.75	17.75	1.6322	2550	30	85	24	0.0156
	10:50	2.00	50.3	62	51.9	50.7	29.2	29.7	11.7	5.03	21.85	17.75	1.6247	2541	30	84.7	24	0.0155
	12:50	4.00	50.6	62.2	51.9	50.7	29.1	29.6	11.6	5.06	21.95	17.75	1.6173	2530	30	84.3333	24	0.0153
	2:50	6.00	50.5	62.1	51.8	50.7	29	29.5	11.6	5.05	22	17.65	1.6045	2520	30	84	23.5	0.0151
11-Jun	7:30	71	52.4	62.8	50.6	49.7	27.6	28	10.4	5.24	22.35	17.4	1.557	2284	30	76.1333	23.5	0.0132

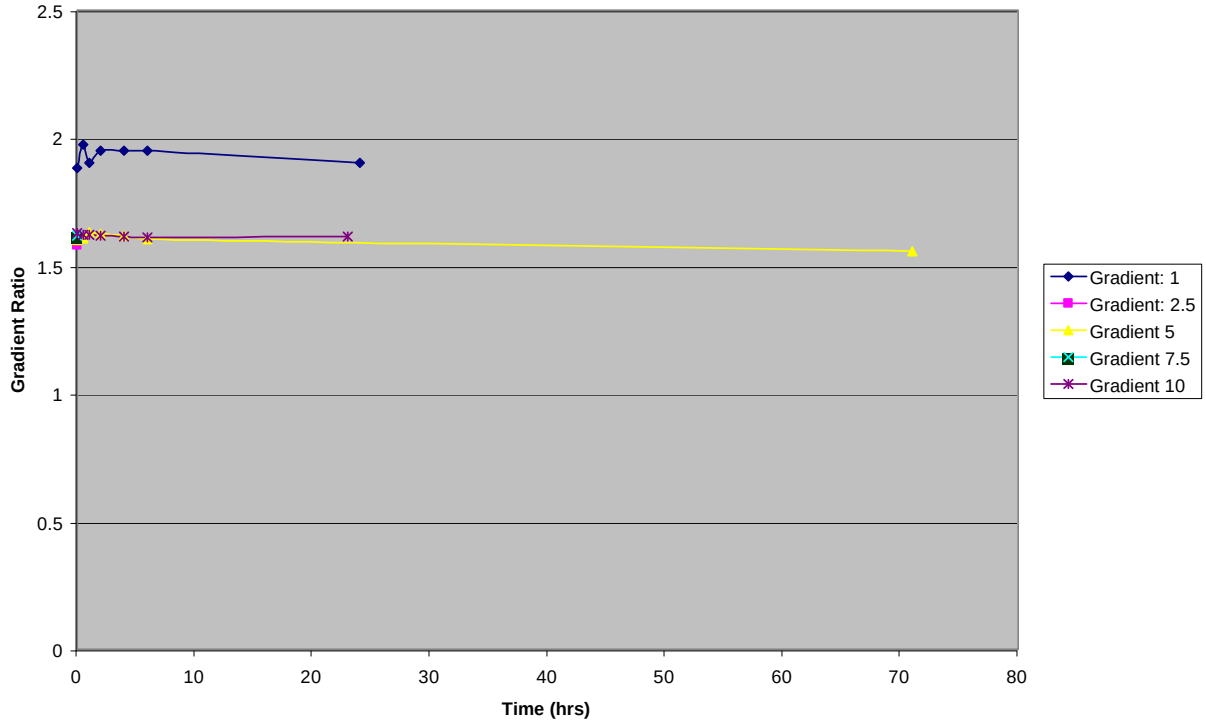
Target Gradient: 7.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm)						*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
				1	2	3	4	5	6									
11-Jun	7:45	0.00	74.6	90.2	73	71.6	40.5	41.4	15.6	7.46	31.35	25.35	1.6172	1550	15	103.333	23.5	0.0126

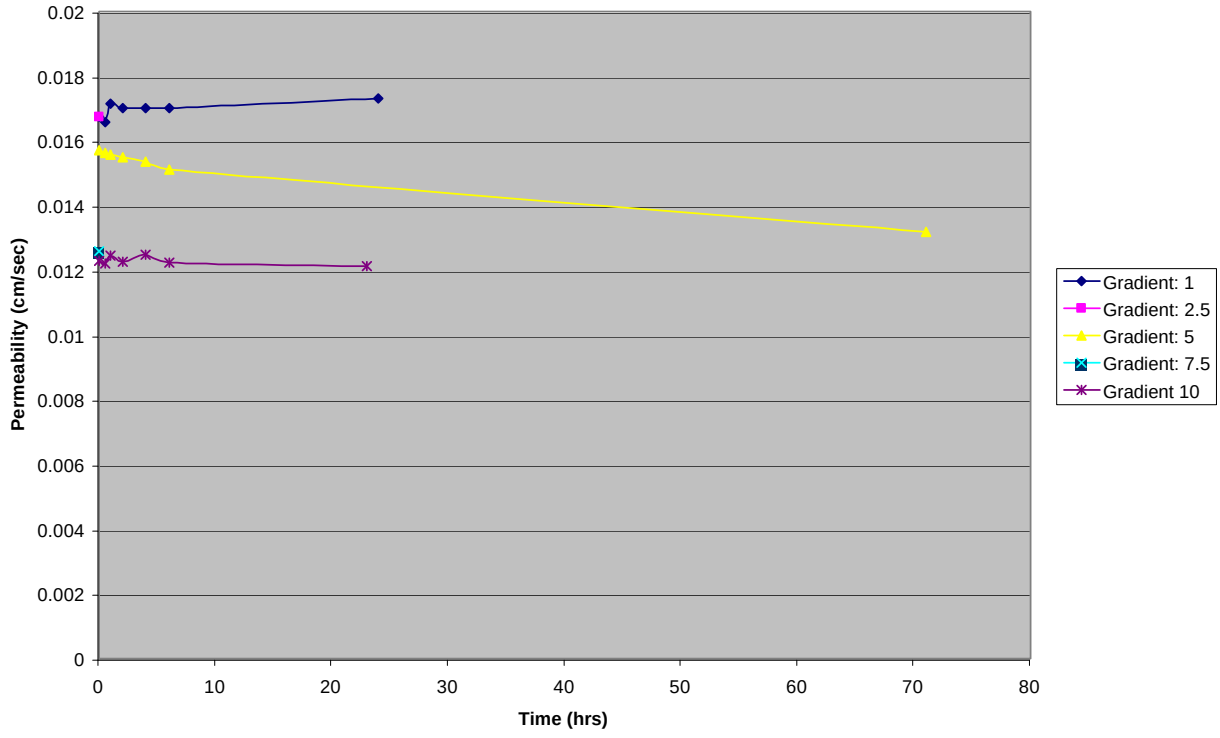
Target Gradient: 10

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm)						*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
				1	2	3	4	5	6									
11-Jun	8:20	0	86.4	105.2	85.3	83.3	47.7	48.7	18.8	8.64	36.1	29.4	1.6288	1755	15	117	23.5	0.0123
	8:50	0.5	86.4	105.2	85.3	83.7	47.7	48.7	18.8	8.64	36.3	29.4	1.6198	1740	15	116	23.5	0.0122
	9:20	1	86.4	105.2	85.3	83.7	47.7	48.7	18.8	8.64	36.3	29.4	1.6198	1775	15	118.333	23.5	0.0124
	10:20	2	86.4	105.2	85.4	83.7	47.7	48.7	18.8	8.64	36.35	29.4	1.6176	1750	15	116.667	23.5	0.0123
	12:20	4	86.4	105.2	85.3	83.7	47.6	48.7	18.8	8.64	36.35	29.35	1.6149	1780	15	118.667	23.5	0.0125
	2:20	6	86.4	105.2	85.2	83.7	47.6	48.6	18.8	8.64	36.35	29.3	1.6121	1745	15	116.333	23.5	0.0122
22-Jun	7:15	23	86.6	105.2	85.1	83.5	47.4	48.5	18.6	8.66	36.35	29.35	1.6149	1710	15	114	24	0.0121

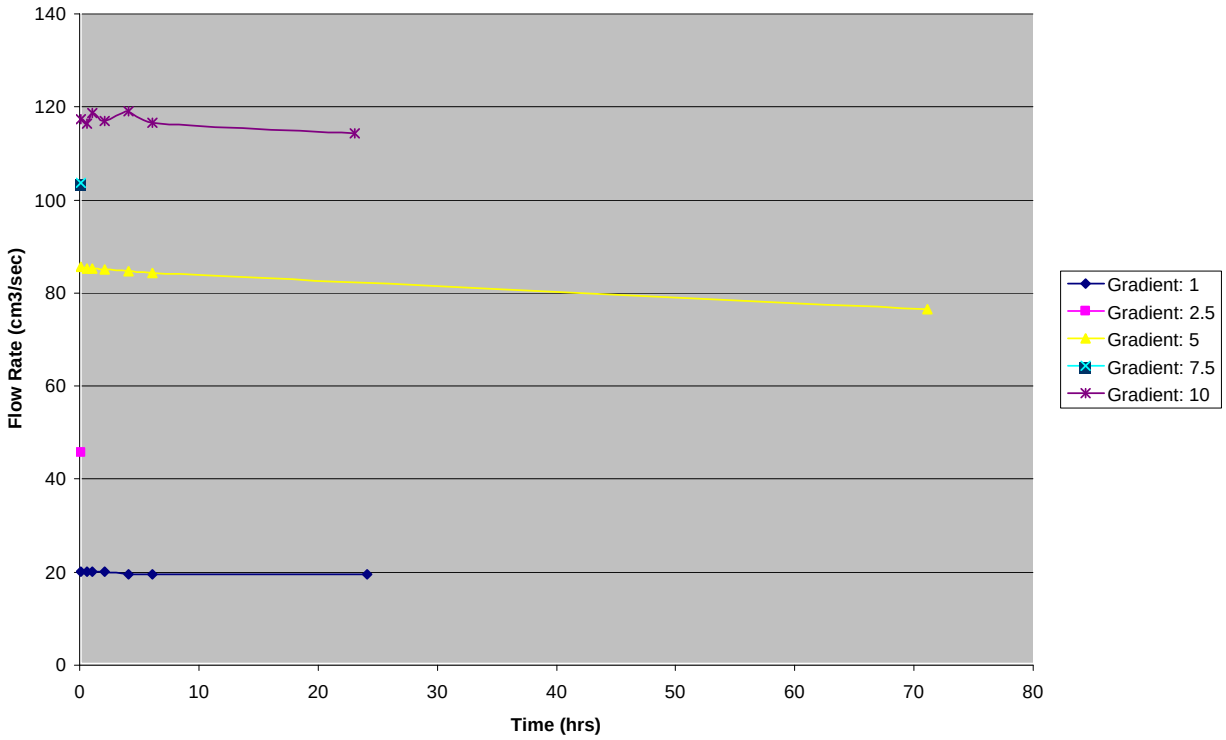
Gradient Ratio vs. Time



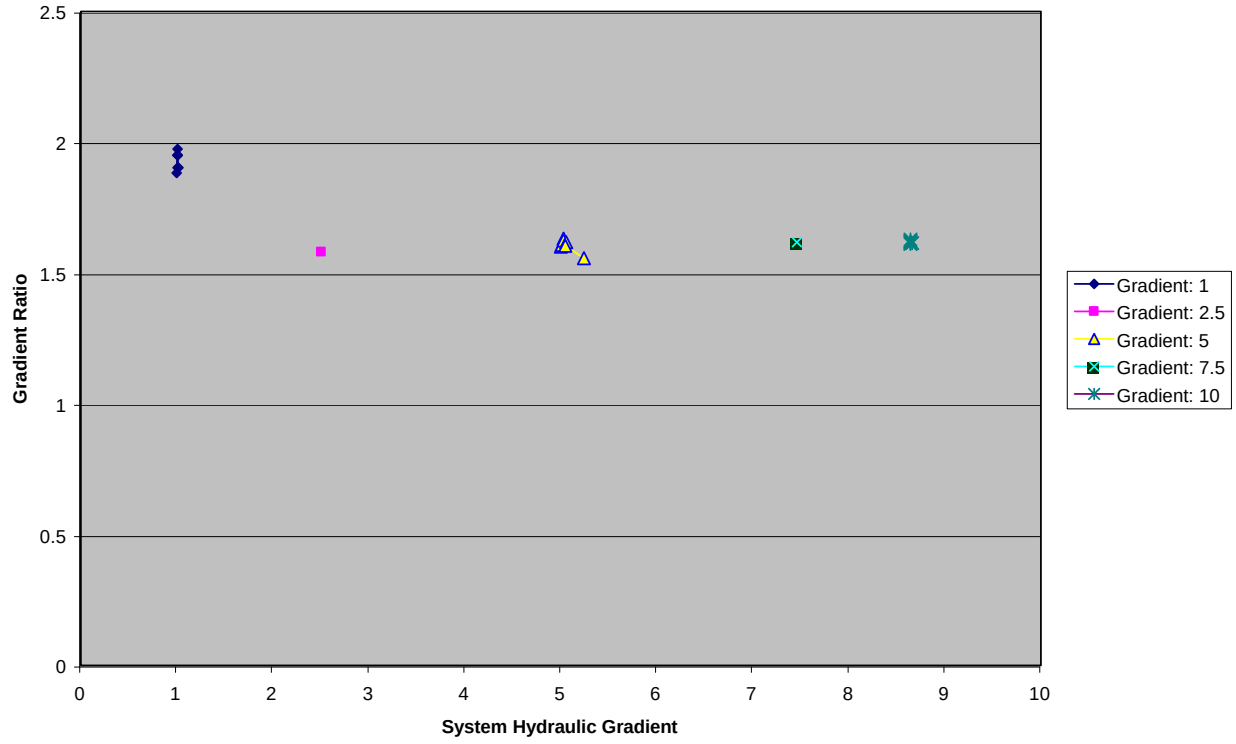
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Geotextile I.D. Woven Monofilament **TEST #4** C-4

Soil I.D. ASTM C778 (20-30 mix)

Geotextile Thickness: 60 mils

Weight of soil used: 3.04 lb Soil Loss: _____

Unit Weight of Dry Soil in Permeamet 17.28 kN/m^3

Volume of Soil: 47.7836 in^3

Target Gradient: 1

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
19-Jun	8:00	0	10.0	12.7	10.7	10.8	6.0	5.9	2.7	1	4.8	3.25	1.3542	1138	60	18.9667	22	0.0166
	8:30	0.5	10.0	12.7	10.6	10.7	5.9	5.8	2.7	1	4.8	3.15	1.3125	1100	60	18.3333	22	0.016
	9:00	1	9.9	12.7	10.6	10.7	5.8	5.8	2.8	0.99	4.85	3	1.2371	1145	60	19.0833	22	0.0168
	10:00	2	10.0	12.8	10.6	10.7	5.8	5.8	2.8	1	4.85	3	1.2371	1152	60	19.2	22	0.0168
	12:00	4	10.0	12.8	10.6	10.7	5.8	5.8	2.8	1	4.85	3	1.2371	1163	60	19.3833	23	0.0174
	2:00	6	10.0	12.8	10.5	10.6	5.8	5.8	2.8	1	4.75	3	1.2632	1160	60	19.3333	23	0.0173
20-Jun	8:00	24	10.0	12.7	10.4	10.6	5.7	5.7	2.7	1	4.8	3	1.25	1130	60	18.8333	24	0.0173

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
20-Jun	8:25	0.5	25	29.5	23.9	24	12.5	12.5	4.5	2.5	11.45	8	1.3974	1350	30	45	24	0.0166

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
20-Jun	8:30	0	50	59.7	48.2	48.6	25.8	25.7	9.7	5	22.65	16.05	1.4172	2500	30	83.3333	24	0.0153
	9:00	0.5	50	59.7	48.1	48.5	25.8	25.7	9.7	5	22.55	16.05	1.4235	2500	30	83.3333	24	0.0153
	9:30	1.00	50	59.7	48.1	48.4	25.8	25.7	9.7	5	22.5	16.05	1.4267	2500	30	83.3333	24	0.0153
	10:30	2.00	49.9	59.7	48.4	48.7	25.9	25.8	9.8	4.99	22.7	16.05	1.4141	2500	30	83.3333	24	0.0154
	12:30	4.00	49.9	59.7	48.3	48.6	25.9	25.8	9.8	4.99	22.6	16.05	1.4204	2500	30	83.3333	24	0.0154
	2:30	6.00	49.9	59.7	48.3	48.7	25.8	25.7	9.8	4.99	22.75	15.95	1.4022	2500	30	83.3333	24	0.0154
21-Jun	8:00	23.5	50	59.7	48.3	48.7	25.8	25.7	9.7	5	22.75	16.05	1.411	2500	30	83.3333	24	0.0153

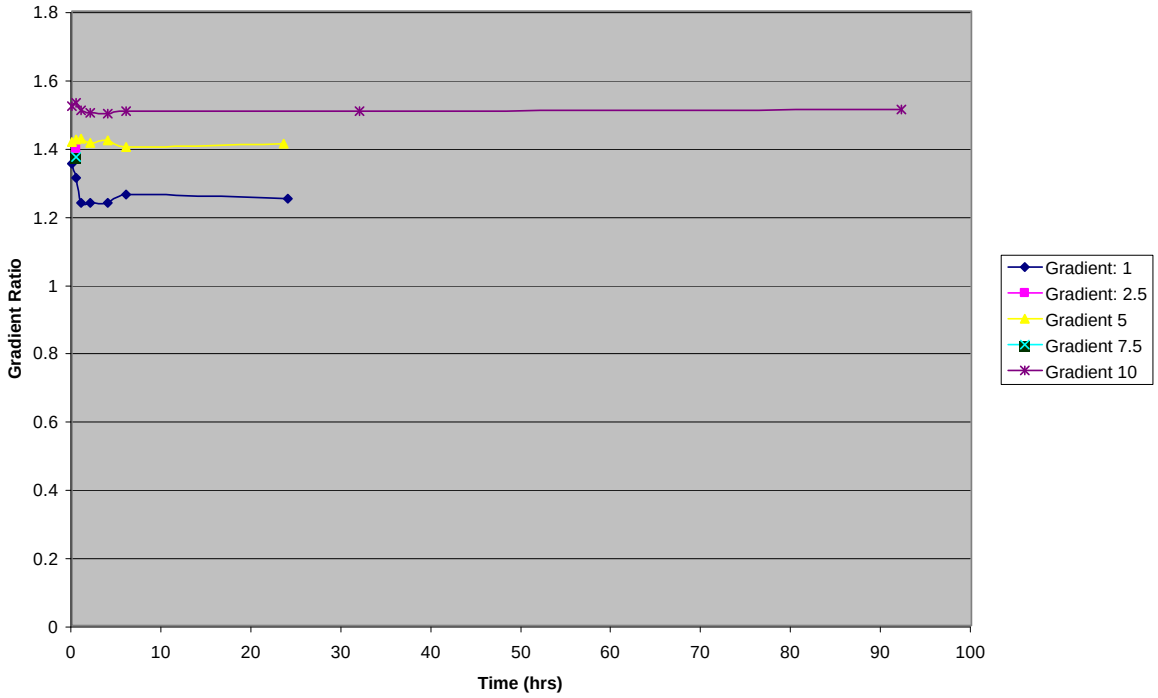
Target Gradient: 7.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm)						*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
				1	2	3	4	5	6									
21-Jun	8:30	0.50	73.3	91.1	73.6	74.1	40.7	40.5	17.8	7.33	33.25	22.8	1.3714	3500	30	116.667	24	0.0147

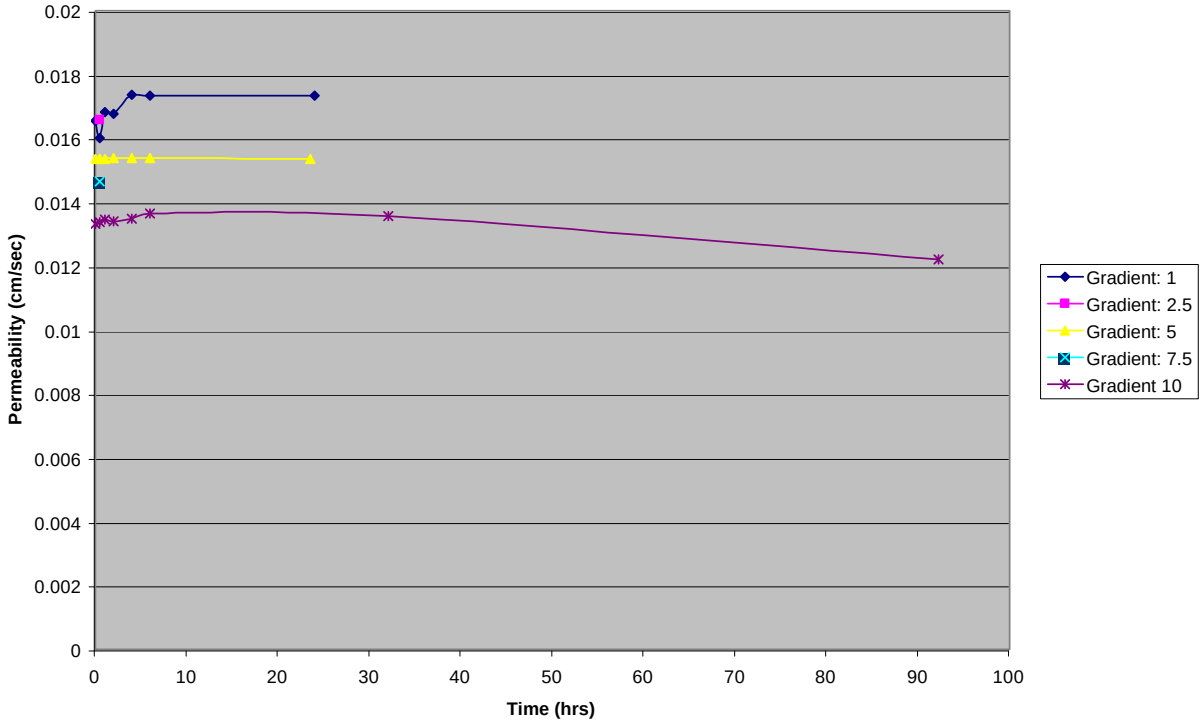
Target Gradient: 10

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm)						*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
				1	2	3	4	5	6									
21-Jun	10:00	0	95.3	100.1	78.0	78.4	36.6	36.4	4.8	9.53	41.7	31.7	1.5204	4140	30	138	24	0.0133
	10:30	0.5	95.3	100.2	78.0	78.4	36.8	36.6	4.9	9.53	41.5	31.8	1.5325	4150	30	138.333	24	0.0134
	11:00	1	95.2	100.2	78.5	78.5	36.7	36.5	5.0	9.52	41.9	31.6	1.5084	4170	30	139	24	0.0134
	12:00	2	95.0	100.3	78.0	78.5	36.7	36.5	5.3	9.5	41.65	31.3	1.503	4150	30	138.333	24	0.0134
	2:00	4	95.0	100.3	78.0	78.5	36.7	36.4	5.3	9.5	41.7	31.25	1.4988	4170	30	139	24	0.0135
	4:00	6	95.2	100.4	78.1	78.5	36.7	36.5	5.2	9.52	41.7	31.4	1.506	4230	30	141	24	0.0136
22-Jun	18:00	32	95.8	101.0	78.1	78.5	36.7	36.5	5.2	9.58	41.7	31.4	1.506	4230	30	141	24-Jan	0.0136
25-Jun	6:20	92.25	98.9	102.0	78.9	79.4	36.0	35.7	3.1	9.89	43.3	32.75	1.5127	3930	30	131	24	0.0122

