Research Report

Research Project GCA1645

FINAL REPORT

POLYACRYLAMIDE (PAM) FLOCCULENT DISSOLUTION RATE TESTING FOR AN EXPERIMENTAL PASSIVE DOSING SYSTEM

by

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May 2000

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
WA-RD 490.1		

4. TITLE AND SUBTITLE	5. REPORT DATE
POLYACRYLAMIDE (PAM) FLOCCULENT DISSOLUTION RATE TESTING FOR AN EXPERIMENTAL PASSIVE DOSING SYSTEM	May 2000
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Thomas McCormack and Kevin House	
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. WORK UNIT NO.
Department of Civil Engineering Saint Martin's College 5300 Pacific Avenue SE Lacey, Washington 98503	11. CONTRACT OR GRANT NO. GCA1645
12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED
Washington State Department of Transportation Transportation Building, MS 7370 Olympia, Washington 98504-7370	Research Report
	14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

WSDOT is considering the use of Polyacrylamide (PAM) flocculent to reduce stormwater runoff turbidity at highway construction sites. This research project conducted a testing program to determine the dissolution rates of PAM introduced to simulated stormwater flow by using an experimental geotextile "tea-bag" dosing system.

The testing program simulated "tea-bags" placed in 2 configurations: 1) suspended in a pipe culvert, and 2) placed in a standard catch-basin insert. The flume in the Saint Martin's College School of Engineering Hydraulics Laboratory was used to conduct a full-scale simulation of flow regimes for these 2 configurations.

Five types of geotextile fabric, five types of PAM flocculent, and ten configurations of tea-bag placement were tested. Empirical relationships between the dissolution rate and flow were found by regressing the test results.

PAM dissolution rate was found to vary as an inverse power function with flow rate, and directly with the amount of PAM introduced into the flow stream. The type of geotextile fabric and the type of PAM flocculent had only a minor effect on dissolution rate.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Key words: Polyacrylamide (PAM), flocculent, flocculant, stormwater, turbidity, highway construction, dissolution rate, geotextile.	No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22616

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None	50	

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EXECUTIVE SUMMARY

WSDOT is considering the use Polyacrylamide (PAM) flocculent to reduce stormwater runoff turbidity at highway construction sites. This research project conducted a testing program to determine the dissolution rates of PAM introduced to simulated stormwater flow by using an experimental geotextile "tea-bag" dosing system.

The testing program simulated "tea-bags" placed in 2 configurations: 1) suspended in a pipe culvert, and 2) placed in a standard catch-basin insert. The flume in the Martin's College School of Engineering Hydraulics Laboratory was used to conduct a full-scale simulation of flow regimes for these 2 configurations.

Five types of geotextile fabric, five types of PAM flocculent, and ten configurations of tea-bag placement were tested. Empirical relationships between the dissolution rate and flow were found by regressing the test results.

PAM dissolution rate was found to vary as an inverse power function with flow rate, and directly with the amount of PAM introduced into the flow stream. The type of geotextile fabric and the type of PAM flocculent had only a minor effect on dissolution rate.

INTRODUCTION

Sponsor's Goals

WSDOT proposes to use PAM flocculent to reduce stormwater runoff turbidity at highway construction sites. PAM is known to be an effective, economic flocculent in this application (WSDOT 1997). WSDOT is considering a passive "bag in the flow stream" dosing system, wherein PAM in granular form is placed in geotextile "tea-bags" suspended in the stormwater flow.

Research Objective

No data exists on dissolution rates for Polyacrylamide (PAM) flocculent delivered to stormwater runoff using a geotextile "tea-bag" dosing system.

The objective of the research was to conduct a testing program to determine the dissolution rates of PAM flocculent introduced to stormwater flow using various experimental configurations of geotextile "tea-bag" dosing systems.

Testing Program

The testing program simulated tea bags placed in 2 configurations: 1) suspended in a pipe culvert, and 2) placed in a catch-basin insert. The dissolution rates were measured for stormwater flows ranging from approximately 0.2 to 2.5 cfs (cubic feet per second). The testing was conducted in 3 successive phases, as follows:

Phase 1: Comparison of 5 geotextile fabric types.

Phase 2: Comparison of 4 additional PAM-types (5 total).

Phase 3: Testing of 8 alternative configurations.

RESEARCH PROCEDURE

The flume in the Saint Martin's College School of Engineering Hydraulics Laboratory was used to simulate flow regimes for full-scale Culvert and Catch-Basin configurations. Photos illustrating the experimental setup and procedure may be found in Appendix A. Flows were determined by measuring the water depth behind a discharge weir (Photo 5); (Kindsvater and Carter 1959).

Culvert Configuration

A metal frame was constructed (Photo 1) to allow the PAM-holding geotextile bags to be suspended in the flume. The bags were C-clamped to the frame (Photo 2) and immersed in the flume-flow (Photos 3,4).