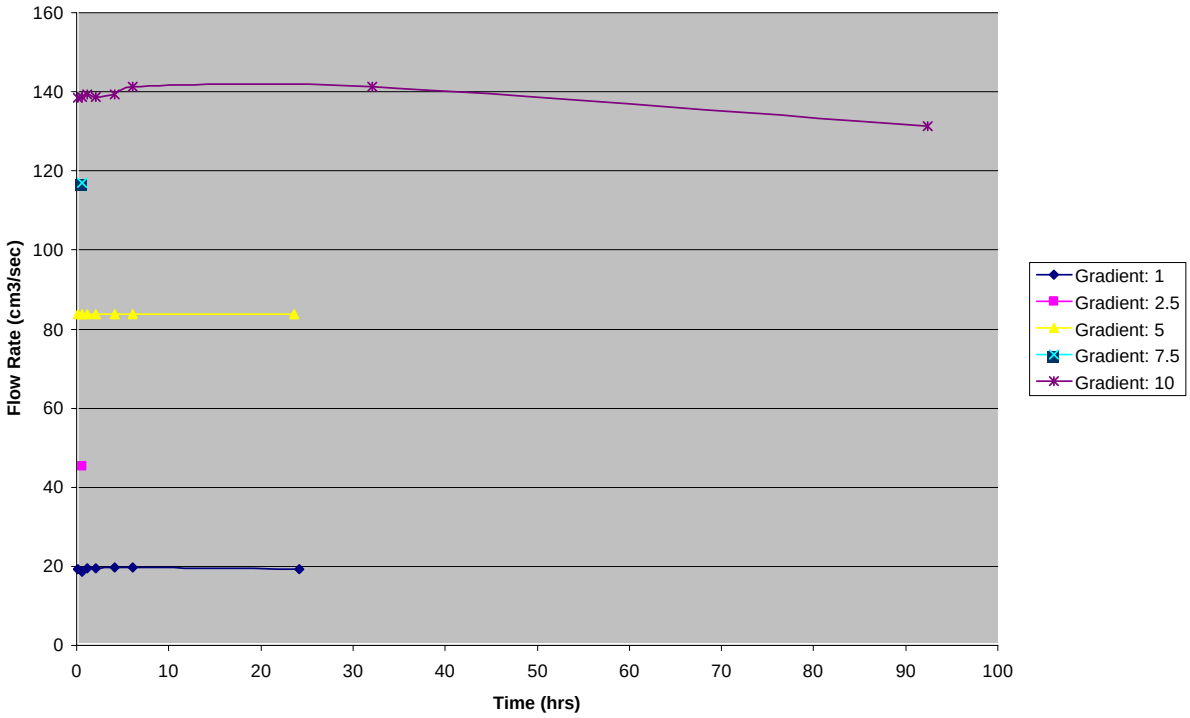
Gradient Ratio vs. Time



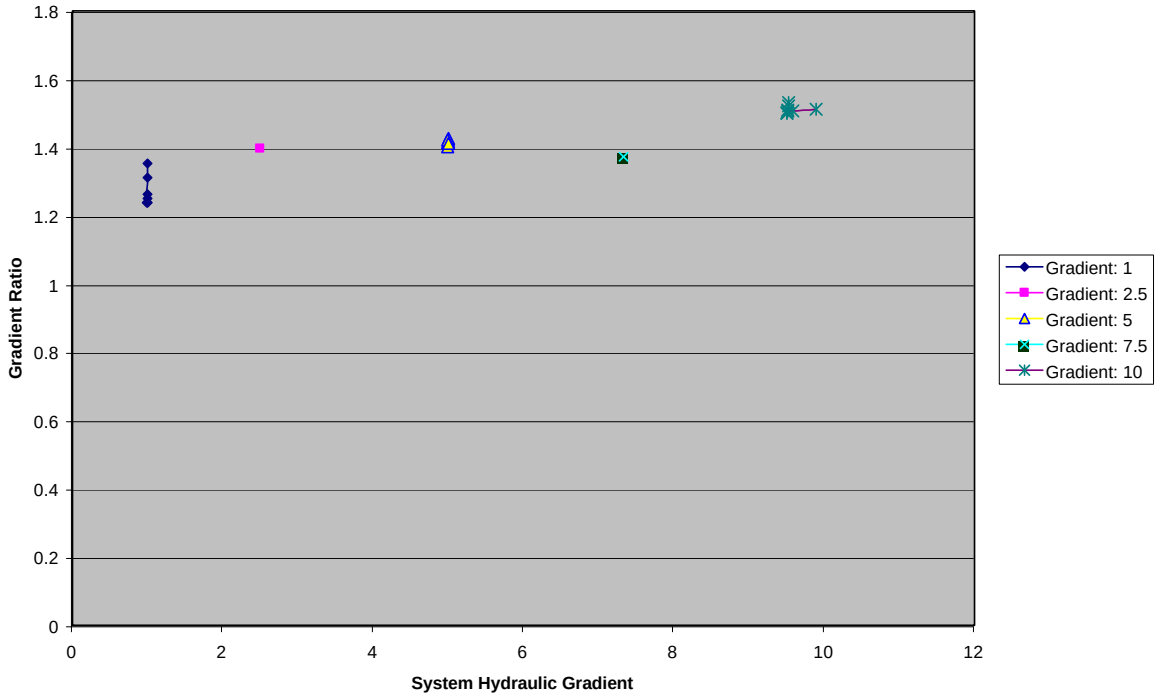
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Geotextile I.D. Carriff Knitted Sock, AOS = #30 **TEST # 6** Lake Alice - 1

Soil I.D. Lake Alice - Scalped 3/8 +

Geotextile Thickness: _____ mils

Weight of soil used: 3.04 lb Soil Loss: 0.413 grams

Unit Weight of Dry Soil in Permeamet 17.28 kN/m^3

Volume of Soil: 47.78 in^3

Target Gradient: 1

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
10-Jul	8:00	0	10.0	15.1	13.7	14.3	8.3	7.8	5.1	1	5.95	2.95	0.9916	1210	60	20.1667	21	0.0172
	8:30	0.5	10.0	15.1	13.7	14.2	8.2	7.8	5.1	1	5.95	2.9	0.9748	1210	60	20.1667	21	0.0172
	9:00	1	10.0	15.1	13.6	14.2	8.2	7.7	5.1	1	5.95	2.85	0.958	1215	60	20.25	22	0.0177
	10:00	2	10.0	15.1	13.6	14.2	8.2	7.7	5.1	1	5.95	2.85	0.958	1215	60	20.25	22	0.0177
	12:00	4	10.0	15.1	13.6	14.2	8.2	7.8	5.1	1	5.9	2.9	0.9831	1215	60	20.25	22	0.0177
	2:00	6	10.0	15.1	13.6	14.2	8.2	7.7	5.1	1	5.95	2.85	0.958	1213	60	20.2167	23	0.0181
11-Jul	8:00	24	10.1	15.1	13.6	14.2	8.1	7.6	5.0	1.01	6.05	2.85	0.9421	1165	60	19.4167	21	0.0164

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
11-Jul	8:15	0.5	26.5	31.5	27.3	28.9	14	13	5	2.65	14.6	8.5	1.1644	1250	30	41.6667	22	0.0137

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
11-Jul	8:20	0	50.1	60.5	52.1	55	25.1	23.3	10.4	5.01	29.35	13.8	0.9404	2180	30	72.6667	22	0.0127
	8:50	0.5	50.1	60.5	52.1	54.9	25	23.2	10.4	5.01	29.4	13.7	0.932	2180	30	72.6667	22	0.0127
	9:20	1.00	50.1	60.5	52.1	54.9	25	23.2	10.4	5.01	29.4	13.7	0.932	2175	30	72.5	22	0.0126
	10:20	2.00	50.1	60.5	52.1	54.9	25	23.2	10.4	5.01	29.4	13.7	0.932	2178	30	72.6	22	0.0127
	12:50	4.00	50.1	60.5	52.1	54.9	25	23.2	10.4	5.01	29.4	13.7	0.932	2180	30	72.6667	22	0.0127
	2:50	6.00	50.1	60.5	52.1	54.9	25	23.2	10.4	5.01	29.4	13.7	0.932	2160	30	72	22	0.0125
12-Jul	7:30	23.25	50.4	60.5	52.1	54.9	24.5	23.1	10.1	5.04	29.7	13.7	0.9226	2115	30	70.5	22	0.0122

Target Gradient: 7.5

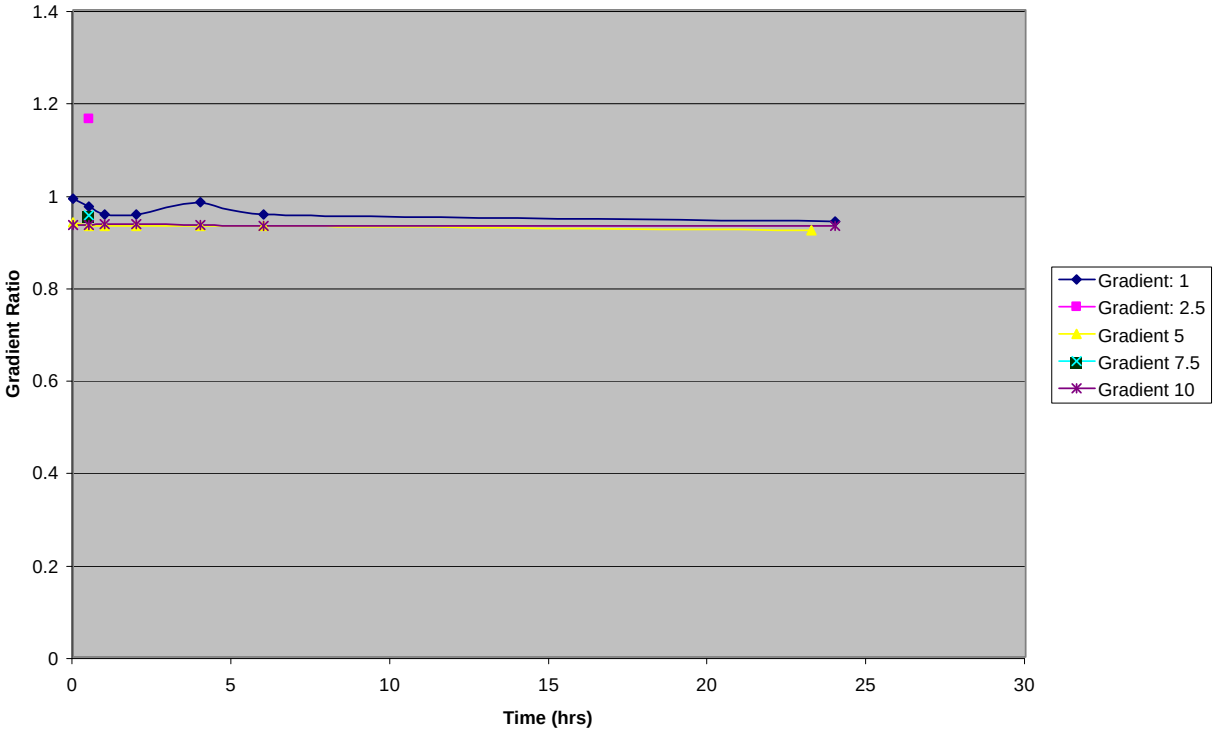
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
12-Jul	8:30	0.50	75	89	76.1	80.3	35.7	33.8	14	7.5	43.45	20.75	0.9551	2870	30	95.6667	22	0.0111

Target Gradient: 10

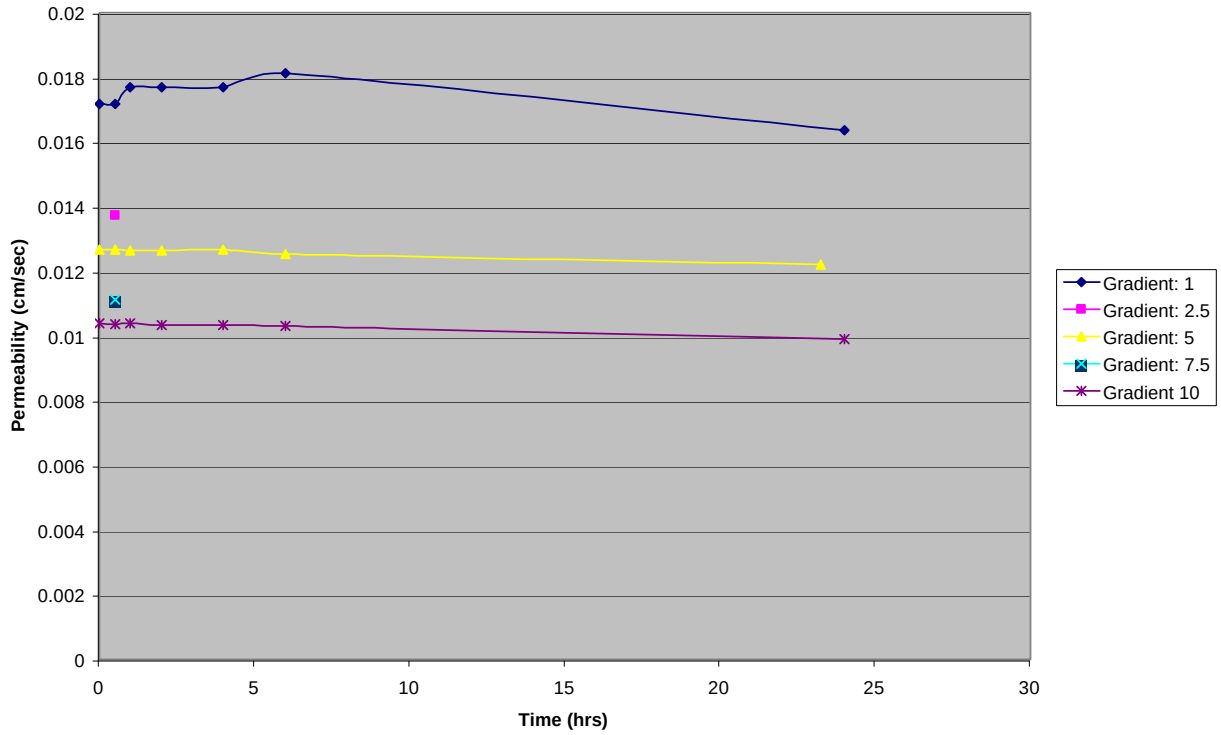
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
12-Jul	8:30	0	100.1	103.3	86.0	91.6	32.1	28.8	3.2	10.01	58.35	27.25	0.934	3570	30	119	22	0.0104
	9:00	0.5	100.1	103.3	86.0	91.6	32.1	28.8	3.2	10.01	58.35	27.25	0.934	3565	30	118.833	22	0.0104
	9:30	1	100.0	103.3	86.0	91.6	32.2	28.9	3.3	10	58.25	27.25	0.9356	3575	30	119.167	22	0.0104
	10:30	2	100.6	103.8	86.2	91.8	32.2	28.9	3.2	10.06	58.45	27.35	0.9358	3575	30	119.167	22	0.0103
	12:30	4	100.6	103.8	86.3	91.9	32.2	28.9	3.2	10.06	58.55	27.35	0.9342	3570	30	119	22	0.0103
	2:30	6	100.7	103.9	86.4	91.9	32.2	28.9	3.2	10.07	58.6	27.35	0.9334	3565	30	118.833	22	0.0103
13-Jul	8:30	24	101.9	104.4	86.7	92.3	31.9	28.4	2.5	10.19	59.35	27.65	0.9318	3469	30	115.633	22	0.0099

Note 1 - Fines at bottom of Permeameter at beginning of teste
Note 2 - Slight increase in fines at Permeameter bottom when gradient increased to 7.5
Note 3 - Total weight of fines in bottom of reservoir = 0.413 grams

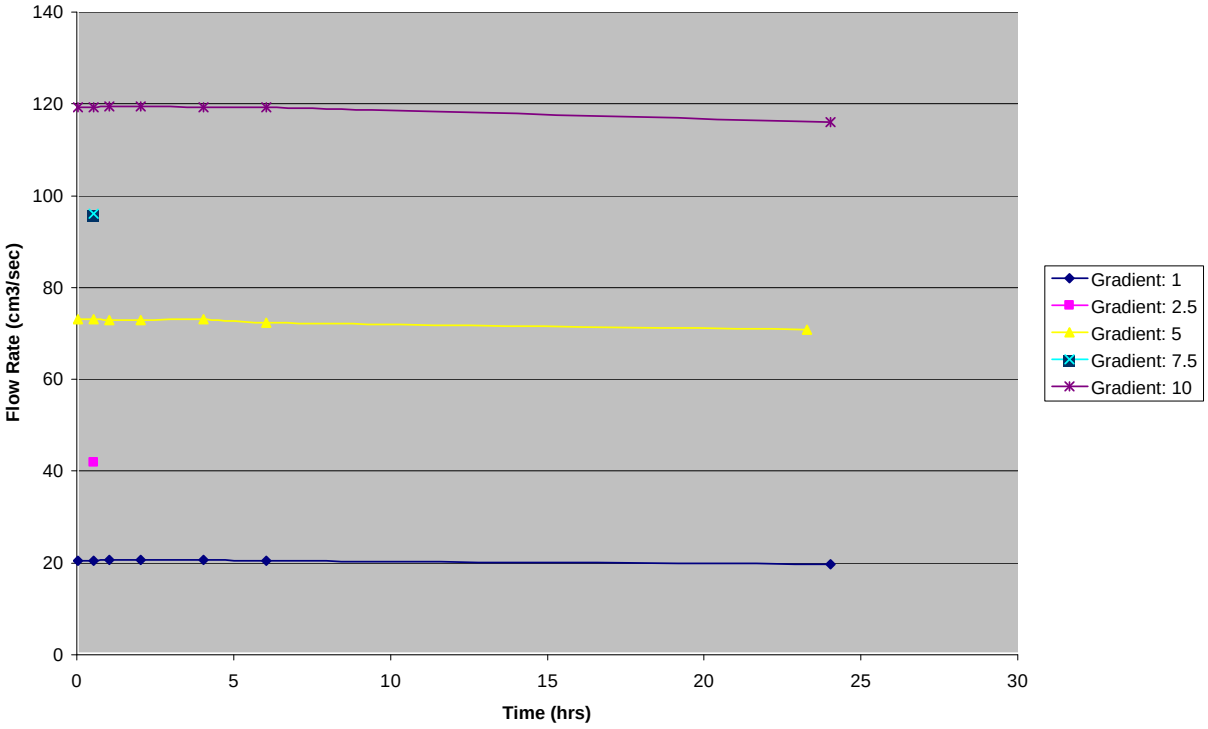
Gradient Ratio vs. Time



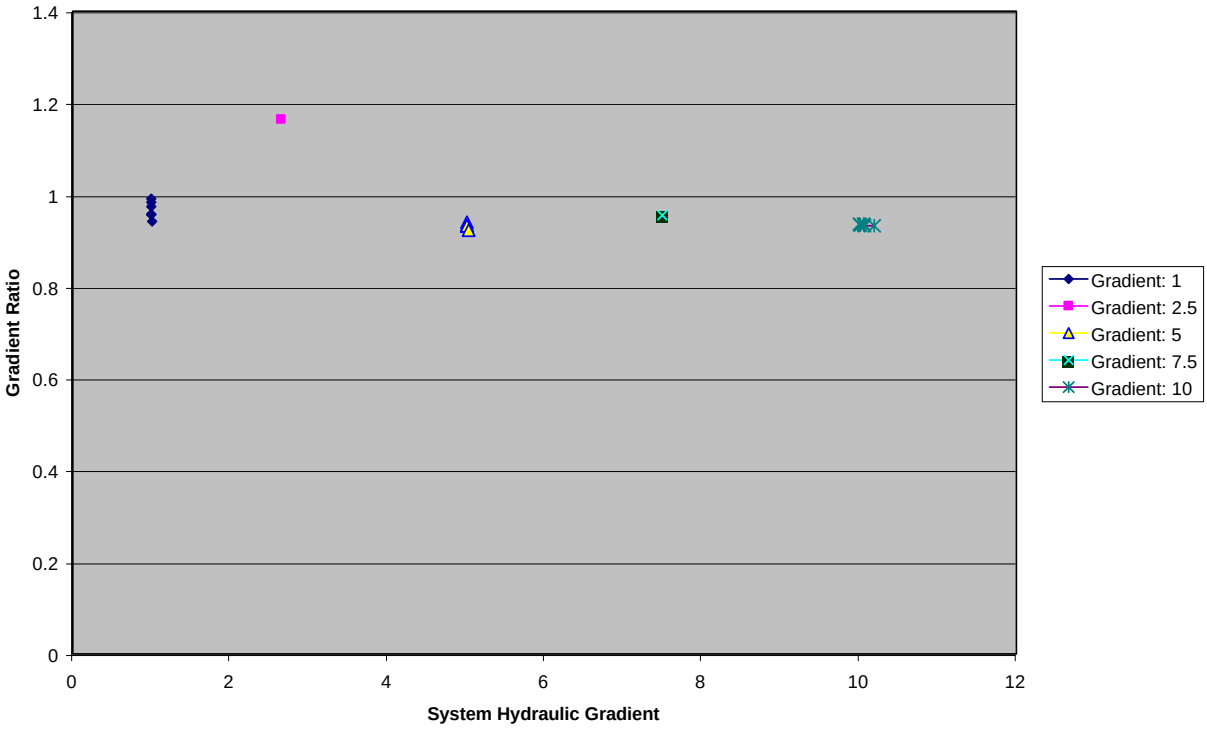
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Geotextile I.D. Knitted Sock AOS = #30 **TEST # 11** Many Farms #3

Soil I.D. Many Farms

Weight of soil used: 3.182 lb Soil Loss: 4.8523 grams

Unit Weight of Dry Soil in Permeamet 18.09 kN/m^3

Volume of Soil 47.78 cu in

Target Gradient: 1

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
23-Oct	8:00	0	10.1	12.6	11.9	12.1	8.3	7.3	2.5	1.01	4.2	5.3	2.5238	150	60	2.5	21	0.0021
	8:30	0.5	10.2	12.7	11.8	12.1	8.3	7.3	2.5	1.02	4.15	5.3	2.5542	158	60	2.63333	22	0.0023
	9:00	1	10.1	12.6	11.8	12.0	8.3	7.3	2.5	1.01	4.1	5.3	2.5854	158	60	2.63333	23	0.0023
	10:00	2	10.1	12.6	11.8	12.0	8.3	7.2	2.5	1.01	4.15	5.25	2.5301	157	60	2.61667	23	0.0023
	0:00	4	10.0	12.6	11.8	12.0	8.3	7.2	2.6	1	4.15	5.15	2.4819	155	60	2.58333	23	0.0023
	14:00	6	10.0	12.6	11.8	12.0	8.3	7.2	2.6	1	4.15	5.15	2.4819	155	60	2.58333	23	0.0023
24-Oct	8:00	24	10.0	12.6	11.7	11.9	8.3	7.2	2.6	1	4.05	5.15	2.5432	150	60	2.5	23	0.0022

Note: Fines at bottom of test chamber

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
24-Oct	8:07	0	24.9	27.3	25.2	25.7	16.5	13.9	2.4	2.49	10.25	12.8	2.4976	360	60	6	23	0.0022
	8:37	0.5	24.8	27.3	25.2	25.6	16.5	13.9	2.5	2.48	10.2	12.7	2.4902	350	60	5.83333	23	0.0021

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
24-Oct	9:10	0	50	52.6	47.8	48.9	30.1	25.2	2.6	5	20.7	25.05	2.4203	680	60	11.3333	23	0.002
	9:40	0.5	49.9	52.6	47.8	48.9	30.1	25.2	2.7	4.99	20.7	24.95	2.4106	670	60	11.1667	23	0.002
	10:10	1.00	50.1	52.7	48	49.1	30.2	25.3	2.6	5.01	20.8	25.15	2.4183	670	60	11.1667	23	0.002
	11:10	2.00	50	52.6	47.9	48.9	30.2	25.3	2.6	5	20.65	25.15	2.4358	670	60	11.1667	23	0.002
	13:10	4.00	50	52.6	47.9	48.9	30.3	25.3	2.6	5	20.6	25.2	2.4466	650	60	10.8333	23	0.0019
	15:10	6.00	50	52.6	47.9	48.9	30.3	25.3	2.6	5	20.6	25.2	2.4466	640	60	10.6667	23	0.0019
25-Oct	7:55	23	50	52.6	47.9	48.9	30.4	25.3	2.6	5	20.55	25.25	2.4574	627	60	10.45	23	0.0019

Note - 10/24/01 @ 10:30 - Added 200 ml of 5 % sodium hypochlorite, eliminated a stale or mildew smell

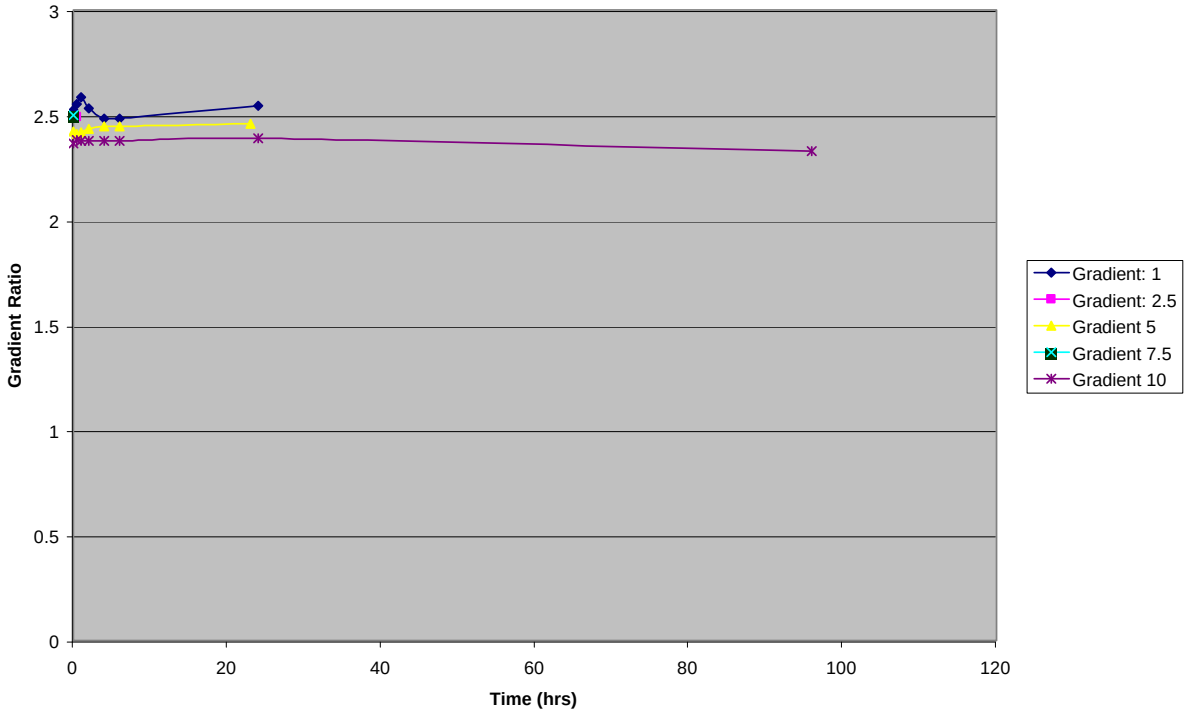
Target Gradient: 7.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
25-Oct	8:05	0	75.1	77.8	70.7	72.2	44.2	37.6	2.7	7.51	30.55	38.2	2.5008	905	60	15.0833	23	0.0018
	8:35	0.5	75.1	77.8	70.5	72.2	44.2	37.6	2.7	7.51	30.45	38.2	2.509	908	60	15.1333	23	0.0018

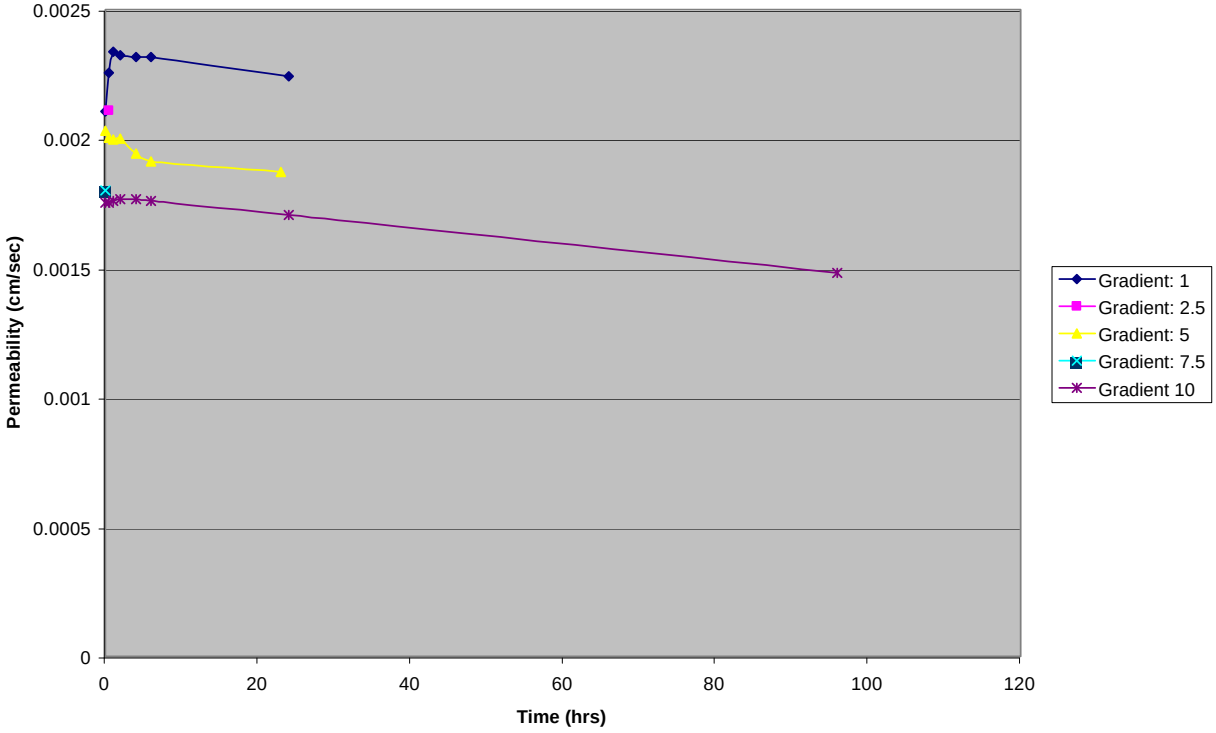
Target Gradient: 10

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
25-Oct	8:40	0	100.1	103.0	93.0	95.3	57.2	47.5	2.9	10.01	41.8	49.45	2.366	1175	60	19.5833	23	0.0018
	9:10	0.5	100.2	103.1	93.0	95.2	57.3	47.6	2.9	10.02	41.65	49.55	2.3794	1175	60	19.5833	23	0.0018
	9:40	1	100.2	103.1	93.0	95.3	57.3	47.6	2.9	10.02	41.7	49.55	2.3765	1180	60	19.6667	23	0.0018
	10:40	2	100.2	103.1	93.0	95.3	57.3	47.6	2.9	10.02	41.7	49.55	2.3765	1185	60	19.75	23	0.0018
	12:30	4	100.1	103.1	92.9	95.2	57.3	47.6	3.0	10.01	41.6	49.45	2.3774	1185	60	19.75	23	0.0018
	14:40	6	100.1	103.1	92.9	95.2	57.3	47.6	3.0	10.01	41.6	49.45	2.3774	1180	60	19.6667	23	0.0018
26-Oct	8:40	24	100.2	103.1	92.7	95.0	57.2	47.6	2.9	10.02	41.45	49.5	2.3884	1145	60	19.0833	23	0.0017
29-Oct	8:40	96	100.2	103.1	90.7	93.5	56.6	45.2	2.9	10.02	41.2	48	2.3301	995	60	16.5833	23	0.0015

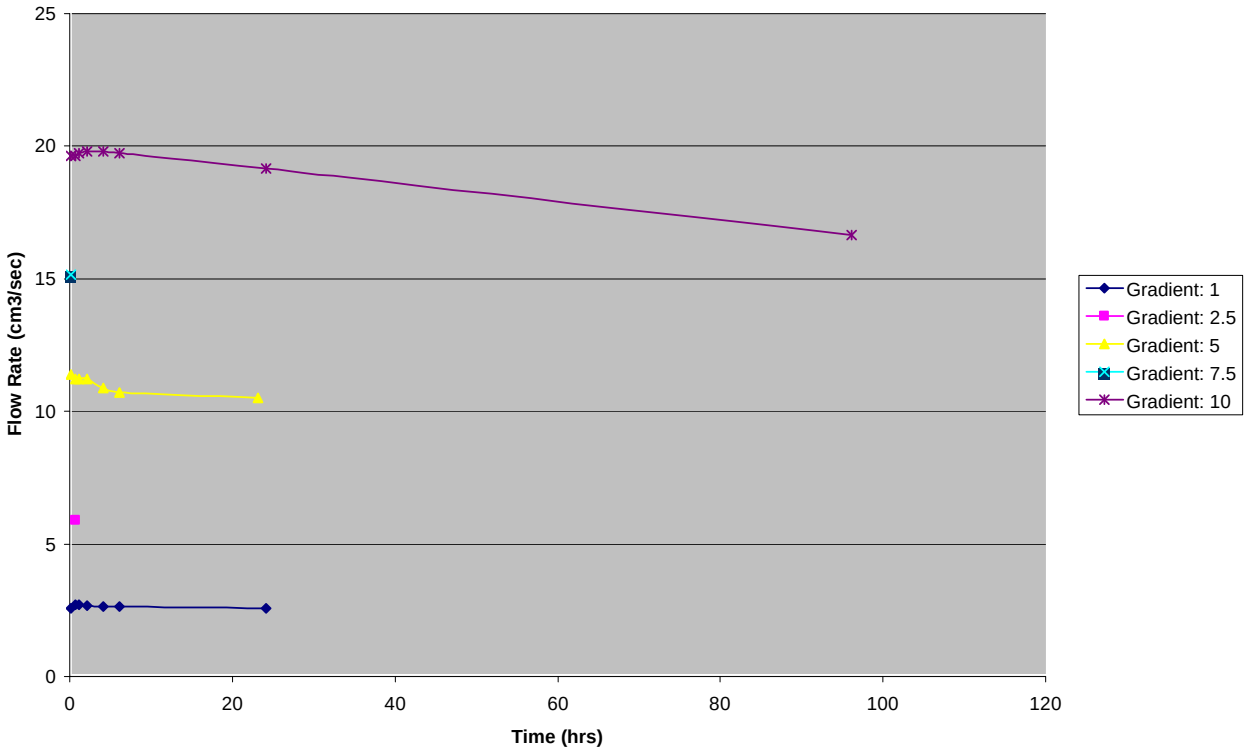
Gradient Ratio vs. Time



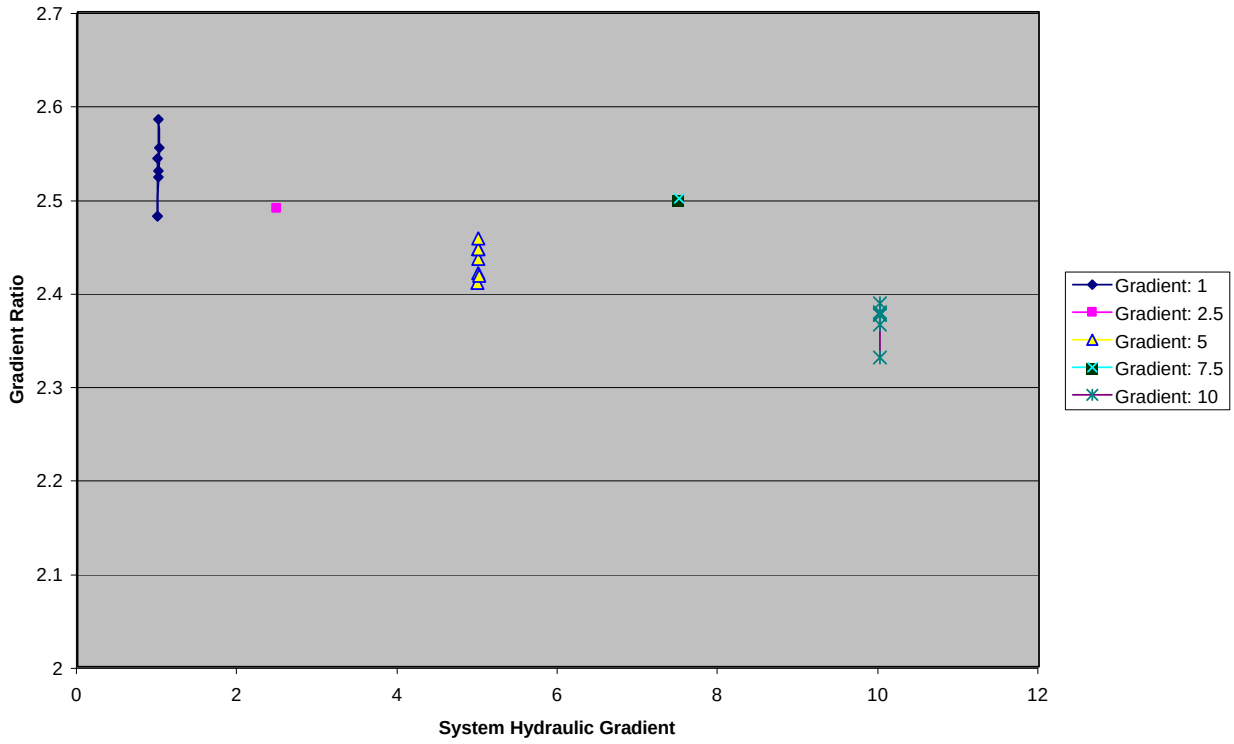
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Geotextile I.D. HDPE with 4 holes @ 3/16 inch with plastic support disk **TEST # 15** A Zone 3

Soil I.D. "A" Zone - 4f

Weight of soil used: 3.46 lb Soil Loss: 4.8523 grams

Unit Weight of Dry Soil in Permeamet 19.67 kN/m^3

Volume of Soil 47.78 cu in

Target Gradient: 1

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
11-Dec	7:00	0	10.2	12.3	11.7	11.8	7.9	9.6	2.1	1.02	3	6.65	4.4333	478	60	7.96667	21	0.0066
	7:30	0.5	10.3	12.3	11.7	11.7	7.9	9.6	2.0	1.03	2.95	6.75	4.5763	480	60	8	22	0.0068
	8:00	1	10.3	12.3	11.6	11.7	7.9	9.6	2.0	1.03	2.9	6.75	4.6552	478	60	7.96667	23	0.0069
	9:00	2	10.3	12.3	11.6	11.7	7.8	9.6	2.0	1.03	2.95	6.7	4.5424	478	60	7.96667	23	0.0069
	11:00	4	10.3	12.3	11.6	11.7	7.8	9.6	2.0	1.03	2.95	6.7	4.5424	470	60	7.83333	23	0.0068
	13:00	6	10.3	12.3	11.6	11.7	7.8	9.6	2.0	1.03	2.95	6.7	4.5424	470	60	7.83333	23	0.0068
12-Dec	7:30	24.5	10.3	12.3	11.6	11.7	7.8	9.6	2.0	1.03	2.95	6.7	4.5424	448	60	7.46667	23	0.0065

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
12-Dec	7:30	0	25.2	27.4	25.7	25.8	16.9	20.8	2.2	2.52	6.9	16.65	4.8261	925	60	15.4167	23	0.0055
	8:00	0.5	25.2	27.4	25.7	25.8	16.9	20.8	2.2	2.52	6.9	16.65	4.8261	925	60	15.4167	23	0.0055

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
12-Dec	8:05	0	50.1	52.8	49.4	49.6	33.3	40	2.7	5.01	12.85	33.95	5.284	1568	60	26.1333	23	0.0047
	8:35	0.5	50.1	53	49.6	49.9	33.5	40.2	2.9	5.01	12.9	33.95	5.2636	1565	60	26.0833	23	0.0047
	9:05	1.00	50.1	53	49.6	49.9	33.6	40.2	2.9	5.01	12.85	34	5.2918	1560	60	26	23	0.0047
	10:05	2.00	50.1	53	49.6	49.9	33.6	40.3	2.9	5.01	12.8	34.05	5.3203	1555	60	25.9167	23	0.0046
	12:05	4.00	50.2	53.1	49.6	49.9	33.7	40.4	2.9	5.02	12.7	34.15	5.378	1545	60	25.75	23	0.0046
	14:05	6.00	50.2	53.1	49.6	49.9	33.8	40.4	2.9	5.02	12.65	34.2	5.4071	1545	60	25.75	23	0.0046
13-Dec	7:30	23.5	50.3	53.1	49.7	50	33.9	40.5	2.8	5.03	12.65	34.4	5.4387	1500	60	25	23	0.0045

Target Gradient: 7.5

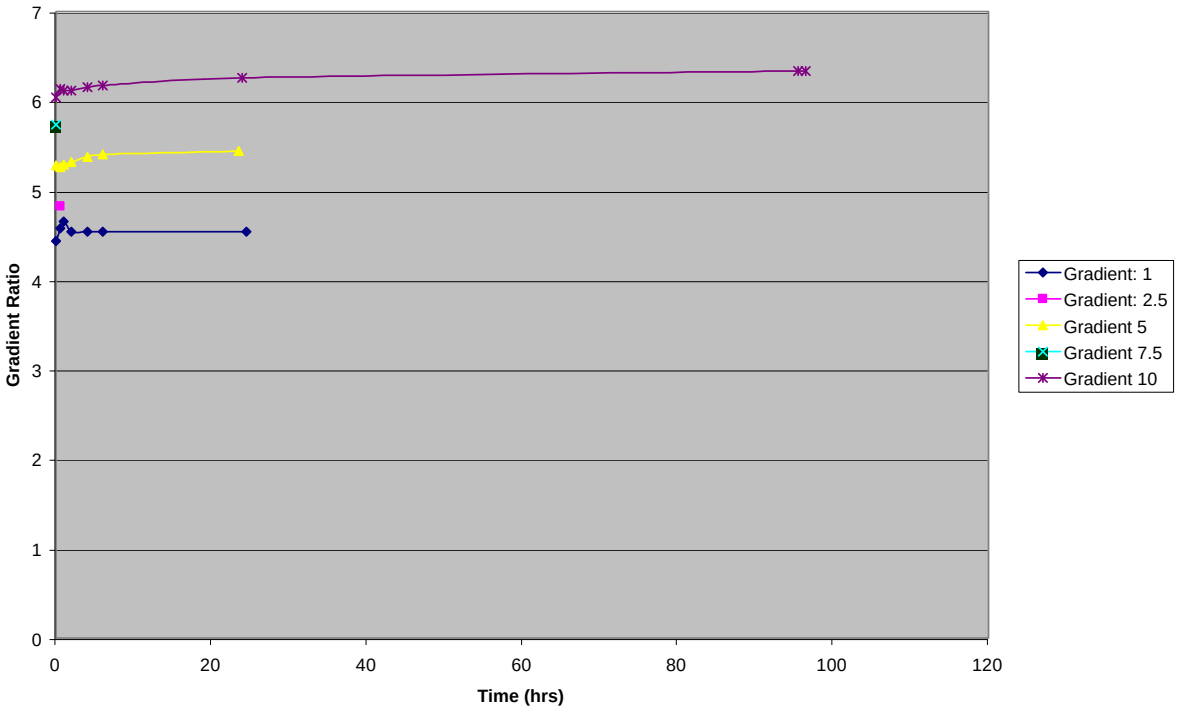
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
13-Dec	7:30	0	75.2	78.5	73.4	73.7	50.8	60.0	3.3	7.52	18.15	52.1	5.741	2000	60	33.3333	23	0.004
	8:00	0.5	75.1	78.5	73.4	73.7	50.8	60	3.4	7.51	18.15	52	5.73	2005	60	33.4167	23	0.004

Target Gradient: 10

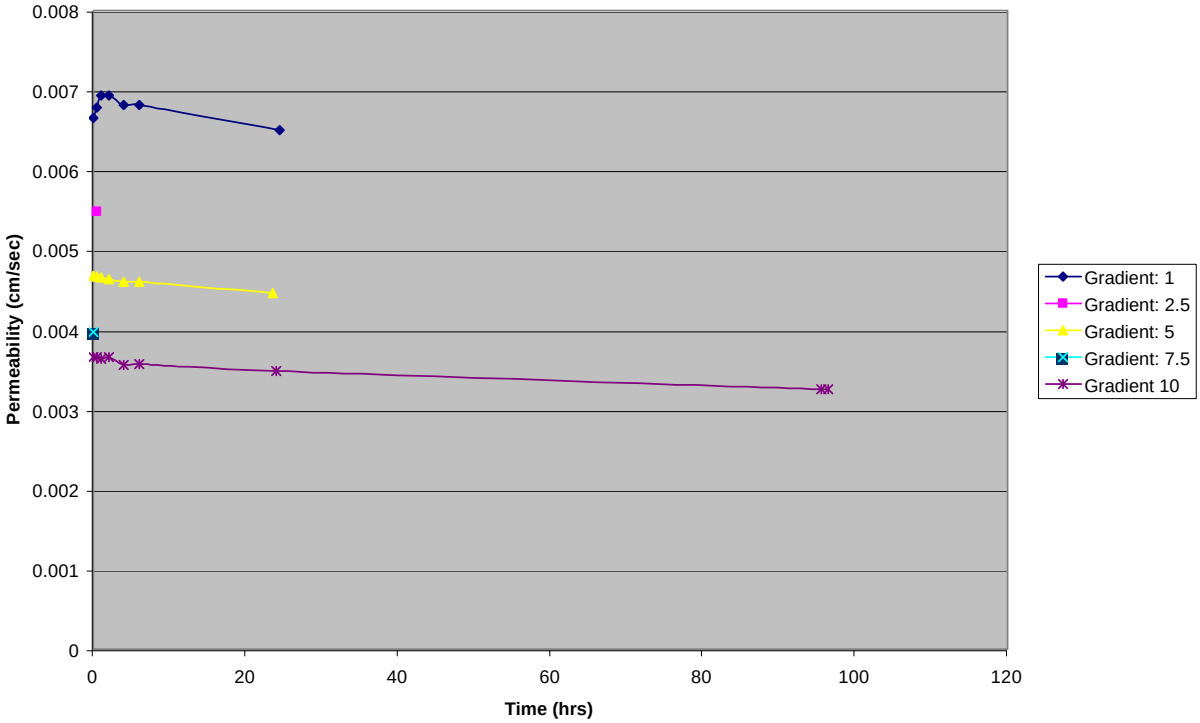
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
13-Dec	8:00	0	100.2	104.2	97.7	98.0	68.8	80.2	4.0	10.02	23.35	70.5	6.0385	2450	60	40.8333	23	0.0037
	8:30	0.5	100.2	104.2	97.5	98.0	69.0	80.4	4.0	10.02	23.05	70.7	6.1345	2455	60	40.9167	23	0.0037
	9:00	1	100.2	104.2	97.6	98.0	69.0	80.4	4.0	10.02	23.1	70.7	6.1212	2440	60	40.6667	23	0.0036
	10:00	2	100.2	104.2	97.6	98.0	69.0	80.4	4.0	10.02	23.1	70.7	6.1212	2450	60	40.8333	23	0.0037
	12:00	4	100.2	104.2	97.6	98.0	69.1	80.5	4.0	10.02	23	70.8	6.1565	2450	60	40.8333	22	0.0036
	14:00	6	100.2	104.2	97.6	98.0	69.2	80.5	4.0	10.02	22.95	70.85	6.1743	2460	60	41	22	0.0036
14-Dec	8:00	24	100.2	104.2	97.2	97.5	69.2	80.3	4.0	10.02	22.6	70.75	6.2611	2400	60	40	22	0.0035
17-Dec	7:30	95.5	100.5	104.2	95.0	95.0	67.7	78.5	3.7	10.05	21.9	69.4	6.3379	2245	60	37.4167	22	0.0033
	8:30	96.5	100.5	104.2	95.0	95.0	67.7	78.5	3.7	10.05	21.9	69.4	6.3379	2245	60	37.4167	22	0.0033

Note 1 - 12/17/01 @ 7:35 - Added 100 ml of 5 % sodium hypochlorite

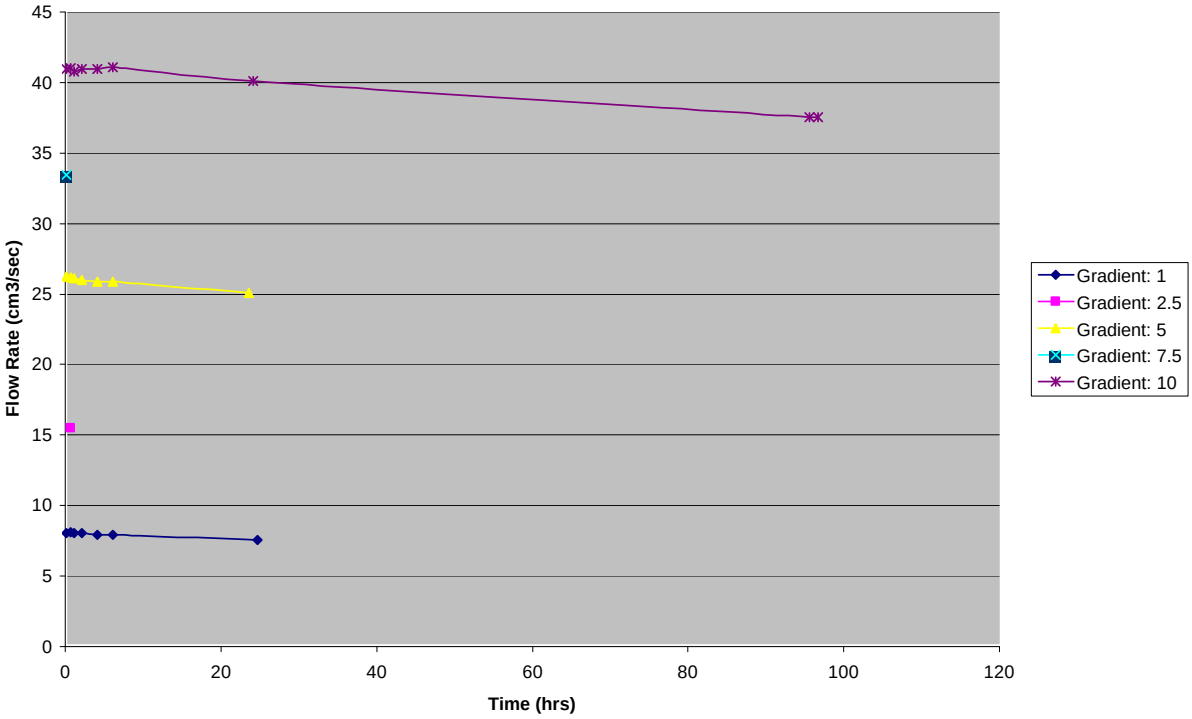
Gradient Ratio vs. Time



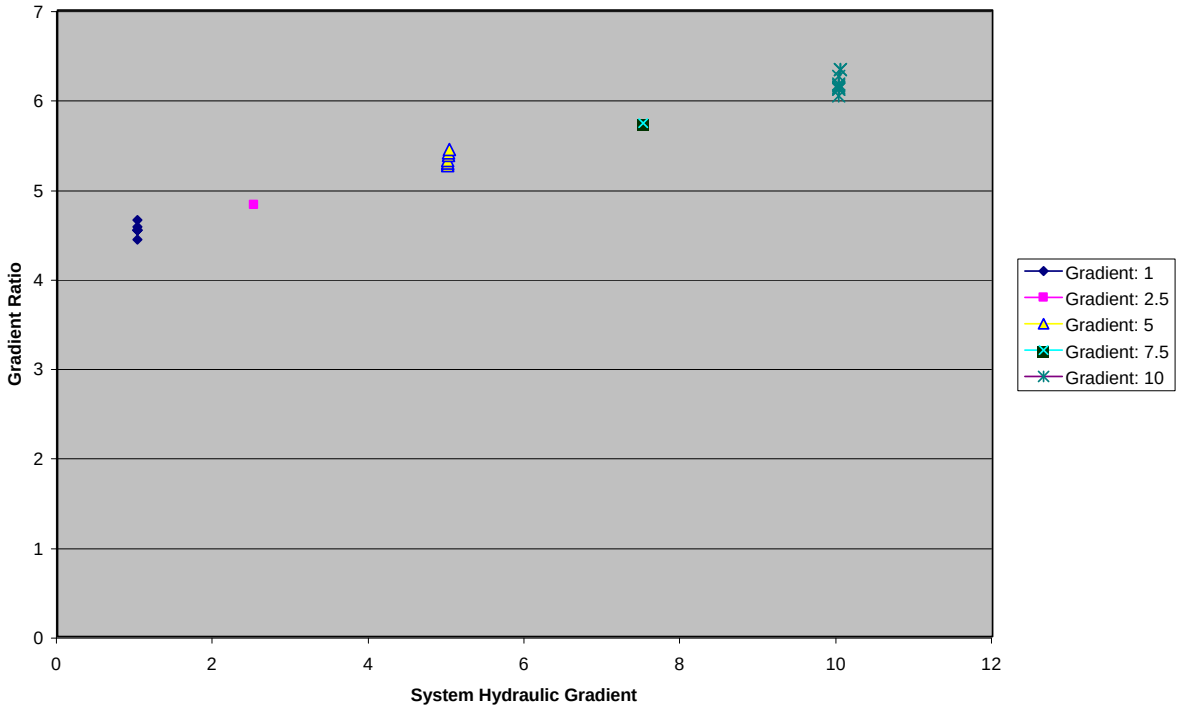
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Geotextile I.D. Plexiglas with 4 holes @ 1/8 inch **TEST # 18** Lake Alice - 5

Soil I.D. Lake Alice

Weight of soil used: 3.423 lb Soil Loss: 0.7388 grams

Unit Weight of Dry Soil in Permeamet 19.46 kN/m^3

Volume of Soil 47.78 cu in

Target Gradient: 1

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
29-Jan	8:00	0	10.2	13.5	12.6	12.9	11.0	11.2	3.3	1.02	1.65	7.8	9.4545	500	60	8.33333	22	0.0071
	8:30	0.5	10.2	13.5	12.6	12.9	11.0	11.2	3.3	1.02	1.65	7.8	9.4545	496	60	8.26667	23	0.0073
	9:00	1	10.2	13.5	12.6	12.9	11.0	11.2	3.3	1.02	1.65	7.8	9.4545	500	60	8.33333	23	0.0073
	10:00	2	10.2	13.5	12.6	12.9	11.0	11.2	3.3	1.02	1.65	7.8	9.4545	495	60	8.25	23	0.0073
	12:00	4	10.3	13.5	12.6	12.9	11.0	11.1	3.2	1.03	1.7	7.85	9.2353	498	60	8.3	23	0.0072
	14:00	6	10.3	13.5	12.5	12.8	11.0	11.1	3.2	1.03	1.6	7.85	9.8125	498	60	8.3	23	0.0072
30-Jan	7:30	23.5	10.3	13.5	12.5	12.8	10.9	11.1	3.2	1.03	1.65	7.8	9.4545	490	60	8.16667	23	0.0071

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
30-Jan	7:30	0	25.1	28.6	26.8	27.4	23.4	23.6	3.5	2.51	3.6	20	11.111	920	60	15.3333	23	0.0055
	8:00	0.5	25.1	28.6	26.8	27.4	23.4	23.6	3.5	2.51	3.6	20	11.111	922	60	15.3667	23	0.0055

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
30-Jan	8:00	0	50.3	54.3	50.9	51.9	45.6	46	4	5.03	5.6	41.8	14.929	1435	60	23.9167	23	0.0043
	8:30	0.5	50.3	54.3	50.9	51.9	45.6	46	4	5.03	5.6	41.8	14.929	1425	60	23.75	23	0.0042
	9:00	1.00	50.3	54.3	50.9	51.9	45.6	46	4	5.03	5.6	41.8	14.929	1427	60	23.7833	23	0.0042
	10:00	2.00	50.3	54.3	50.9	51.9	45.6	46	4	5.03	5.6	41.8	14.929	1430	60	23.8333	23	0.0042
	12:00	4.00	50.3	54.3	50.9	51.9	45.6	46	4	5.03	5.6	41.8	14.929	1418	60	23.6333	23	0.0042
	14:00	6.00	50.3	54.3	50.9	51.9	45.6	46	4	5.03	5.6	41.8	14.929	1420	60	23.6667	23	0.0042
31-Jan	7:30	23.5	50.3	54.3	50.9	51.9	45.6	46	4	5.03	5.6	41.8	14.929	1410	60	23.5	23	0.0042

Note - 1-30-02 @ 10:05, added 200 ml of 5% solution Sodium Hypochlorite

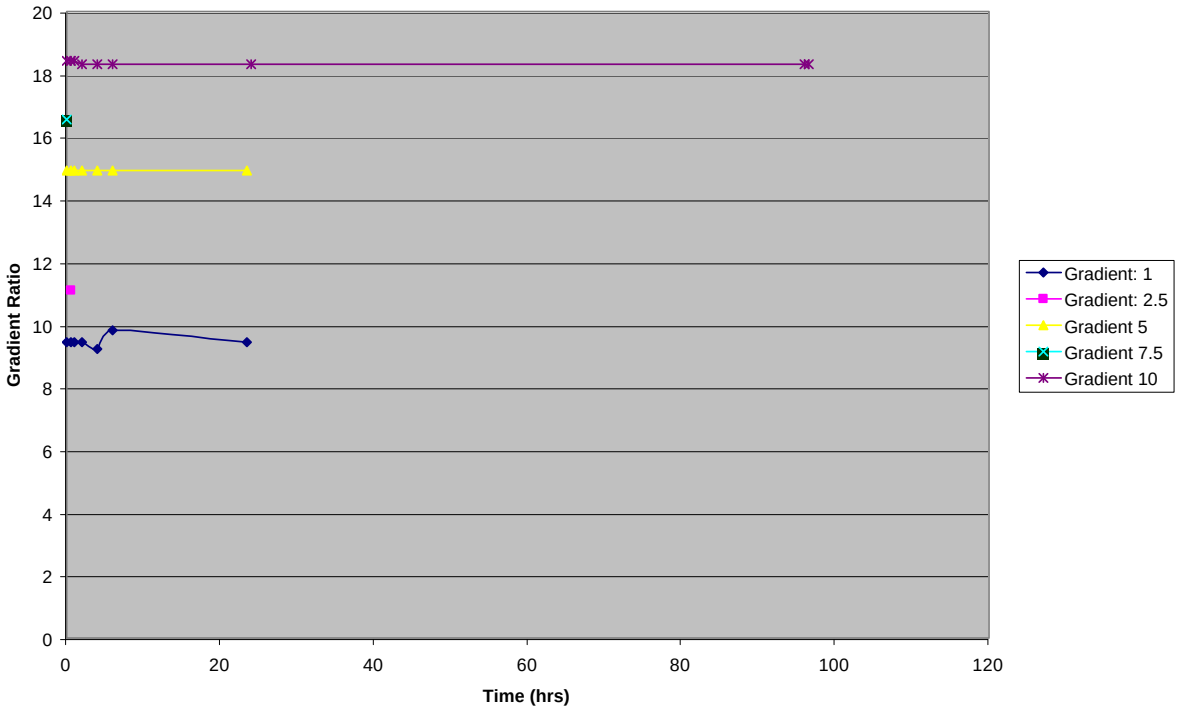
Target Gradient: 7.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
31-Jan	7:30	0	75.4	79.8	75.2	76.4	67.8	68.4	4.4	7.54	7.7	63.7	16.545	1805	60	30.0833	23	0.0036
	8:00	0.5	75.3	79.8	75.2	76.4	67.8	68.4	4.5	7.53	7.7	63.6	16.519	1807	60	30.1167	23	0.0036

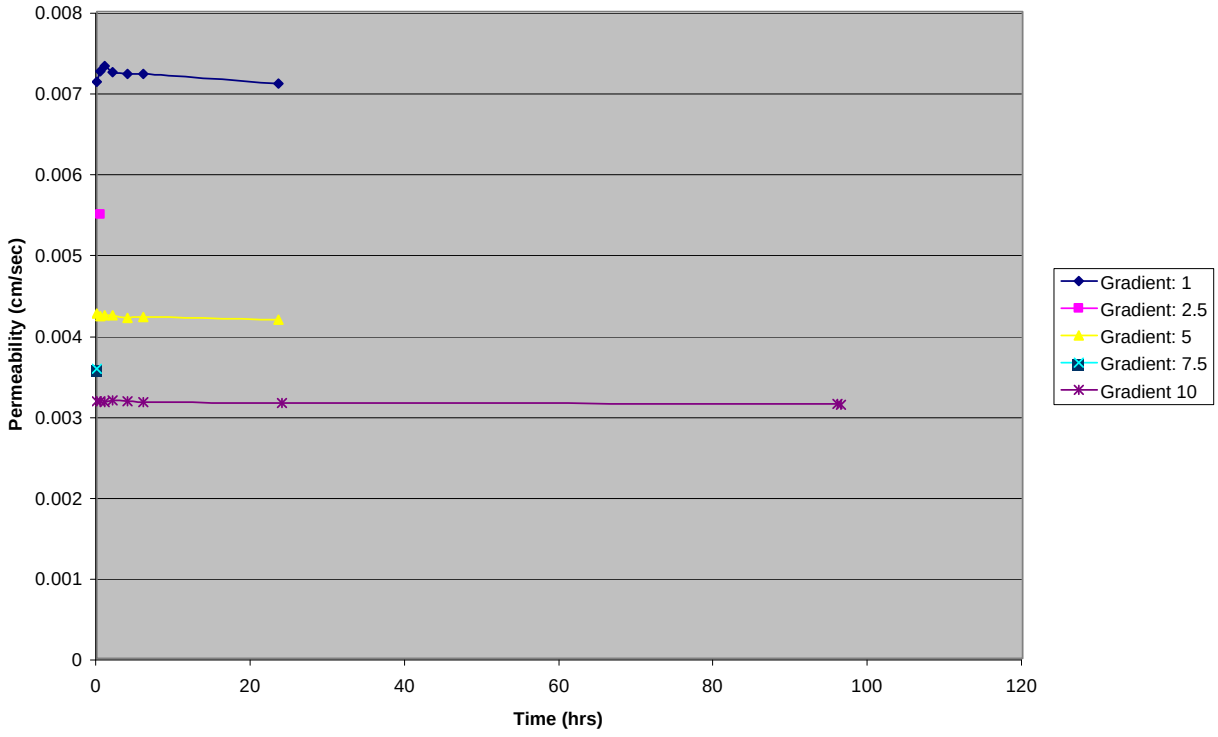
Target Gradient: 10

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
31-Jan	8:05	0	100.3	105.2	99.6	101.2	90.7	91.4	4.9	10.03	9.35	86.15	18.428	2135	60	35.5833	23	0.0032
	8:40	0.5	100.3	105.2	99.6	101.2	90.7	91.4	4.9	10.03	9.35	86.15	18.428	2133	60	35.55	23	0.0032
	9:10	1	100.3	105.2	99.6	101.2	90.7	91.4	4.9	10.03	9.35	86.15	18.428	2130	60	35.5	23	0.0032
	10:10	2	100.3	105.2	99.7	101.2	90.7	91.4	4.9	10.03	9.4	86.15	18.33	2145	60	35.75	23	0.0032
	12:10	4	100.3	105.2	99.7	101.2	90.7	91.4	4.9	10.03	9.4	86.15	18.33	2135	60	35.5833	23	0.0032
	14:10	6	100.3	105.2	99.7	101.2	90.7	91.4	4.9	10.03	9.4	86.15	18.33	2130	60	35.5	23	0.0032
1-Feb	8:10	24	100.3	105.2	99.7	101.2	90.7	91.4	4.9	10.03	9.4	86.15	18.33	2120	60	35.3333	23	0.0032
4-Feb	8:00	96	100.3	105.2	99.7	101.2	90.7	91.4	4.9	10.03	9.4	86.15	18.33	2115	60	35.25	23	0.0032
	8:30	96.5	100.3	105.2	99.7	101.2	90.7	91.4	4.9	10.03	9.4	86.15	18.33	2105	60	35.0833	23	0.0031

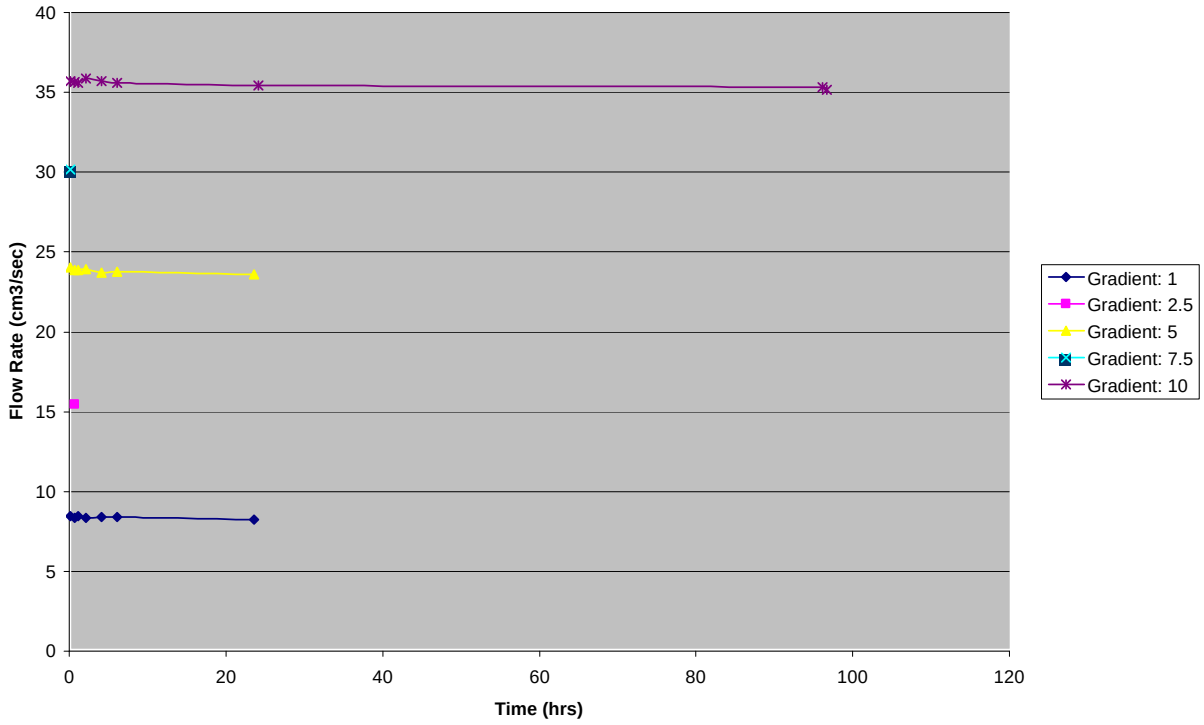
Gradient Ratio vs. Time



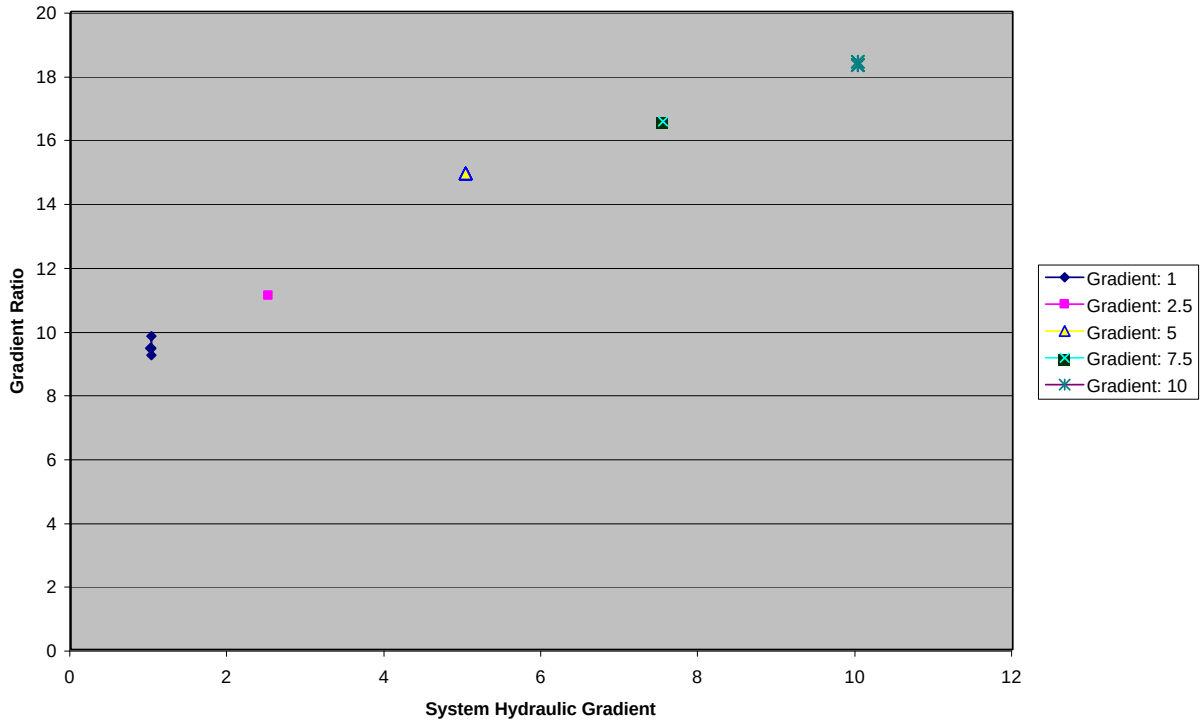
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Geotextile I.D. Plexiglas with 4 holes @ 1/8 inch **TEST # 19** "A" Zone - 4C

Soil I.D. "A" Zone - 4C

PlexiGlas Thickness 342 mils

Weight of soil used: 3.248 lb Soil Loss: 0.7388 grams

Unit Weight of Dry Soil in Permeamete 18.47 kN/m^3

Volume of Soil 47.78 cu in

Target Gradient: 1

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
5-Feb	8:00	0	10.2	12.8	12.5	12.4	11.9	11.9	2.6	1.02	0.55	9.3	33.818	675	60	11.25	22	0.0096
	8:30	0.5	10.2	12.8	12.5	12.4	11.9	11.9	2.6	1.02	0.55	9.3	33.818	673	60	11.2167	23	0.0099
	9:00	1	10.2	12.8	12.5	12.4	11.9	11.9	2.6	1.02	0.55	9.3	33.818	672	60	11.2	23	0.0098
	10:00	2	10.2	12.8	12.5	12.4	12.0	11.9	2.6	1.02	0.5	9.35	37.4	670	60	11.1667	23	0.0098
	12:00	4	10.2	12.8	12.5	12.4	12.0	11.9	2.6	1.02	0.5	9.35	37.4	665	60	11.0833	23	0.0097
	14:00	6	10.2	12.8	12.5	12.4	12.0	11.9	2.6	1.02	0.5	9.35	37.4	660	60	11	23	0.0097
6-Feb	7:20	23.5	10.2	12.8	12.5	12.4	12.0	11.9	2.6	1.02	0.5	9.35	37.4	640	60	10.6667	23	0.0094

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
6-Feb	7:25	0	25.2	28.0	27.4	27.2	26.4	26.3	2.8	2.52	0.95	23.55	49.579	920	60	15.3333	23	0.0055
	7:55	0.5	25.2	28.0	27.4	27.2	26.4	26.3	2.8	2.52	0.95	23.55	49.579	922	60	15.3667	23	0.0055

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
6-Feb	8:00	0	50.2	53.5	52.5	52.1	50.7	50.6	3.3	5.02	1.65	47.35	57.394	1668	60	27.8	23	0.005
	8:30	0.5	50.1	53.5	52.5	52.0	50.7	50.5	3.4	5.01	1.65	47.2	57.212	1660	60	27.6667	23	0.005
	9:00	1.00	50	53.4	52.5	52.0	50.7	50.5	3.4	5	1.65	47.2	57.212	1653	60	27.55	23	0.0049
	10:00	2.00	50	53.4	52.5	52.1	50.7	50.5	3.4	5	1.7	47.2	55.529	1650	60	27.5	23	0.0049
	12:00	4.00	50.1	53.4	52.5	52.1	50.7	50.5	3.3	5.01	1.7	47.3	55.647	1640	60	27.3333	23	0.0049
	14:00	6.00	50.1	53.5	52.5	52.2	50.8	50.6	3.4	5.01	1.65	47.3	57.333	1610	60	26.8333	23	0.0048
7-Feb	7:25	23.5	50.2	53.5	52.5	52.2	51.0	50.7	3.3	5.02	1.5	47.55	63.4	1575	60	26.25	23	0.0047

Note - 2-6-02 @ 10:05, added 200 ml of 5% solution Sodium Hypochlorite

Target Gradient: 7.5

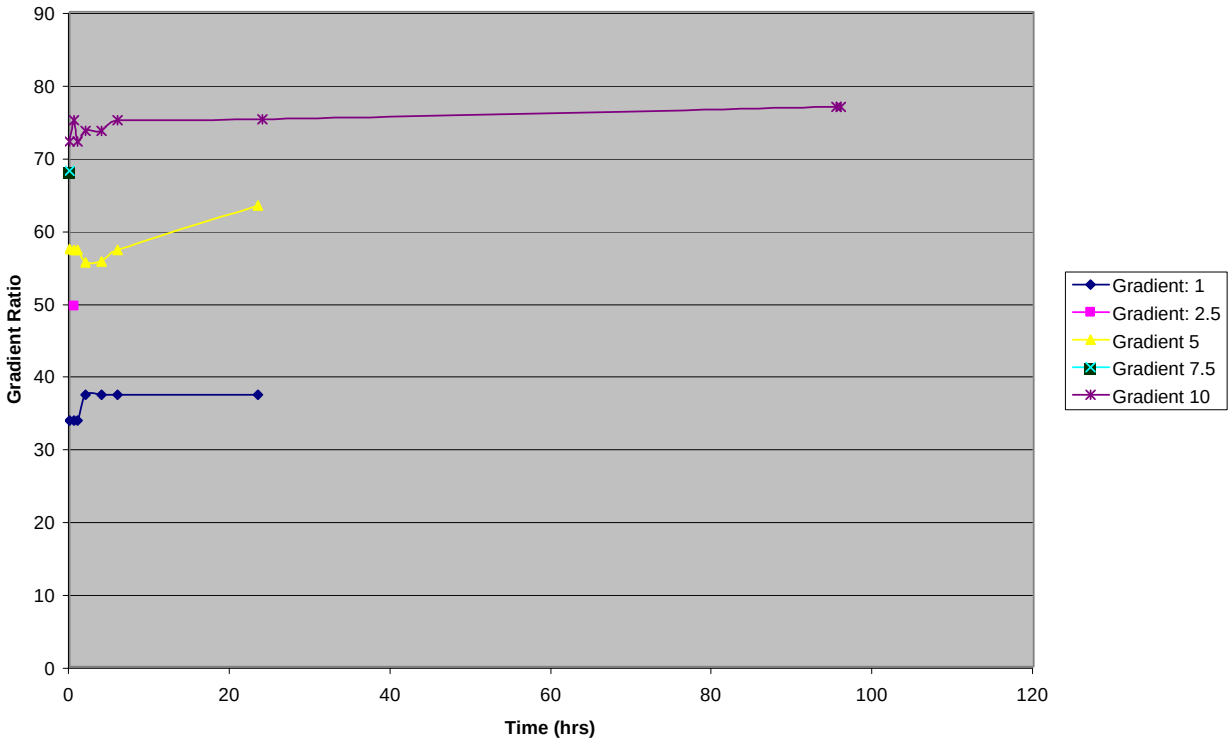
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
7-Feb	7:30	0	75.2	79.0	77.7	77.2	75.5	75.2	3.8	7.52	2.1	71.55	68.143	1965	60	32.75	23	0.0039
	8:00	0.5	75.1	78.9	77.7	77.2	75.5	75.2	3.8	7.51	2.1	71.55	68.143	1960	60	32.6667	23	0.0039

Target Gradient: 10

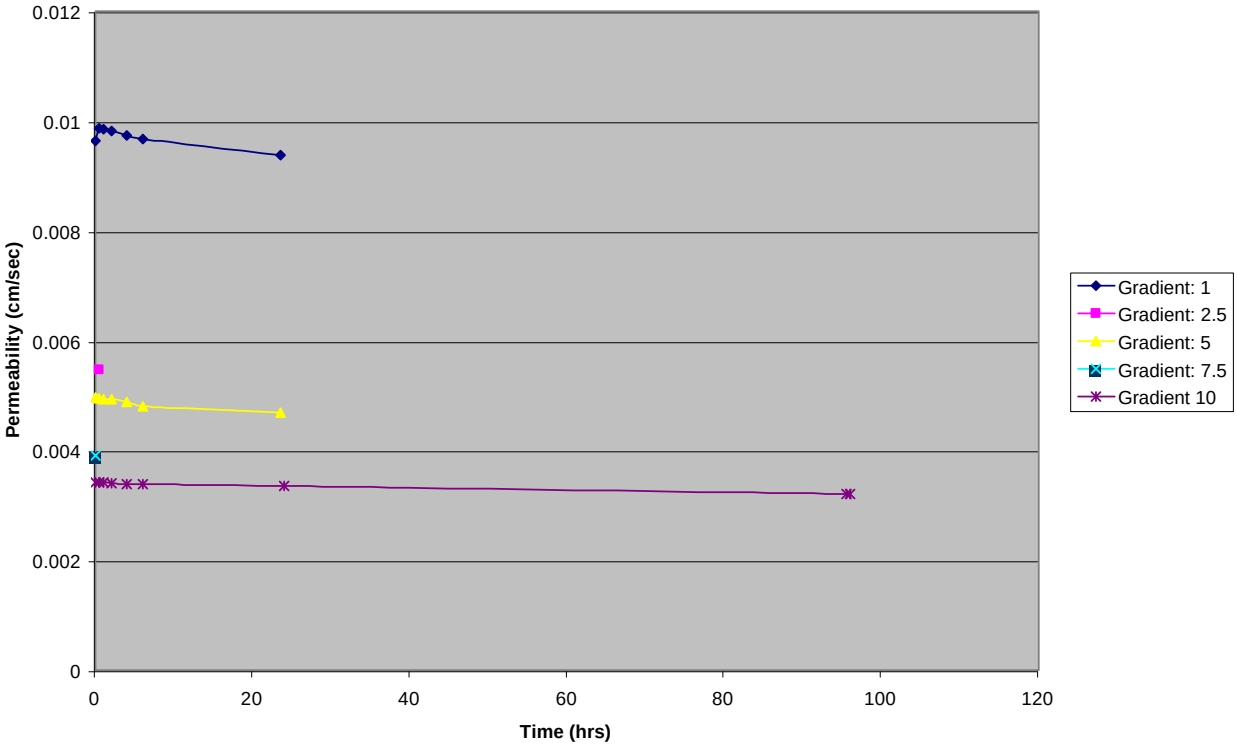
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
7-Feb	8:05	0	100.3	104.5	102.8	102.2	100.0	99.7	4.2	10.03	2.65	95.65	72.189	2298	60	38.3	23	0.0034
	8:30	0.5	100.3	104.5	102.8	102.2	100.1	99.8	4.2	10.03	2.55	95.75	75.098	2297	60	38.2833	23	0.0034
	9:00	1	100.2	104.5	102.9	102.2	100.1	99.7	4.3	10.02	2.65	95.6	72.151	2292	60	38.2	23	0.0034
	10:00	2	100.3	104.6	102.9	102.2	100.1	99.8	4.3	10.03	2.6	95.65	73.577	2286	60	38.1	23	0.0034
	12:00	4	100.4	104.6	102.9	102.3	100.2	99.8	4.2	10.04	2.6	95.8	73.692	2280	60	38	23	0.0034
	14:00	6	100.3	104.6	102.9	102.3	100.2	99.9	4.3	10.03	2.55	95.75	75.098	2275	60	37.9167	23	0.0034
8-Feb	8:00	24	100.4	104.6	102.9	102.3	100.2	99.9	4.2	10.04	2.55	95.85	75.176	2255	60	37.5833	23	0.0034
11-Feb	7:35	95.5	100.6	104.7	103.0	102.4	100.4	100.0	4.1	10.06	2.5	96.1	76.88	2160	60	36	23	0.0032
	8:00	96	100.6	104.7	103.0	102.4	100.4	100.0	4.1	10.06	2.5	96.1	76.88	2160	60	36	23	0.0032

Note - 2-11-02 @ 7:35, added 100 ml of 5% solution Sodium Hypochlorite
Note - 2-11-02 @ 8:10, noticed fines collecting in bottom return hose

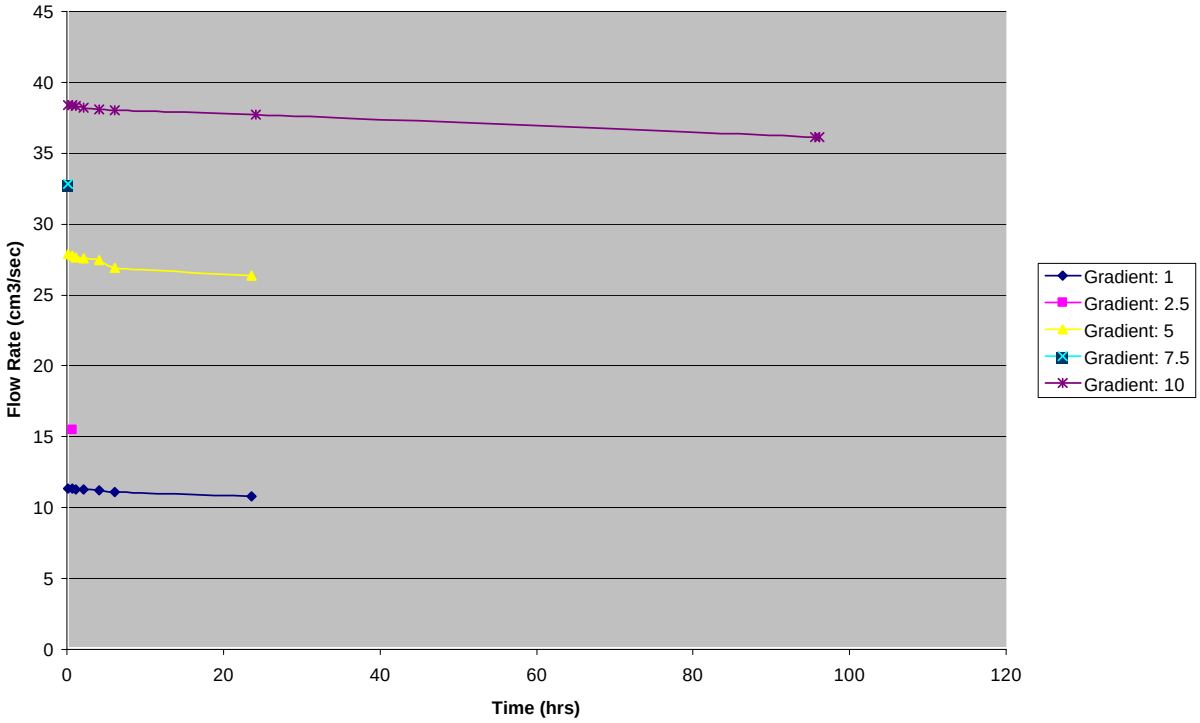
Gradient Ratio vs. Time



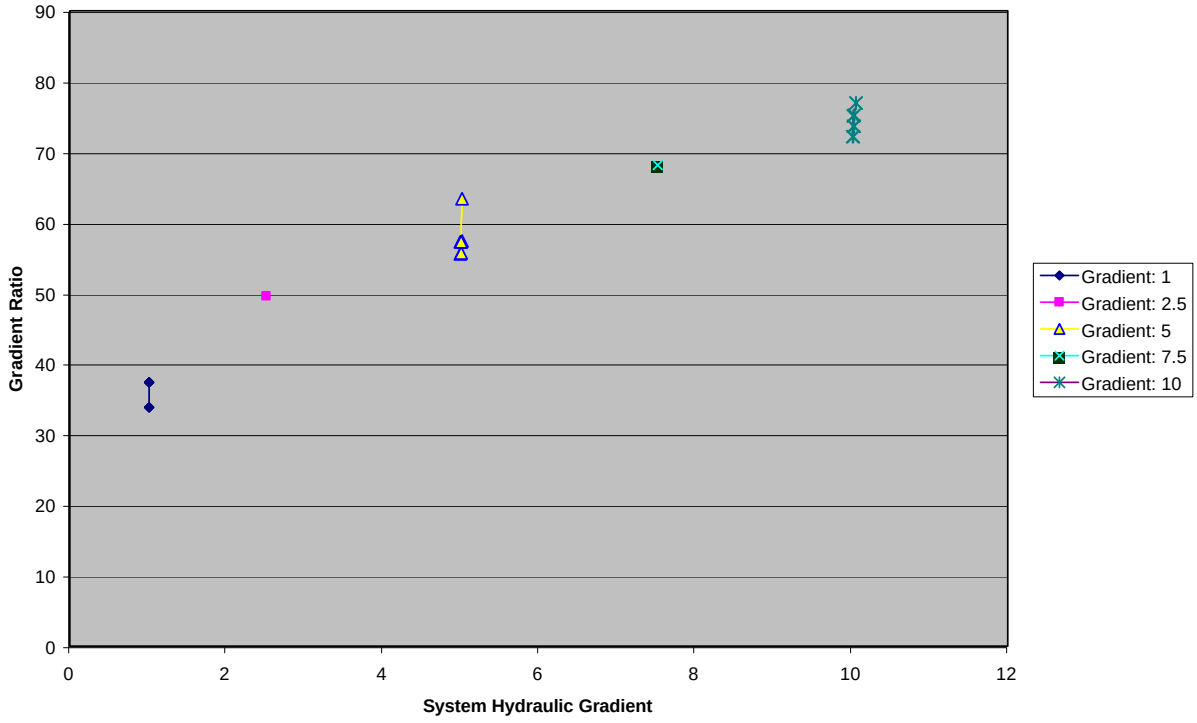
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Geotextile I.D. Plexiglas with 4 holes @ 1/8 inch, Geonet with Carriff Knitted Sock **TEST # 20** "A" Zone - 4C

Soil I.D. "A" Zone - 4C

PlexiGlas Thickness 342 mils

Weight of soil used: 3.14 lb Soil Loss: negligible

Unit Weight of Dry Soil in Permeamet 17.85 kN/m^3

Volume of Soil 47.78 cu in

Target Gradient: 1

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
12-Feb	8:00	0	10.2	14.4	14.1	14.0	13.6	13.2	4.2	1.02	0.65	9.2	28.308	1670	60	27.8333	22	0.0238
	8:30	0.5	10.2	14.4	14.0	13.9	13.5	13.2	4.2	1.02	0.6	9.15	30.5	1660	60	27.6667	22	0.0237
	9:00	1	10.2	14.4	14.0	13.9	13.5	13.2	4.2	1.02	0.6	9.15	30.5	1662	60	27.7	22	0.0237
	10:00	2	10.2	14.4	13.9	13.9	13.5	13.1	4.2	1.02	0.6	9.1	30.333	1658	60	27.6333	22	0.0237
	12:00	4	10.2	14.4	13.9	13.8	13.5	13.1	4.2	1.02	0.55	9.1	33.091	1652	60	27.5333	22	0.0236
	14:00	6	10.2	14.4	13.9	13.8	13.4	13.1	4.2	1.02	0.6	9.05	30.167	1650	60	27.5	22	0.0235
13-Feb	7:20	23.5	10.2	14.4	13.8	13.8	13.5	13.0	4.2	1.02	0.55	9.05	32.909	1638	60	27.3	22	0.0234

Note - 2-12-02 @ 8:05 small amount of fines in bottom chamber

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
13-Feb	7:25	0	25.1	30.7	29.7	29.5	28.6	28.0	5.6	2.51	1.3	22.7	34.923	2682	60	44.7	22	0.0156
	7:55	0.5	25.1	30.8	29.6	29.5	28.6	28.0	5.7	2.51	1.25	22.6	36.16	2690	60	44.8333	22	0.0156

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
13-Feb	8:05	0	50.4	58.5	56.4	56.1	54.6	53.6	8.1	5.04	2.15	46	42.791	3915	60	65.25	22	0.0113
	8:30	0.5	50.3	58.4	56.3	56.0	54.5	53.5	8.1	5.03	2.15	45.9	42.698	3907	60	65.1167	22	0.0113
	9:00	1.00	50.3	58.4	56.3	56.0	54.5	53.5	8.1	5.03	2.15	45.9	42.698	3900	60	65	22	0.0113
	10:00	2.00	50.3	58.4	56.3	56.0	54.5	53.5	8.1	5.03	2.15	45.9	42.698	3880	60	64.6667	22	0.0112
	12:00	4.00	50.3	58.4	56.3	56.0	54.5	53.5	8.1	5.03	2.15	45.9	42.698	3880	60	64.6667	22	0.0112
	14:00	6.00	50.4	58.4	56.3	56.0	54.5	53.5	8.0	5.04	2.15	46	42.791	3875	60	64.5833	22	0.0112
14-Feb	7:25	23.5	50.3	58.4	56.2	56.0	54.5	53.4	8.1	5.03	2.15	45.85	42.651	3830	60	63.8333	22	0.0111

Note - 2-13-02 @ 10:05, added 200 ml of 5% solution Sodium Hypochlorite, noticed that fines were washed out of bottom chamber at start of i = 5 test interval

Target Gradient: 7.5

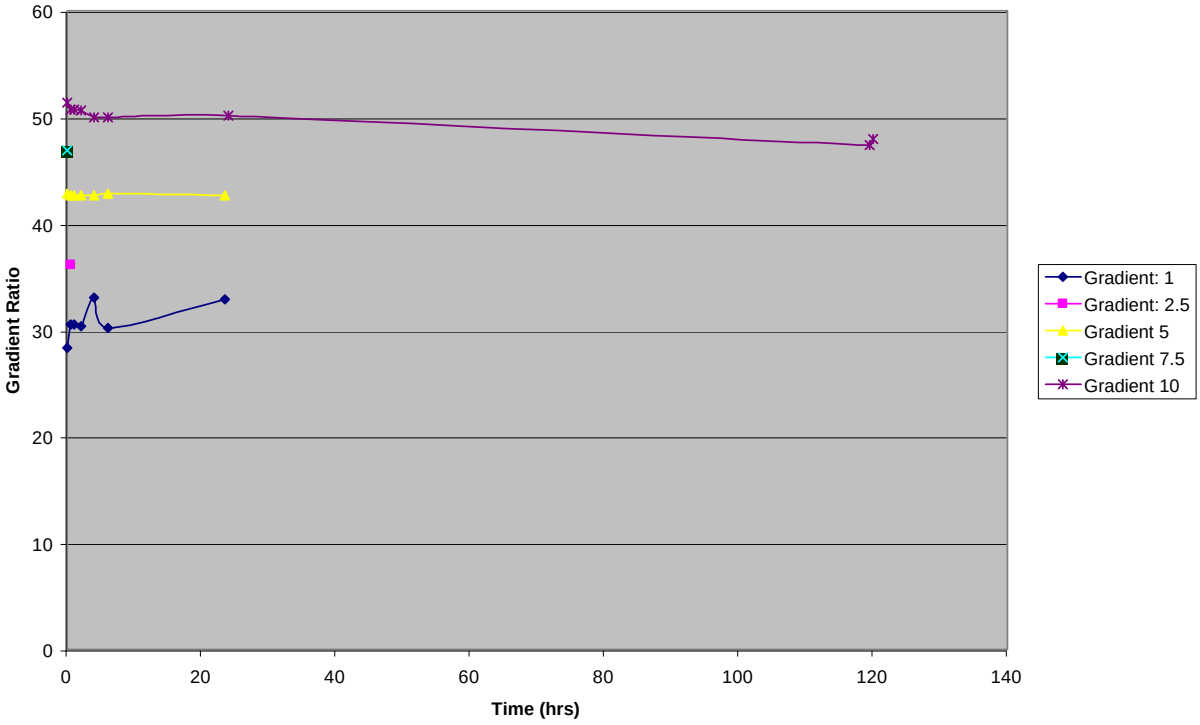
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
14-Feb	7:35	0	75.2	85.6	82.7	82.3	80.3	78.8	10.4	7.52	2.95	69.15	46.881	2390	30	79.6667	23	0.0095
	8:05	0.5	75.3	85.7	82.6	82.3	80.2	78.8	10.4	7.53	2.95	69.1	46.847	2378	30	79.2667	23	0.0094

Target Gradient: 10

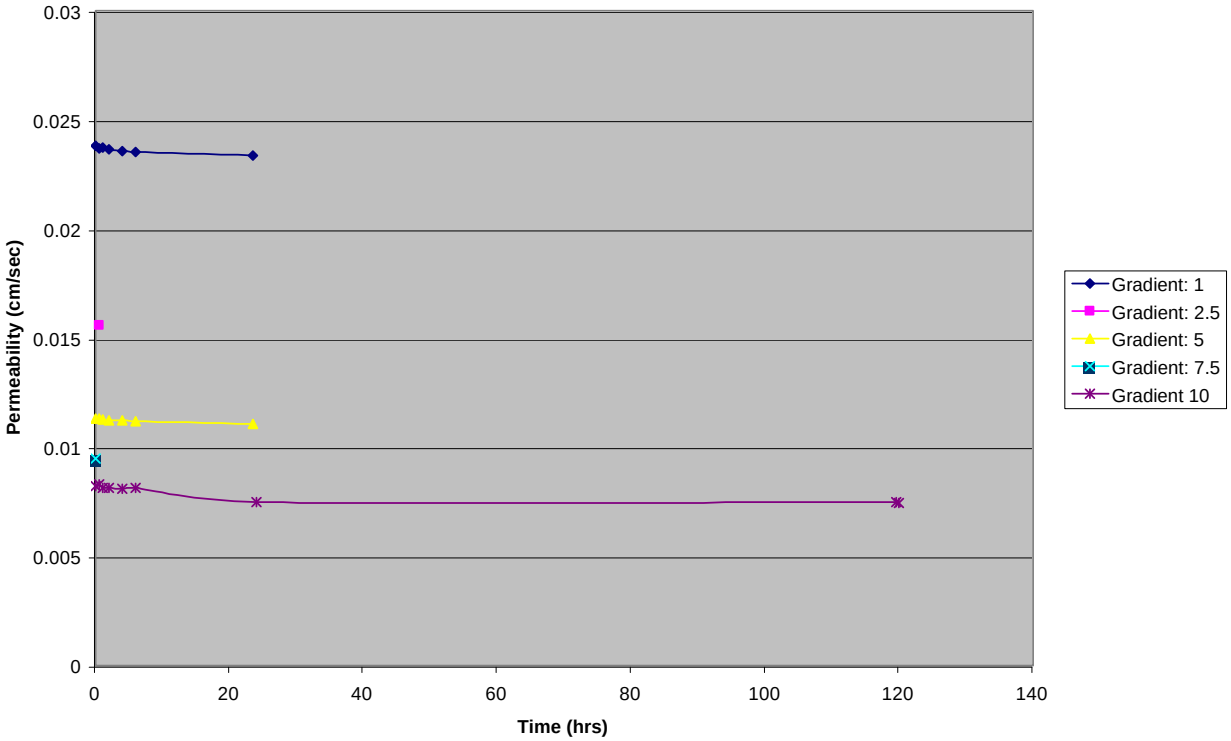
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
14-Feb	8:10	0	100.2	108.0	104.0	103.6	101.0	99.4	7.8	10.02	3.6	92.4	51.333	2762	30	92.0667	23	0.0082
	8:35	0.5	100.3	108.0	104.1	103.6	101.0	99.4	7.7	10.03	3.65	92.5	50.685	2790	30	93	23	0.0083
	9:00	1	100.4	108.1	104.1	103.6	101.0	99.4	7.7	10.04	3.65	92.5	50.685	2740	30	91.3333	23	0.0082
	10:00	2	100.4	108.1	104.0	103.6	101.0	99.3	7.7	10.04	3.65	92.45	50.658	2740	30	91.3333	23	0.0082
	12:00	4	100.5	108.1	104.0	103.6	101.0	99.2	7.6	10.05	3.7	92.5	50	2720	30	90.6667	23	0.0081
	14:00	6	100.5	108.1	104.0	103.6	101.0	99.2	7.6	10.05	3.7	92.5	50	2740	30	91.3333	23	0.0081
15-Feb	8:00	24	101.0	108.3	101.3	101.0	98.4	96.7	7.3	10.1	3.6	90.25	50.139	2664	30	88.8	21	0.0075
19-Feb	7:40	119.5	101.7	108.6	98.4	98.1	95.5	93.6	6.9	10.17	3.7	87.65	47.378	2610	30	87	22	0.0075
	8:10	120	101.8	108.6	98.2	97.8	95.1	93.6	6.8	10.18	3.65	87.55	47.973	2610	30	87	22	0.0075

Note - 2-14-02 @ 11:45, all fines completely washed out of lower chamber, some fines in return reservoir

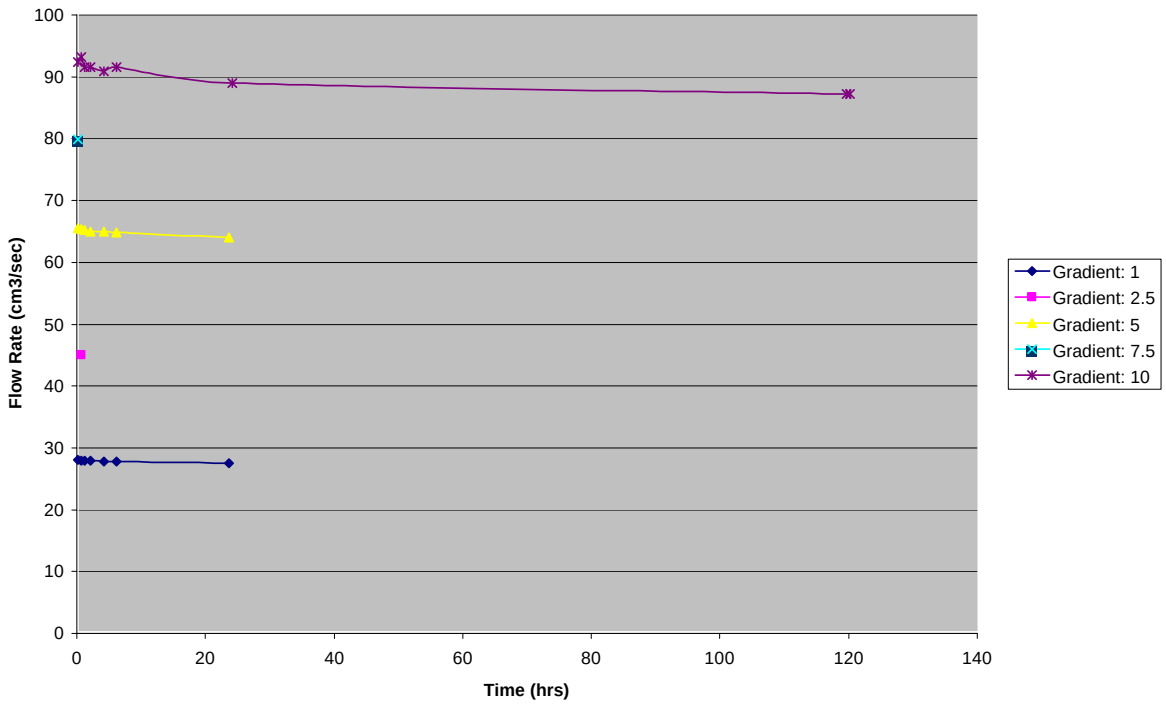
Gradient Ratio vs. Time



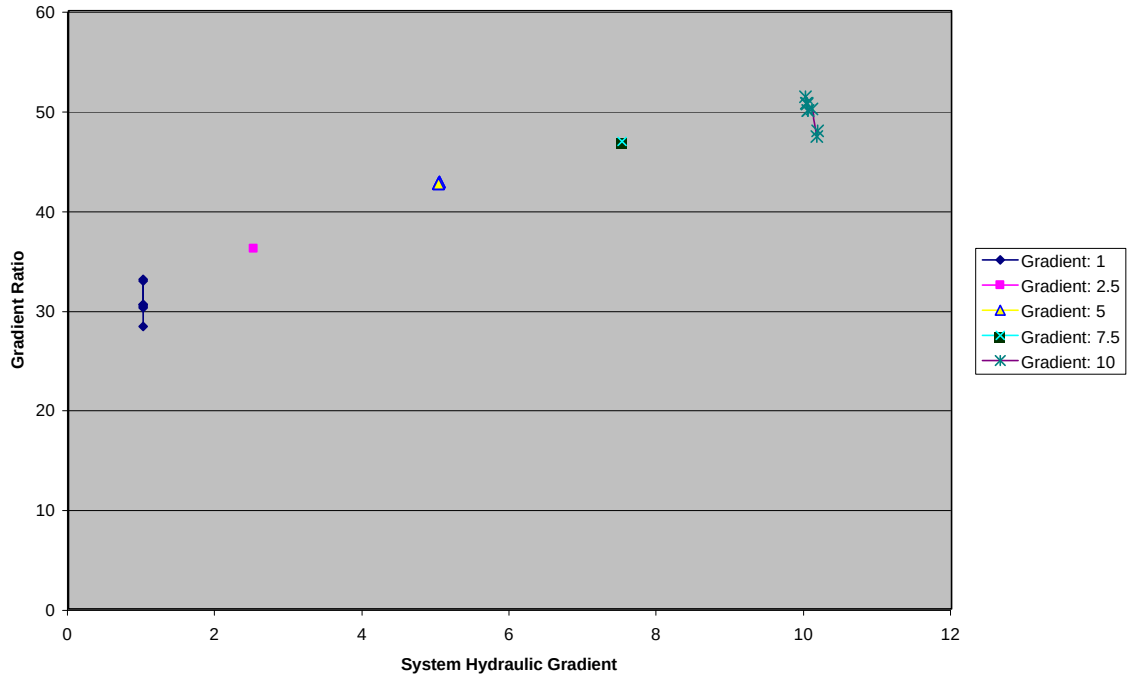
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Geotextile I.D. Plexiglas with 4 holes @ 3/16, w/o sock **TEST # 21** "A" Zone - 4C

Soil I.D. "A" Zone - 4C

PlexiGlas Thickness 342 mils

Weight of soil used: 3.332 lb Soil Loss: 2.7338 grams

Unit Weight of Dry Soil in Permeamet 18.95 kN/m^3

Volume of Soil 47.78 cu in

Target Gradient: 1

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
12-Mar	8:00	0	10.2	12.6	12.5	12.5	12.3	12.3	2.4	1.02	0.2	9.9	99	310	60	5.16667	20	0.0042
	8:30	0.5	10.2	12.6	12.5	12.5	12.3	12.3	2.4	1.02	0.2	9.9	99	313	60	5.21667	22	0.0045
	9:00	1	10.2	12.6	12.5	12.5	12.3	12.3	2.4	1.02	0.2	9.9	99	313	60	5.21667	23	0.0046
	10:00	2	10.2	12.6	12.5	12.5	12.3	12.3	2.4	1.02	0.2	9.9	99	310	60	5.16667	23	0.0045
	12:00	4	10.3	12.6	12.4	12.5	12.3	12.2	2.3	1.03	0.2	9.95	99.5	308	60	5.13333	23	0.0045
	14:00	6	10.3	12.6	12.4	12.5	12.3	12.2	2.3	1.03	0.2	9.95	99.5	303	60	5.05	23	0.0044
13-Mar	7:30	23.5	10.3	12.6	12.4	12.5	12.3	12.2	2.3	1.03	0.2	9.95	99.5	293	60	4.88333	23	0.0043

Note - 3-12-02 @ 8:05 small amount of fines in bottom chamber

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
13-Mar	7:25	0	25.2	27.6	27.5	27.6	27.2	27.2	2.4	2.52	0.35	24.8	141.71	529	60	8.81667	23	0.0031
	7:55	0.5	25.2	27.6	27.5	27.6	27.2	27.2	2.4	2.52	0.35	24.8	141.71	532	60	8.86667	23	0.0032

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
13-Mar	8:00	0	50.2	52.7	51.8	51.9	51.4	51.3	2.5	5.02	0.5	48.85	195.4	802	60	13.3667	23	0.0024
	8:30	0.5	50.1	52.7	51.8	51.9	51.4	51.3	2.6	5.01	0.5	48.75	195	797	60	13.2833	23	0.0024
	9:00	1.00	50.1	52.7	51.8	51.9	51.4	51.3	2.6	5.01	0.5	48.75	195	798	60	13.3	23	0.0024
	10:00	2.00	50.1	52.7	51.8	51.9	51.4	51.3	2.6	5.01	0.5	48.75	195	798	60	13.3	23	0.0024
	12:00	4.00	50.1	52.7	51.9	52.0	51.4	51.4	2.6	5.01	0.55	48.8	177.45	770	60	12.8333	23	0.0023
	14:00	6.00	50.1	52.7	51.9	52.0	51.5	51.4	2.6	5.01	0.5	48.85	195.4	768	60	12.8	23	0.0023
14-Mar	7:25	23.5	50.1	52.7	51.9	52.0	51.5	51.4	2.6	5.01	0.5	48.85	195.4	736	60	12.2667	23	0.0022

Note - 3-13-02 @ 8:05, slight increase in fines in bottom chamber

Note - 3-13-02 @ 10:05, added 200 ml of 5% solution Sodium Hypochlorite

Target Gradient: 7.5

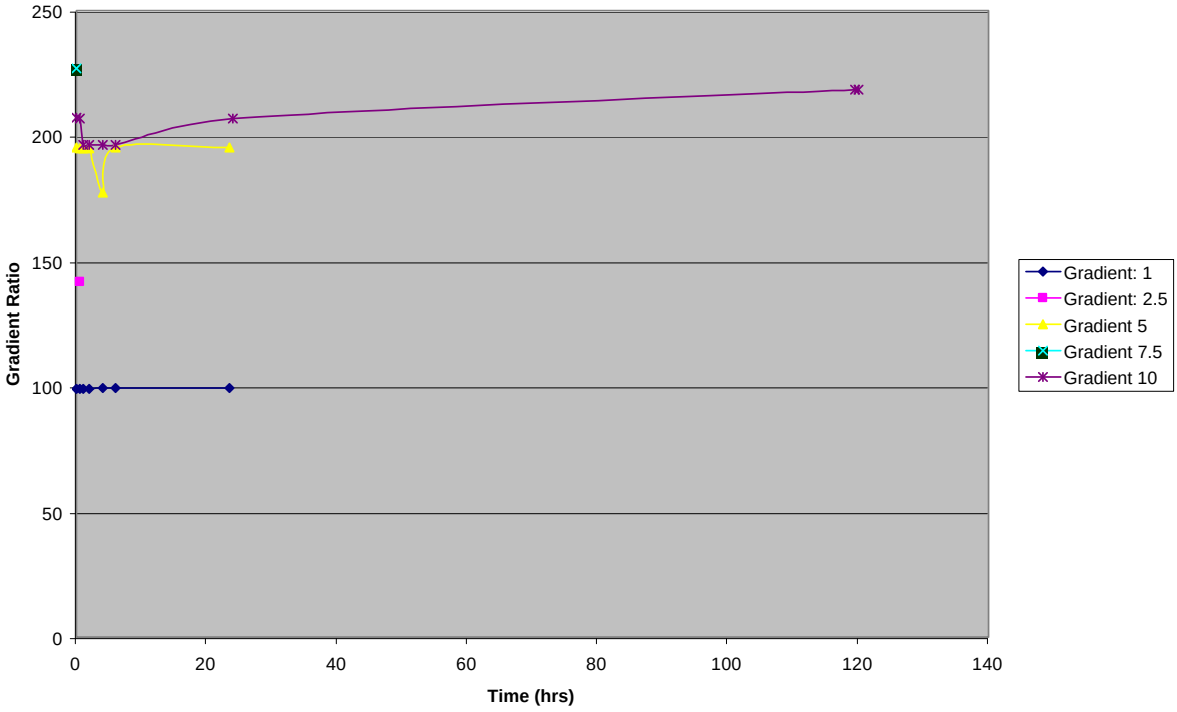
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
14-Mar	7:55	0	75.2	77.8	76.9	77.1	76.4	76.3	2.6	7.52	0.65	73.75	226.92	930	60	15.5	23	0.0018
	8:25	0.5	75.2	77.8	76.9	77.1	76.4	76.3	2.6	7.52	0.65	73.75	226.92	930	60	15.5	23	0.0018

Target Gradient: 10

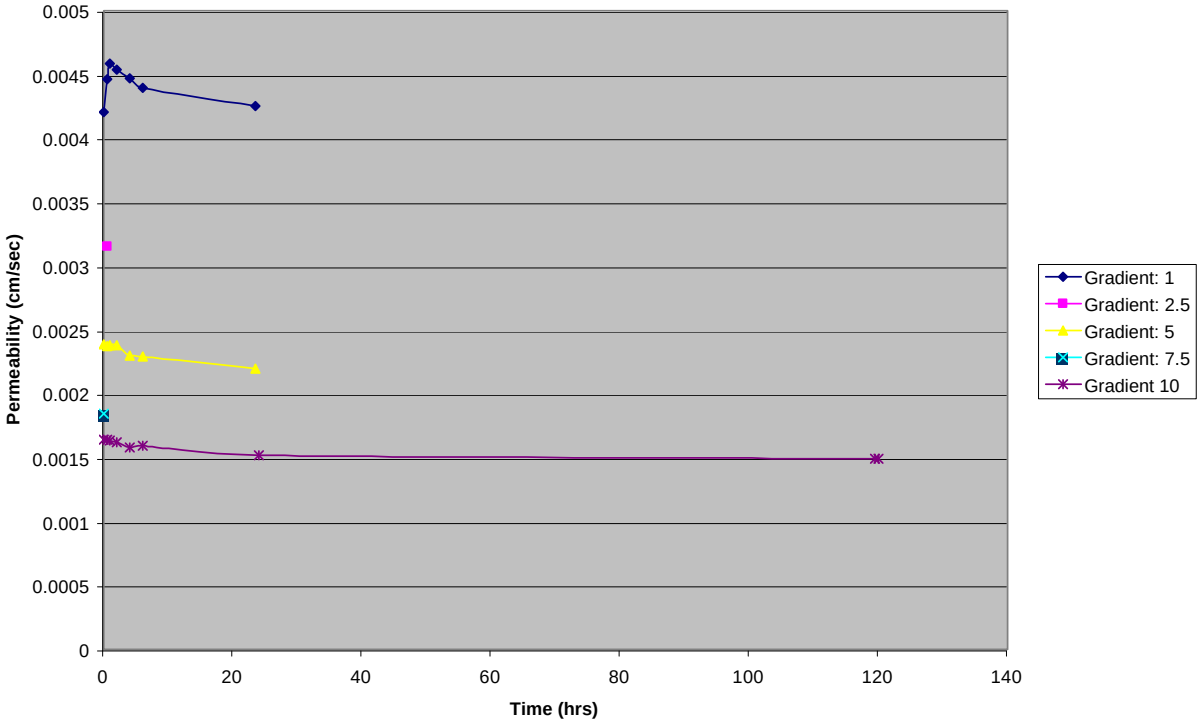
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
14-Mar	8:30	0	100.3	103.0	102.0	102.2	101.2	101.1	2.7	10.03	0.95	98.45	207.26	1103	60	18.3833	23	0.0016
	9:00	0.5	100.2	103.0	102.0	102.2	101.2	101.1	2.8	10.02	0.95	98.35	207.05	1100	60	18.3333	23	0.0016
	9:30	1	100.2	103.0	102.0	102.1	101.1	101.0	2.8	10.02	1	98.25	196.5	1098	60	18.3	23	0.0016
	10:30	2	100.2	103.0	102.0	102.1	101.1	101.0	2.8	10.02	1	98.25	196.5	1088	60	18.1333	23	0.0016
	12:30	4	100.1	103.0	102.0	102.1	101.1	101.0	2.9	10.01	1	98.15	196.3	1060	60	17.6667	23	0.0016
	14:30	6	100.2	103.0	102.0	102.1	101.1	101.0	2.8	10.02	1	98.25	196.5	1068	60	17.8	23	0.0016
15-Mar	8:30	24	100.2	103.0	102.0	102.1	101.2	101.0	2.8	10.02	0.95	98.3	206.95	1018	60	16.9667	23	0.0015
18-Mar	8:00	119.5	100.2	103.0	102.0	102.1	101.2	101.1	2.8	10.02	0.9	98.35	218.56	1000	60	16.6667	23	0.0015
	8:30	120	100.2	103.0	102.0	102.1	101.2	101.1	2.8	10.02	0.9	98.35	218.56	1000	60	16.6667	23	0.0015

Note - 3-14-02 @ 8:00 slight increase in fines in the bottom chamber
Note - 3-18-02 @ 8:05, added 100 ml of 5% solution Sodium Hypochlorite

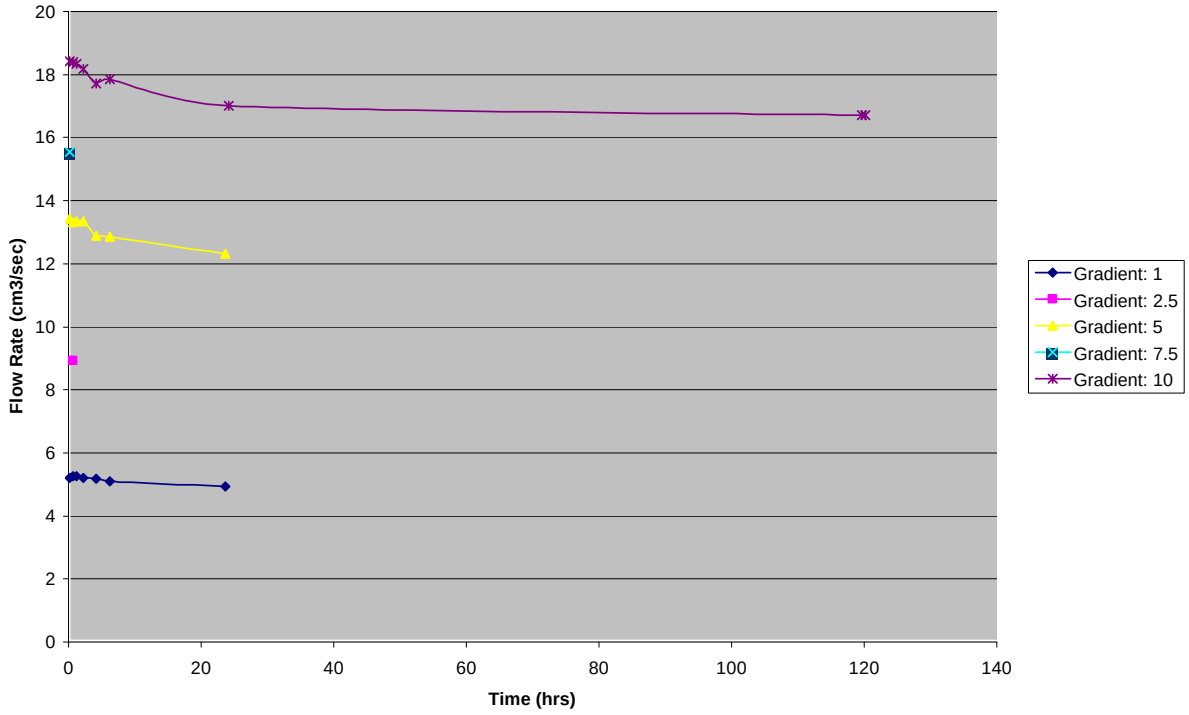
Gradient Ratio vs. Time



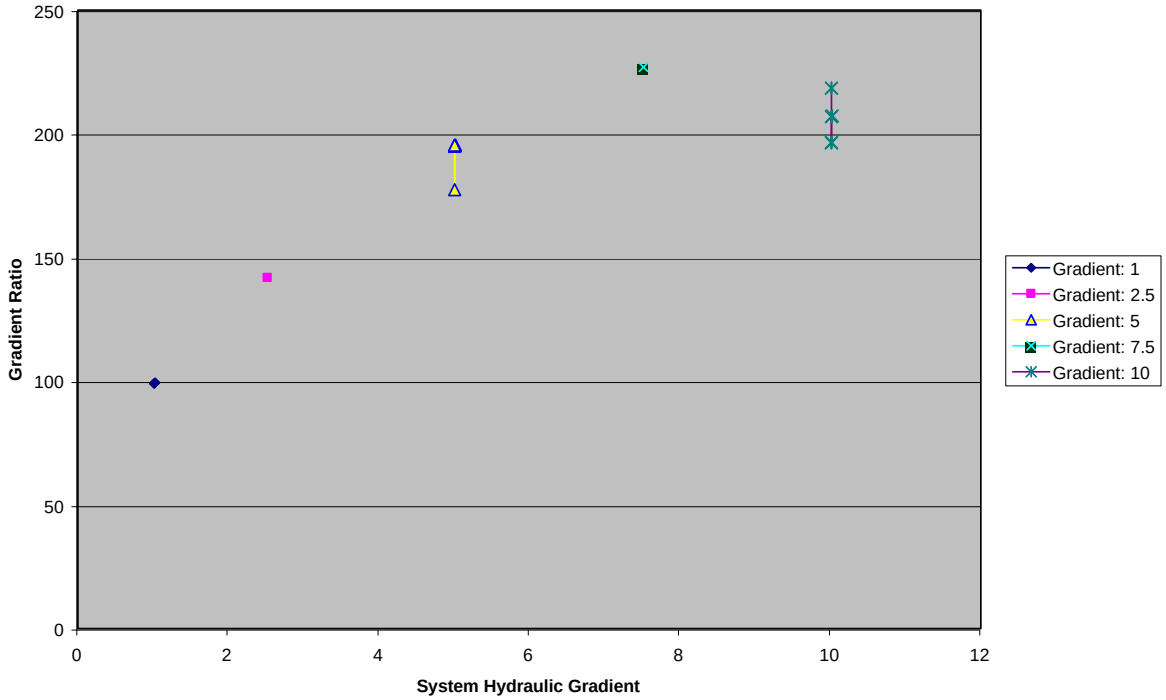
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Geotextile I.D. 4 holes @ 3/16, with sock

TEST # 22 "A" Zone - 4C with sock

Soil I.D. "A" Zone - 4C

PlexiGlas Thickness 342 mils

Weight of soil used: 3.212 lb

Soil Loss: negligible

Unit Weight of Dry Soil in Permeamet 18.26 kN/m^3

Volume of Soil 47.78 cu in

Target Gradient: 1

Date	Time	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
19-Mar	8:00	0	10.3	13.7	12.8	12.8	12.2	12.1	3.4	1.03	0.65	8.75	26.923	1900	60	31.6667	18	0.0243
	8:30	0.5	10.2	13.6	12.7	12.8	12.2	12.1	3.4	1.02	0.6	8.75	29.167	1895	60	31.5833	22	0.027
	9:00	1	10.2	13.6	12.7	12.7	12.1	12.0	3.4	1.02	0.65	8.65	26.615	1897	60	31.6167	22	0.0271
	10:00	2	10.2	13.6	12.7	12.8	12.1	12.0	3.4	1.02	0.7	8.65	24.714	1892	60	31.5333	22	0.027
	12:00	4	10.2	13.6	12.7	12.7	12.0	11.9	3.4	1.02	0.75	8.55	22.8	1890	60	31.5	22	0.027
	14:00	6	10.2	13.6	12.7	12.7	12.0	11.9	3.4	1.02	0.75	8.55	22.8	1890	60	31.5	22	0.027
20-Mar	7:30	23.5	10.2	13.6	12.6	12.6	11.9	11.9	3.4	1.02	0.7	8.5	24.286	1878	60	31.3	22	0.0268

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
20-Mar	7:45	0	25.0	30.2	28.3	28.3	26.9	26.7	5.2	2.5	1.5	21.6	28.8	3060	60	51	22	0.0178
	8:15	0.5	25.1	30.3	28.3	28.3	26.9	26.7	5.2	2.51	1.5	21.6	28.8	3060	60	51	22	0.0177

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
20-Mar	8:25	0	50.1	58.2	54.7	54.8	52.5	52.2	8.1	5.01	2.4	44.25	36.875	2245	30	74.8333	22	0.013
	9:00	0.5	50.3	58.4	54.8	54.9	52.6	52.3	8.1	5.03	2.4	44.35	36.958	2180	30	72.6667	22	0.0126
	9:30	1.00	50.3	58.4	54.8	54.9	52.6	52.3	8.1	5.03	2.4	44.35	36.958	2188	30	72.9333	22	0.0127
	10:30	2.00	50.3	58.4	54.8	54.9	52.5	52.3	8.1	5.03	2.45	44.3	36.163	2190	30	73	22	0.0127
	12:30	4.00	50.2	58.4	54.7	54.7	52.4	52.1	8.2	5.02	2.45	44.05	35.959	2188	30	72.9333	22	0.0127
	14:30	6.00	50.3	58.4	54.6	54.6	52.3	52.0	8.1	5.03	2.45	44.05	35.959	2175	30	72.5	22	0.0126
21-Mar	7:30	23	50.3	58.4	54.9	54.9	52.6	52.3	8.1	5.03	2.45	44.35	36.204	2175	30	72.5	22	0.0126

Note - 3-20-02 @ 10:25, with increased flow rate, the fines in the bottom chamber have been washed out

Note - 3-20-02 @ 10:35, added 200 ml of 5% solution Sodium Hypochlorite

Target Gradient: 7.5

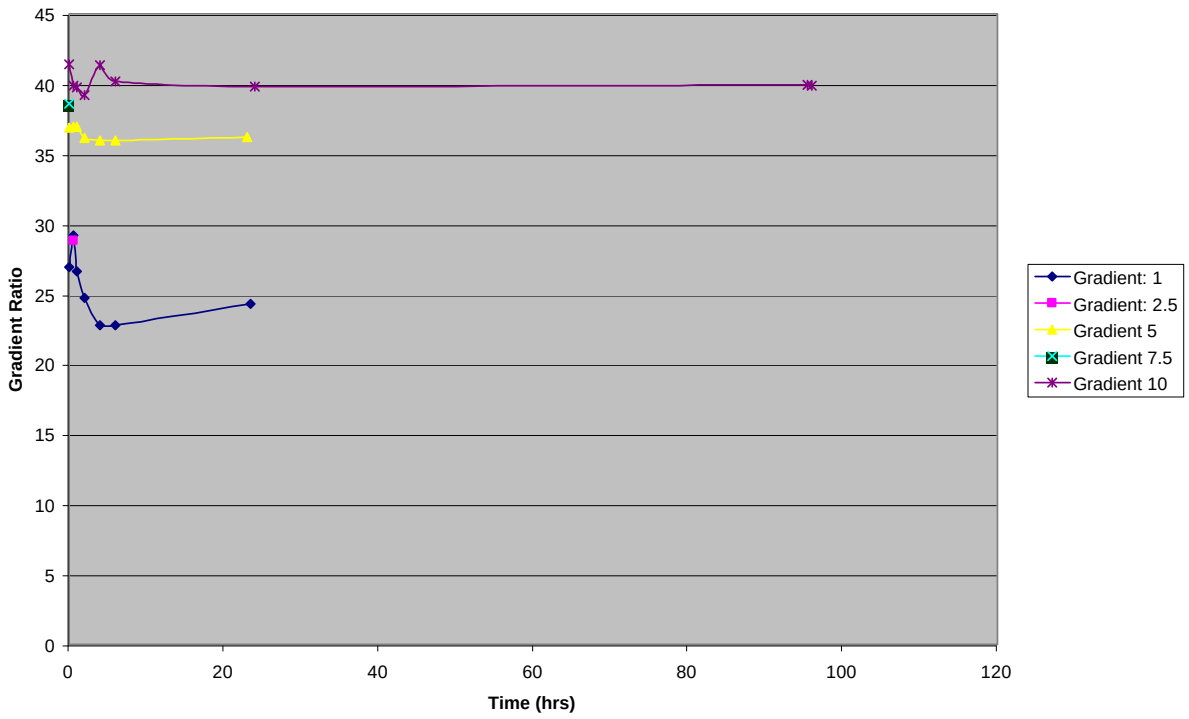
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
21-Mar	7:30	0	75.2	86.1	79.9	79.8	76.6	76.3	10.9	7.52	3.4	65.55	38.559	2680	30	89.3333	22	0.0104
	8:00	0.5	75.1	86.1	79.8	79.7	76.5	76.1	11	7.51	3.45	65.3	37.855	2680	30	89.3333	22	0.0104

Target Gradient: 10

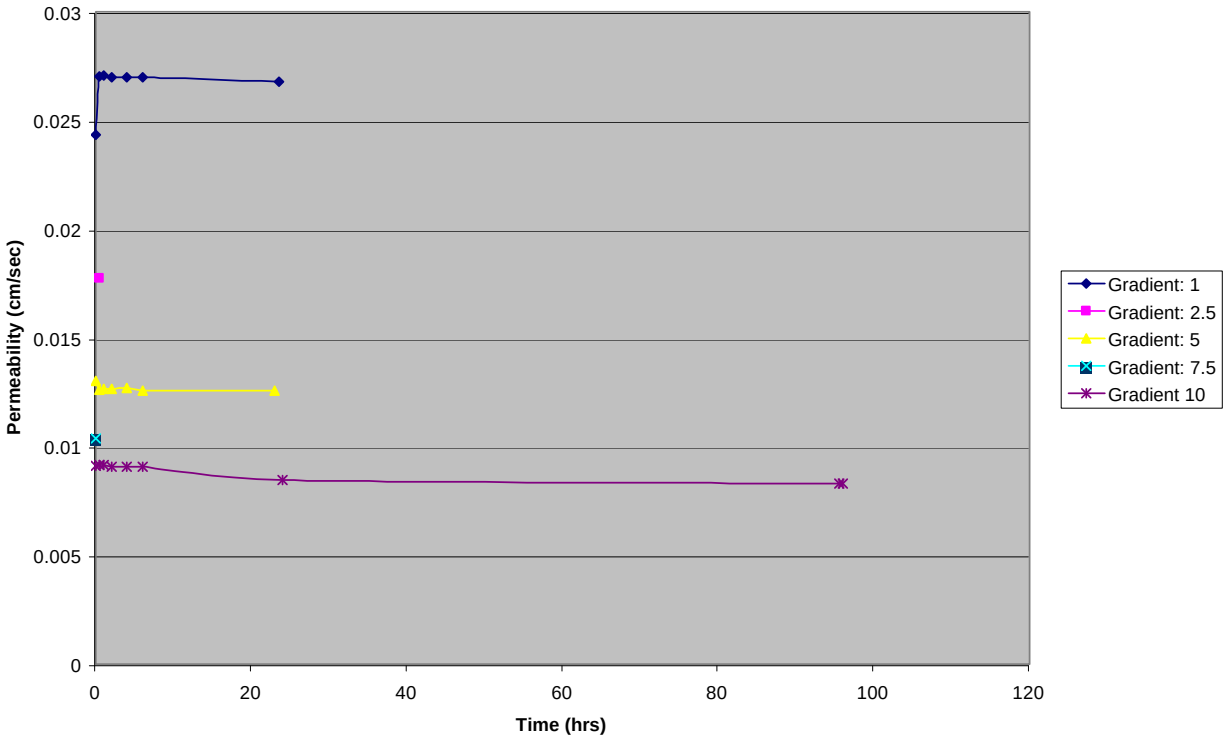
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
21-Mar	8:05	0	100.3	106.2	98.2	98.1	94.1	93.7	5.9	10.03	4.25	88	41.412	3140	30	104.667	22	0.0091
	8:30	0.5	100.4	106.2	97.9	97.9	93.7	93.3	5.8	10.04	4.4	87.7	39.864	3155	30	105.167	22	0.0091
	9:00	1	100.4	106.2	97.7	97.7	93.5	93.1	5.8	10.04	4.4	87.5	39.773	3155	30	105.167	22	0.0091
	10:00	2	100.5	106.2	97.3	97.4	93.1	92.7	5.7	10.05	4.45	87.2	39.191	3140	30	104.667	22	0.0091
	12:00	4	100.6	106.2	96.6	96.6	92.6	92.2	5.6	10.06	4.2	86.8	41.333	3130	30	104.333	22	0.0091
	14:00	6	100.5	106.3	96.5	96.5	92.5	91.9	5.8	10.05	4.3	86.4	40.186	3140	30	104.667	22	0.0091
22-Mar	8:00	24	100.7	106.4	95.6	95.6	91.5	91.1	5.7	10.07	4.3	85.6	39.814	3079	30	102.633	20	0.0085
25-Mar	7:30	95.5	101.2	106.6	95.5	95.5	91.3	91.1	5.4	10.12	4.3	85.8	39.907	3030	30	101	20	0.0083
	8:00	96	101.0	106.4	95.4	95.4	91.2	91.0	5.4	10.1	4.3	85.7	39.86	3030	30	101	20	0.0083

Note - 3-21-02 @ 14:00 surging in return line to water tank varies flow rate readings, took 3 readings and used the average
Note - 3-25-02 @ 7:35, added 100 ml of 5% solution Sodium Hypochlorite
Note - 3-25-02 @ 10:35 noticed that all the fines have completely washed out of the bottom chamber

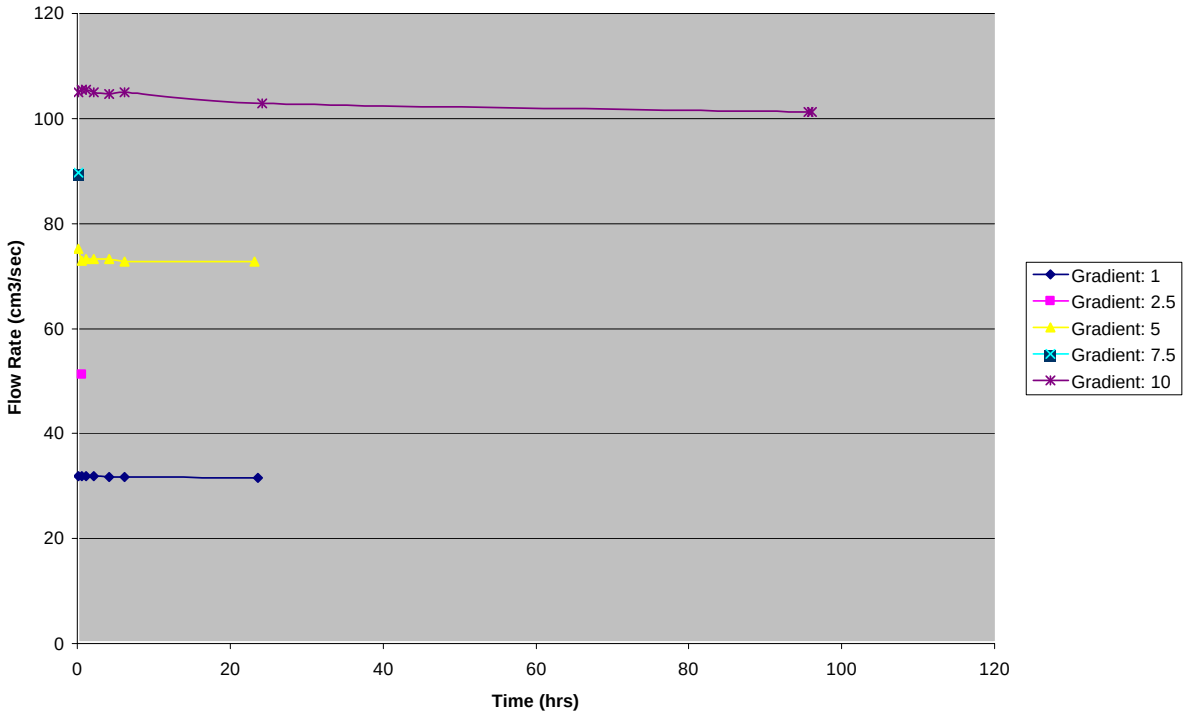
Gradient Ratio vs. Time



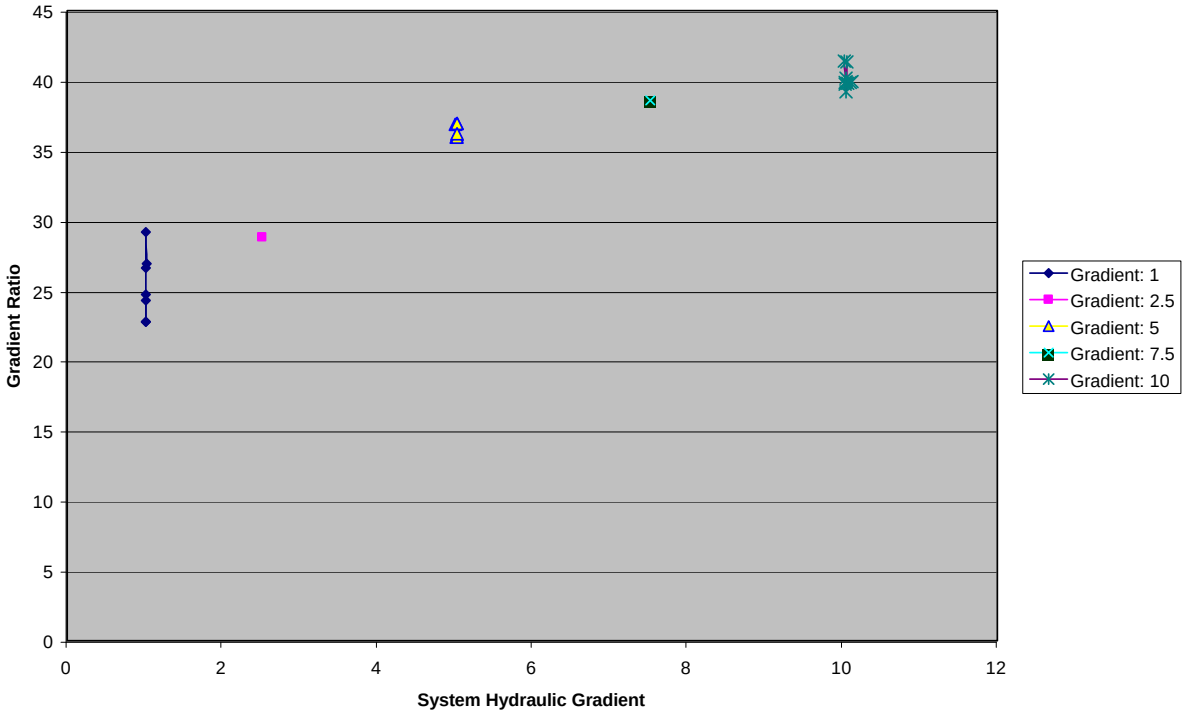
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Geotextile I.D. 4 holes @ 3/16, with heat-bonded geotextile **TEST # 23** "A" Zone - 1C with heat-bonded geotex

Soil I.D. "A" Zone - 1C

PlexiGlas Thickness 342 mils

Weight of soil used: 3.172 lb Soil Loss: negligible

Unit Weight of Dry Soil in Permeamet 18.04 kN/m^3

Volume of Soil 47.78 cu in

Target Gradient: 1

Date	Time	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
2-Apr	8:00	0	10.1	13.0	12.1	12.1	11.2	11.4	2.9	1.01	0.8	8.4	21	1828	60	30.4667	22	0.0263
	8:30	0.5	10.1	13.0	12.0	12.1	11.1	11.3	2.9	1.01	0.85	8.3	19.529	1818	60	30.3	22	0.0262
	9:00	1	10.1	13.0	11.9	12.0	11.0	11.3	2.9	1.01	0.8	8.25	20.625	1810	60	30.1667	22	0.0261
	10:00	2	10.2	13.0	11.8	11.9	11.0	11.2	2.8	1.02	0.75	8.3	22.133	1800	60	30	22	0.0257
	12:00	4	10.2	13.0	11.7	11.8	10.9	11.0	2.8	1.02	0.8	8.15	20.375	1780	60	29.6667	22	0.0254
	14:00	6	10.2	13.0	11.6	11.7	10.8	11.0	2.8	1.02	0.75	8.1	21.6	1775	60	29.5833	22	0.0253
3-Apr	7:40	23.5	10.3	13.0	11.3	11.4	10.5	10.7	2.7	1.03	0.75	7.9	21.067	1730	60	28.8333	22	0.0244

Note - 4-2-02 @ 8:35, Very slight amount of fines in the bottom chamber

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
3-Apr	7:45	0	25.1	29.5	26.7	26.7	25.0	25.3	4.4	2.51	1.55	20.75	26.774	2908	60	48.4667	22	0.0169
	8:15	0.5	25.1	29.5	26.7	26.7	24.9	25.3	4.4	2.51	1.6	20.7	25.875	2910	60	48.5	22	0.0169

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
3-Apr	8:20	0	50.1	57.5	52.7	52.8	49.8	50.4	7.4	5.01	2.65	42.7	32.226	2110	30	70.3333	22	0.0123
	8:50	0.5	50.2	57.5	52.4	52.5	49.5	50.1	7.3	5.02	2.65	42.5	32.075	2130	30	71	22	0.0124
	9:30	1.00	50.2	57.5	52.1	52.2	49.2	49.8	7.3	5.02	2.65	42.2	31.849	2110	30	70.3333	22	0.0122
	10:30	2.00	50.2	57.5	51.8	51.9	49.0	49.5	7.3	5.02	2.6	41.95	32.269	2105	30	70.1667	22	0.0122
	12:30	4.00	50.5	57.6	50.3	50.4	47.5	48.1	7.1	5.05	2.55	40.7	31.922	2060	30	68.6667	22	0.0119
	14:30	6.00	50.6	57.6	49.7	49.8	47.0	47.6	7.0	5.06	2.45	40.3	32.898	2057	30	68.5667	22	0.0118
4-Apr	7:25	23	51.1	57.8	47.1	47.3	44.5	45.1	6.7	5.11	2.4	38.1	31.75	1982	30	66.0667	22	0.0113

Note - 4-3-02 @ 9:35, with increased flow rate, the fines in the bottom chamber have been washed out

Note - 4-3-02 @ 10:35, added 200 ml of 5% solution Sodium Hypochlorite

Target Gradient: 7.5

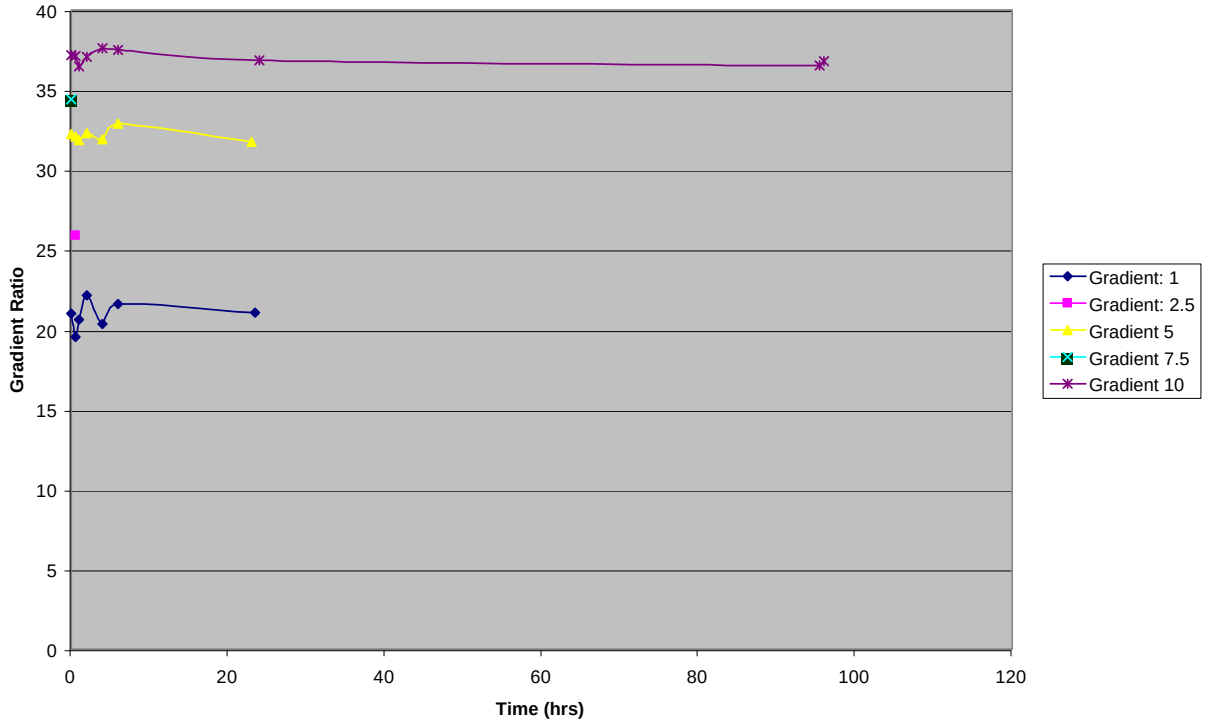
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
4-Apr	7:30	0	75.1	84.4	70.2	70.3	66.6	67.2	9.3	7.51	3.35	57.6	34.388	2450	30	81.6667	22	0.0095
	7:55	0.5	75.2	84.5	70.0	70.1	66.3	67.0	9.3	7.52	3.4	57.35	33.735	2450	30	81.6667	22	0.0095

Target Gradient: 10

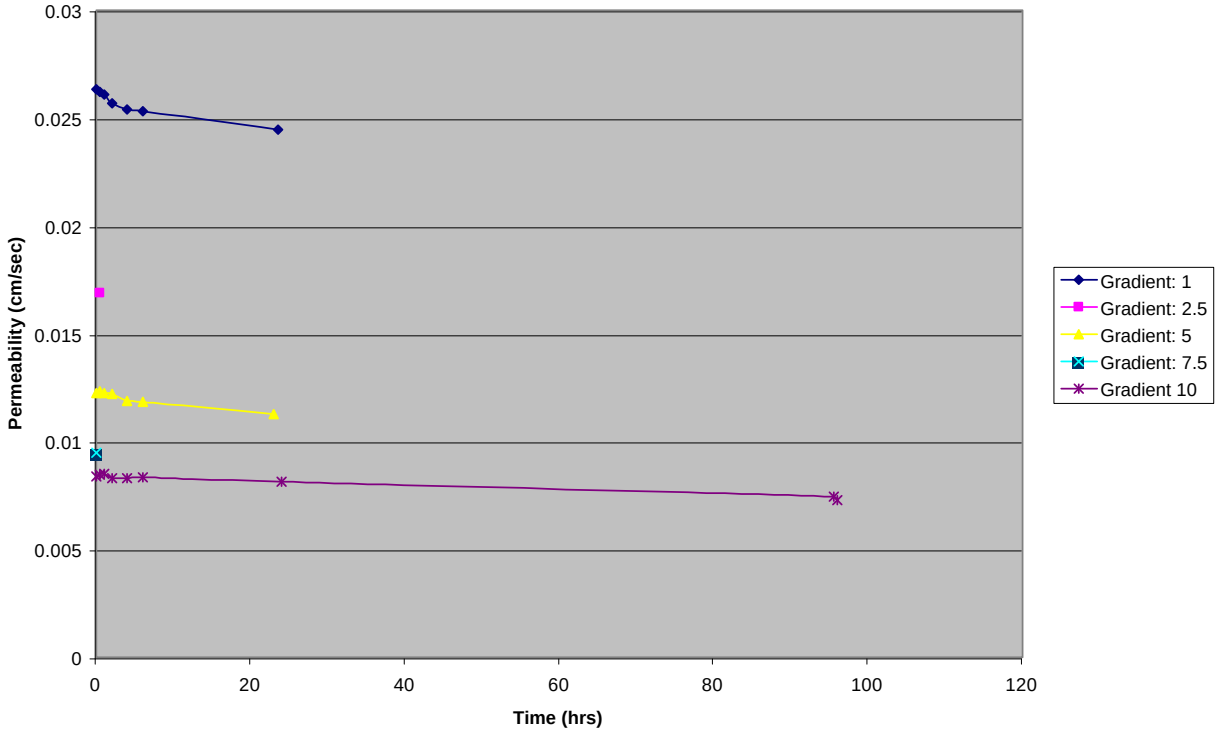
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
4-Apr	8:00	0	100.2	107.2	90.1	90.3	85.5	86.4	7.0	10.02	4.25	78.95	37.153	2890	30	96.3333	22	0.0084
	8:30	0.5	100.2	107.2	90.0	90.2	85.4	86.3	7.0	10.02	4.25	78.85	37.106	2920	30	97.3333	22	0.0085
	9:00	1	100.2	107.2	89.6	89.9	85.0	85.9	7.0	10.02	4.3	78.45	36.488	2930	30	97.6667	22	0.0085
	10:00	2	100.3	107.2	88.8	89.0	84.3	85.1	6.9	10.03	4.2	77.8	37.048	2865	30	95.5	22	0.0083
	12:00	4	100.5	107.2	87.8	88.0	83.4	84.2	6.7	10.05	4.1	77.1	37.61	2860	30	95.3333	22	0.0083
	14:00	6	100.5	107.2	87.6	87.8	83.2	84.0	6.7	10.05	4.1	76.9	37.512	2876	30	95.8667	22	0.0083
5-Apr	8:00	24	101.0	107.4	85.9	86.1	81.5	82.3	6.4	10.1	4.1	75.5	36.829	2822	30	94.0667	22	0.0081
8-Apr	7:30	95.5	102.8	108.4	76.8	76.9	72.7	73.6	5.6	10.28	3.7	67.55	36.514	2626	30	87.5333	22	0.0074
	8:00	96	103.7	108.6	75.7	75.8	71.7	72.5	4.9	10.37	3.65	67.2	36.822	2590	30	86.3333	22	0.0073

Note - 4-4-02 @ 8:05 surging in return line
Note - 4-5-02 @ all monometers surging slightly (rising/falling) - recorded average value
Note - 4-8-02 @ 7:35 added 100 ml 5% solution of sodium hypochlorite

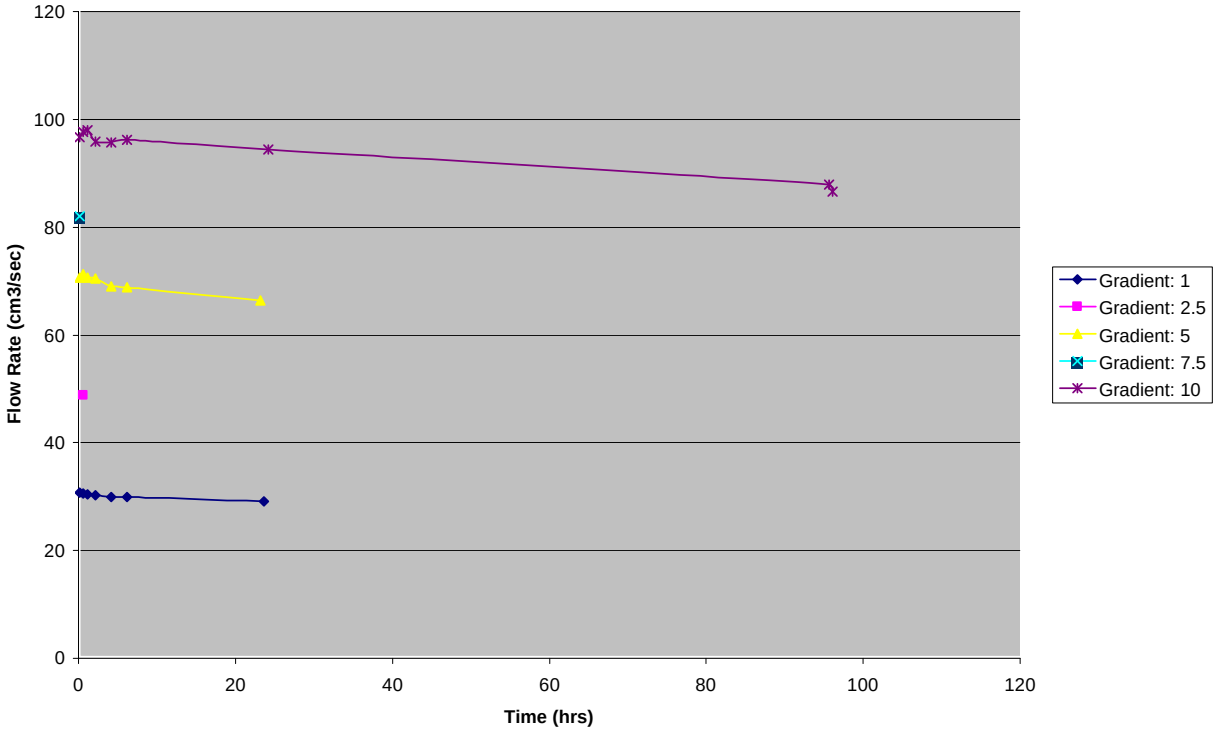
Gradient Ratio vs. Time



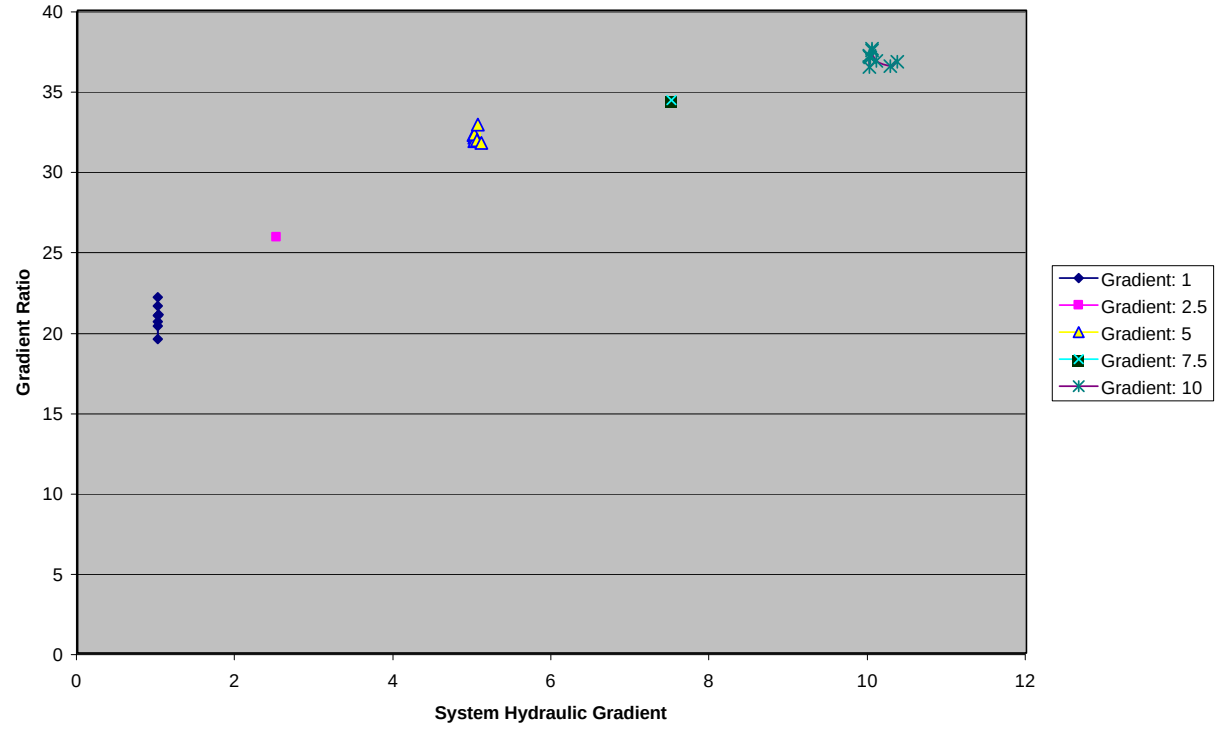
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Geotextile I.D. 4 holes @ 3/16, with needle-punched nonwoven geotextile **TEST # 24** "A" Zone - 1C with needle-punched

Soil I.D. "A" Zone - 1C nonwoven geotextil

PlexiGlas Thickness 342 mils

Weight of soil used: 3.284 lb Soil Loss: negligible

Unit Weight of Dry Soil in Permeamet 18.67 kN/m^3

Volume of Soil 47.78 cu in

Target Gradient: 1

Date	Time	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
9-Apr	8:00	0	10.3	13.7	13.0	13.0	11.7	11.8	3.4	1.03	1.25	8.35	13.36	1530	60	25.5	23	0.0222
	8:30	0.5	10.3	13.7	12.9	12.9	11.7	11.8	3.4	1.03	1.15	8.35	14.522	1520	60	25.3333	23	0.0221
	9:00	1	10.3	13.7	12.9	12.9	11.7	11.8	3.4	1.03	1.15	8.35	14.522	1510	60	25.1667	23	0.0219
	10:00	2	10.3	13.7	12.8	12.8	11.6	11.7	3.4	1.03	1.15	8.25	14.348	1502	60	25.0333	23	0.0218
	12:00	4	10.3	13.7	12.7	12.7	11.5	11.6	3.4	1.03	1.15	8.15	14.174	1485	60	24.75	23	0.0215
	14:00	6	10.3	13.7	12.7	12.7	11.5	11.6	3.4	1.03	1.15	8.15	14.174	1480	60	24.6667	23	0.0215
10-Apr	7:25	23.5	10.3	13.7	12.6	12.6	11.5	11.4	3.4	1.03	1.15	8.05	14	1450	60	24.1667	23	0.021

Note - 4-9-02 @ 8:35, Very slight amount of fines in the bottom chamber

Target Gradient: 2.5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
10-Apr	7:28	0	25.3	30.0	27.8	27.8	25.2	25.4	4.7	2.53	2.5	20.6	16.48	2545	60	42.4167	23	0.015
	8:00	0.5	25.2	30.0	27.7	27.7	25.6	25.4	4.8	2.52	2.2	20.7	18.818	2530	60	42.1667	23	0.015

Target Gradient: 5

Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
	8:10	0	50.2	57.4	53.4	53.4	48.9	49.2	7.2	5.02	4.35	41.85	19.241	1890	30	63	23	0.0113
	8:35	0.5	50.2	57.4	53.2	53.3	48.7	49.0	7.2	5.02	4.4	41.65	18.932	1880	30	62.6667	23	0.0112
	9:05	1.00	50.2	57.4	53.1	53.2	48.6	48.9	7.2	5.02	4.4	41.55	18.886	1878	30	62.6	23	0.0112
	10:00	2.00	50.3	57.5	52.9	53.0	48.4	48.8	7.2	5.03	4.35	41.4	19.034	1880	30	62.6667	23	0.0112
	12:00	4.00	50.4	57.5	52.4	52.6	48.0	48.4	7.1	5.04	4.3	41.1	19.116	1860	30	62	23	0.011
	14:00	6.00	50.6	57.6	52.3	52.6	47.8	48.2	7.0	5.06	4.45	41	18.427	1850	30	61.6667	23	0.0109
11-Apr	7:25	23.25	50.6	57.6	52.1	52.3	47.7	48.0	7.0	5.06	4.35	40.85	18.782	1838	30	61.2667	23	0.0109

Note - 4-10-02 @ 9:35, with increased flow rate, the fines in the bottom chamber have been washed out

Note - 4-10-02 @ 10:35, added 200 ml of 5% solution Sodium Hypochlorite

Target Gradient: 7.5

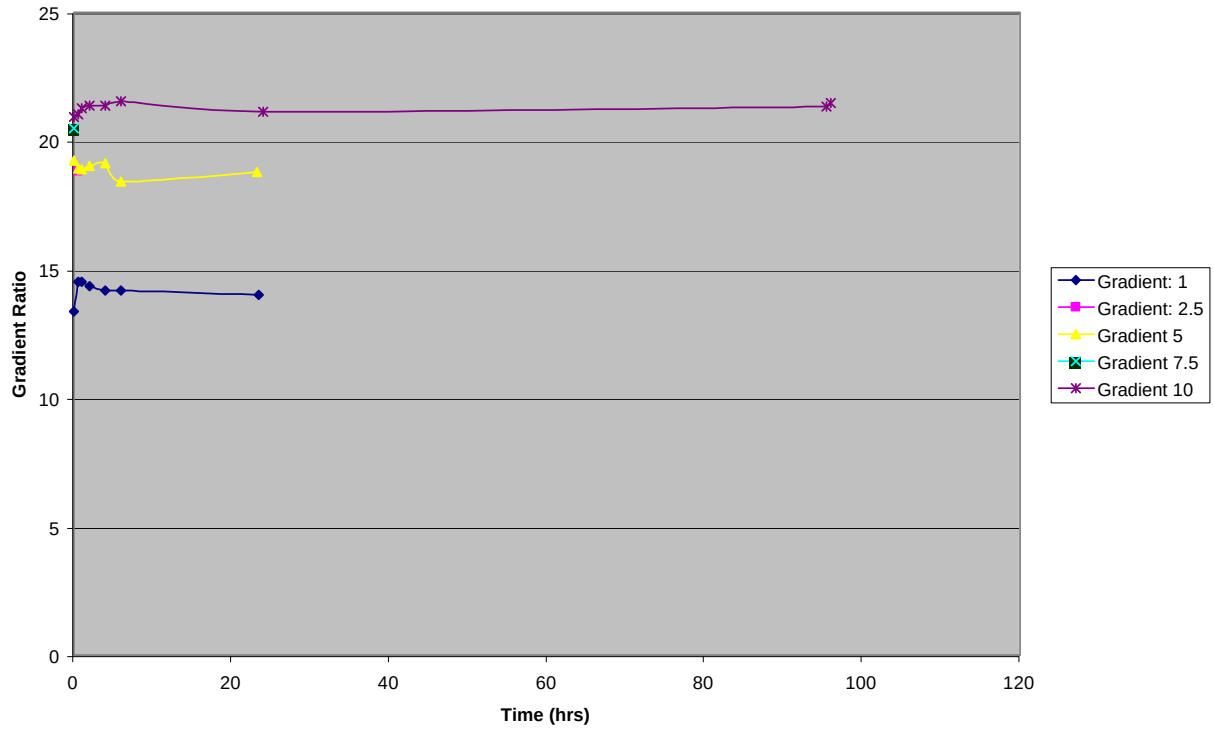
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
11-Apr	7:27	0	75.3	84.7	76.7	77.1	70.6	71.2	9.4	7.53	6	61.5	20.5	2330	30	77.6667	23	0.0092
	8:00	0.5	75.3	84.7	76.5	76.8	70.4	70.9	9.4	7.53	6	61.25	20.417	2300	30	76.6667	23	0.0091

Target Gradient: 10

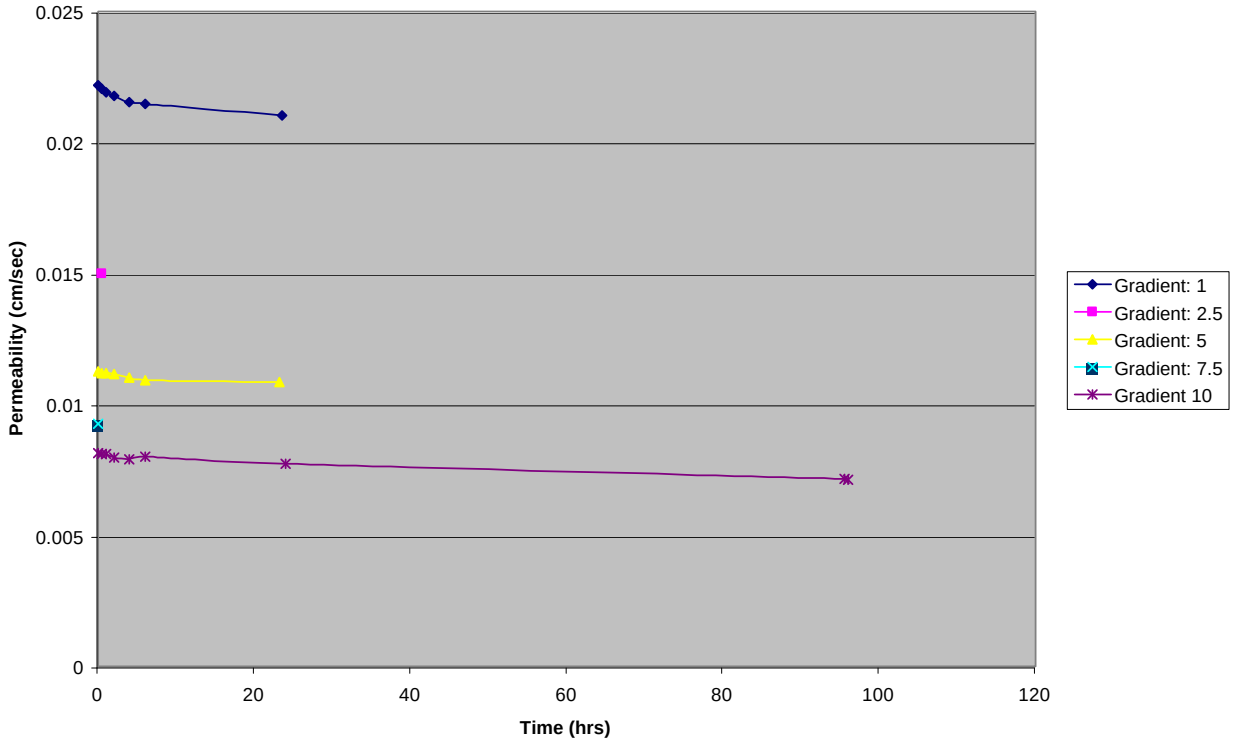
Date	Time of Test	Elapsed Time (hrs.)	Δh (cm), 1-6	Manometer Readings (cm) 1	2	3	4	5	6	*i* (Δh/L)	Δh_s	Δh_{sf}	G.R.	Q (cc)	Flow Time (s)	Flow Rate cm^3/sec	Temp (^oC)	k_{20} (m/s)
11-Apr	8:00	0	100.1	108.3	98.0	98.5	90.2	90.6	8.2	10.01	7.85	82.2	20.943	2732	30	91.0667	23	0.0082
	8:30	0.5	100.2	108.3	97.7	98.2	89.9	90.4	8.1	10.02	7.8	82.05	21.038	2720	30	90.6667	23	0.0081
	9:00	1	100.2	108.3	97.4	97.9	89.7	90.2	8.1	10.02	7.7	81.85	21.26	2720	30	90.6667	23	0.0081
	10:00	2	101.5	108.4	97.2	97.7	89.5	89.9	6.9	10.15	7.75	82.8	21.368	2710	30	90.3333	23	0.008
	12:00	4	101.7	108.4	96.9	97.5	89.3	89.6	6.7	10.17	7.75	82.75	21.355	2690	30	89.6667	23	0.0079
	14:00	6	100.4	108.4	96.5	97.1	88.9	89.6	8.0	10.04	7.55	81.25	21.523	2690	30	89.6667	23	0.008
12-Apr	8:00	24	100.8	108.6	94.2	95.0	86.7	87.5	7.8	10.08	7.5	79.3	21.147	2648	30	88.2667	22.5	0.0077
15-Apr	7:30	95.5	102.1	109.1	89.2	90.6	82.3	83.3	7.0	10.21	7.1	75.8	21.352	2515	30	83.8333	22	0.0072
	8:00	96	102.3	109.2	88.4	89.8	81.6	82.6	6.9	10.23	7	75.2	21.486	2500	30	83.3333	22	0.0071

Note - 4-12-02 @ 8:05 surging through monometers 1, 3, 5 and 6
Note - 4-15-02 @ all monometers surging slightly (rising/falling) - recorded average value
Note - 4-15-02 @ 7:35 added 100 ml 5% solution of sodium hypochlorite

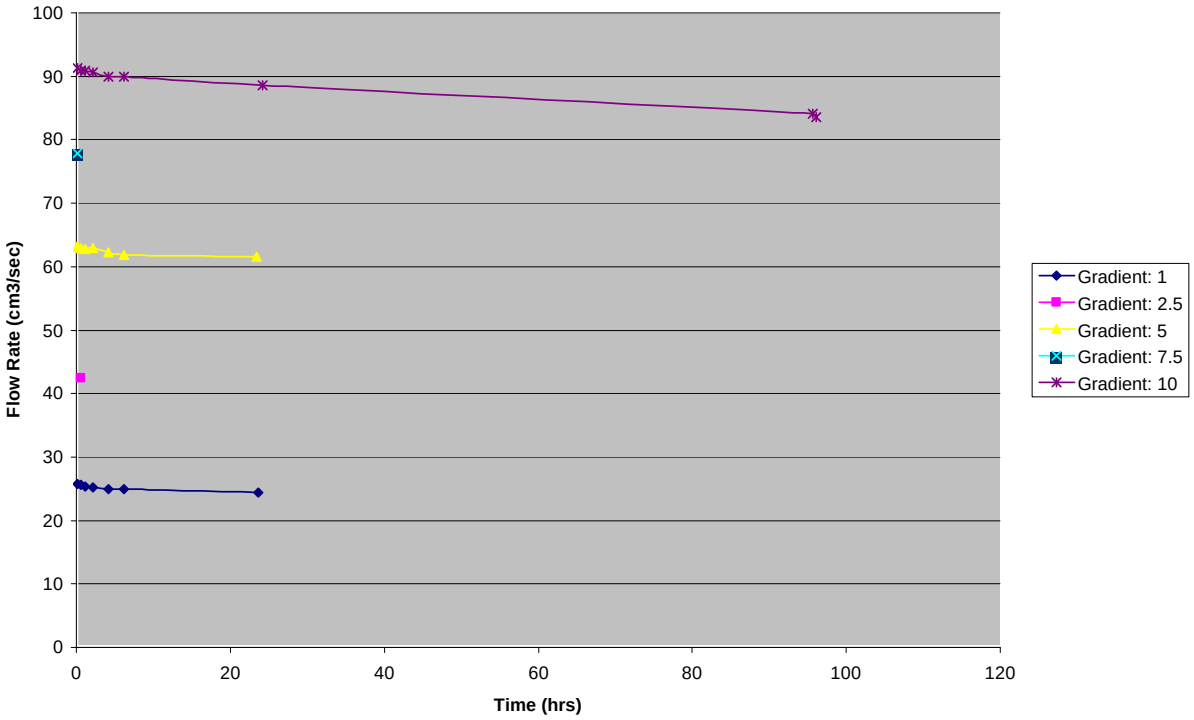
Gradient Ratio vs. Time



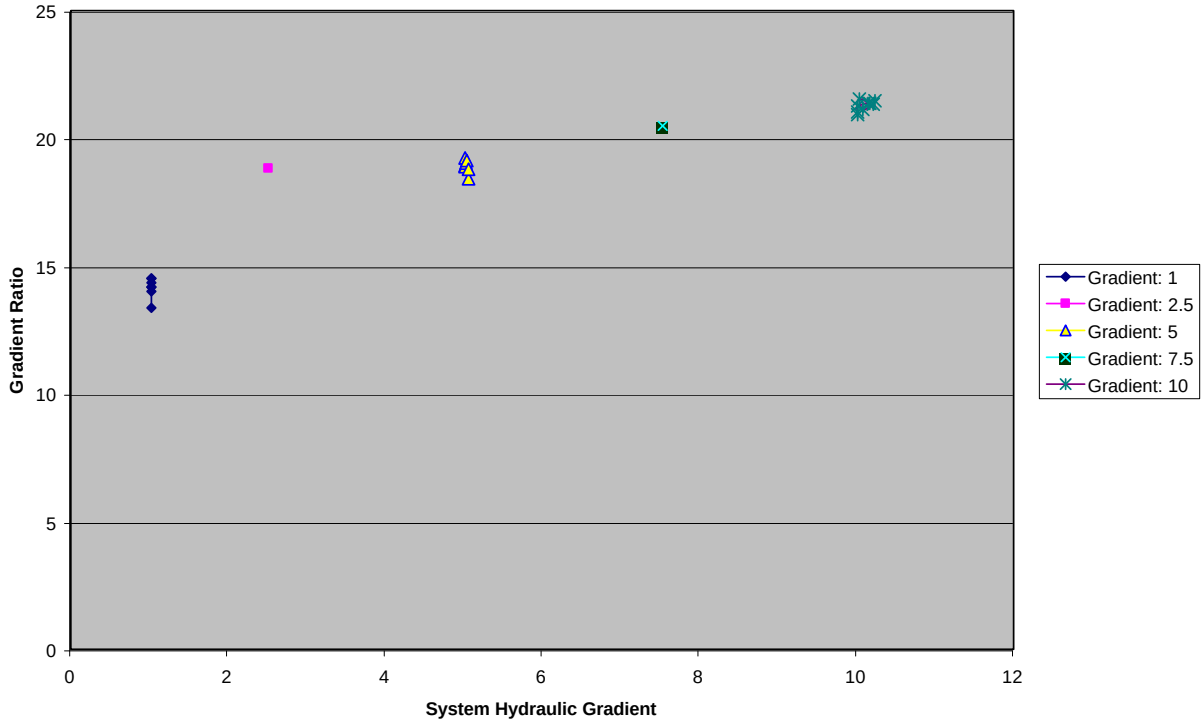
System Permeability vs. Time



Flow Rate vs. Time



Gradient Ratio vs. System Hydraulic Gradient



Mission Statement

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian tribes and our commitments to island communities.