Catch Basin Configuration

A box was constructed to simulate an 18-inch by 24-inch catch basin. The box was suspended just beyond the weir at the discharge end of the flume, so that all the flume flow was captured in the box (Photo 13). A "Streamguard" catch basin insert (supplied by WSDOT) was fastened in the box (Photos 7,8). A wooden grate was installed over the insert (Photo 9), to simulate a standard catch basin grate.

The water flowed from the weir onto the grate, and exited the bottom of the simulated catch basin (Photos 10,11,12).

Geotextile Fabric "Tea-Bags"

Teabags constructed from geotextile fabric were manufactured and supplied by WSDOT. The bags for use in the culvert test were approximately 6 x 9-inches. The bags for use in the catch-basin test were approximately 9 x 9-inches.

Testing Procedure

Approximately 1 pound of PAM was placed in a geotextile bag, and weighed to an accuracy of 0.1-gram (Photo 16). The open end of the bag was folded over and securely stapled shut. Pumps were turned on in the proper combination to achieve the desired flow (three permanent flume pumps (Photo 6) were augmented by a large auxiliary pump (Photo 4) at higher flows). The bag was placed in the flow for 2 hours, during which time the flow depth was re-checked every 30 minutes. Following testing, the used bag containing the remaining PAM was oven-dried (Photo 14) at 180-degrees-F a minimum of 72-hours, weighed, then dried an additional 12-hours and re-weighed. This drying/weighing was repeated until successive weight changes following a 12-hour drying period differed by less than 1.5 percent.

A detailed description of the testing procedure, along with the actual test data, may be found in Appendix B.

Calculations

The weight of PAM dissolved was determined from the difference in the amount of dry PAM in the bags before and after each test. The PAM Dissolution Rate, hereafter called "D-Rate", was found by:

$$\text{D-Rate} = \frac{(W1 - W2)}{Q * T} \qquad \text{(Equation 1)}$$

where: W1 = weight of PAM before test
W2 = weight of (dried) PAM after test
Q = rate of flow during test
T = time of test

Microsoft Excel was used to develop continuous empirical relationships between D-Rate and Flow by regressing the test result values (Photo 15). A good fit was found by using a Power-Function, of the form:

$$\text{D-Rate} = b(0) * Q^{(b1)} \qquad \text{(Equation 2)}$$

where: $b(0)$, $b(1)$ = the regression coefficients

Q = flow rate (cfs)

PHASE 1 - GEOTEXTILE COMPARISONS

Testing

In Phase 1, the variation in dissolution rate with flow was determined for 5 geotextile types, using PAM type 9905N. Geotextiles tested were: FW300, FW401, FW402, FW403, FW500. The approximate flow rates (see Appendix B) tested were:

Culvert Flow: .5, .8, 1.7, 2.0 and 2.5 cfs;
Catch Basin: .2, .5, .8 and 1.6 cfs.

Results

The data points and regressed curves of D-Rate vs. Flow are presented graphically in the Culvert Flow Chart - Phase 1 (Fig. 1) and the Catch-Basin Flow Chart - Phase 1 (Fig. 2). The curves clearly show 2 results from the testing:

1. D-Rate decreases with increasing flow.
2. D-Rate varies only slightly between geotextiles.

Discrete regressed values of D-Rate vs. Flow are presented in Tables 1 and 2 for the culvert and catch basin configurations, respectively. The regressed values of D-Rate ranged from .073 to .383 mg/liter for culvert flow, and from .150 to 1.208 mg/liter for catch basin flow.

Catch-Basin Insert Failure

The Streamguard catch-basin insert manufacturer recommends that the insert not be used for flows exceeding 0.8 cfs. In the testing, the catch-basin insert failed by tearing at a flow of 1.64 cfs. The test was repeated with a new insert bag, and failure again occurred at 1.64 cfs. A photo of the failed insert bag is provided in Photos 17 & 18 in Appendix A.

TABLE 1

PHASE 1 - GEOTEXTILE COMPARISONS

REGRESSED D-RATES FOR CULVERT FLOWS

FLOW (cfs)	CORRESP. VELOCITY (ft/s)	D-RATE (mg/liter) by GEOTEXTILE TYPE				
		FW 300	FW 401	FW 402	FW 403	FW 500
.5	0.64	.361	.356	.359	.318	.383
1.0	1.08	.196	.182	.187	.169	.190
1.5	1.43	.138	.122	.128	.116	.127
2.0	1.73	.107	.093	.098	.089	.095
2.5	1.99	.088	.074	.079	.073	.076

TABLE 2

PHASE 1 - GEOTEXTILE COMPARISONS

REGRESSED D-RATES FOR CATCH-BASIN FLOWS

FLOW (cfs)	CORRESP. VELOCITY (ft/s)	D-RATE (mg/liter) by GEOTEXTILE TYPE				
		FW 300	FW 401	FW 402	FW 403	FW 500
.2	0.31	.942	1.077	1.997	1.111	1.208
.5	0.64	.452	.494	.451	.455	.467
1.0	1.08	.259	.274	.246	.231	.228
1.5	1.43	.187	.194	.172	.156	.150

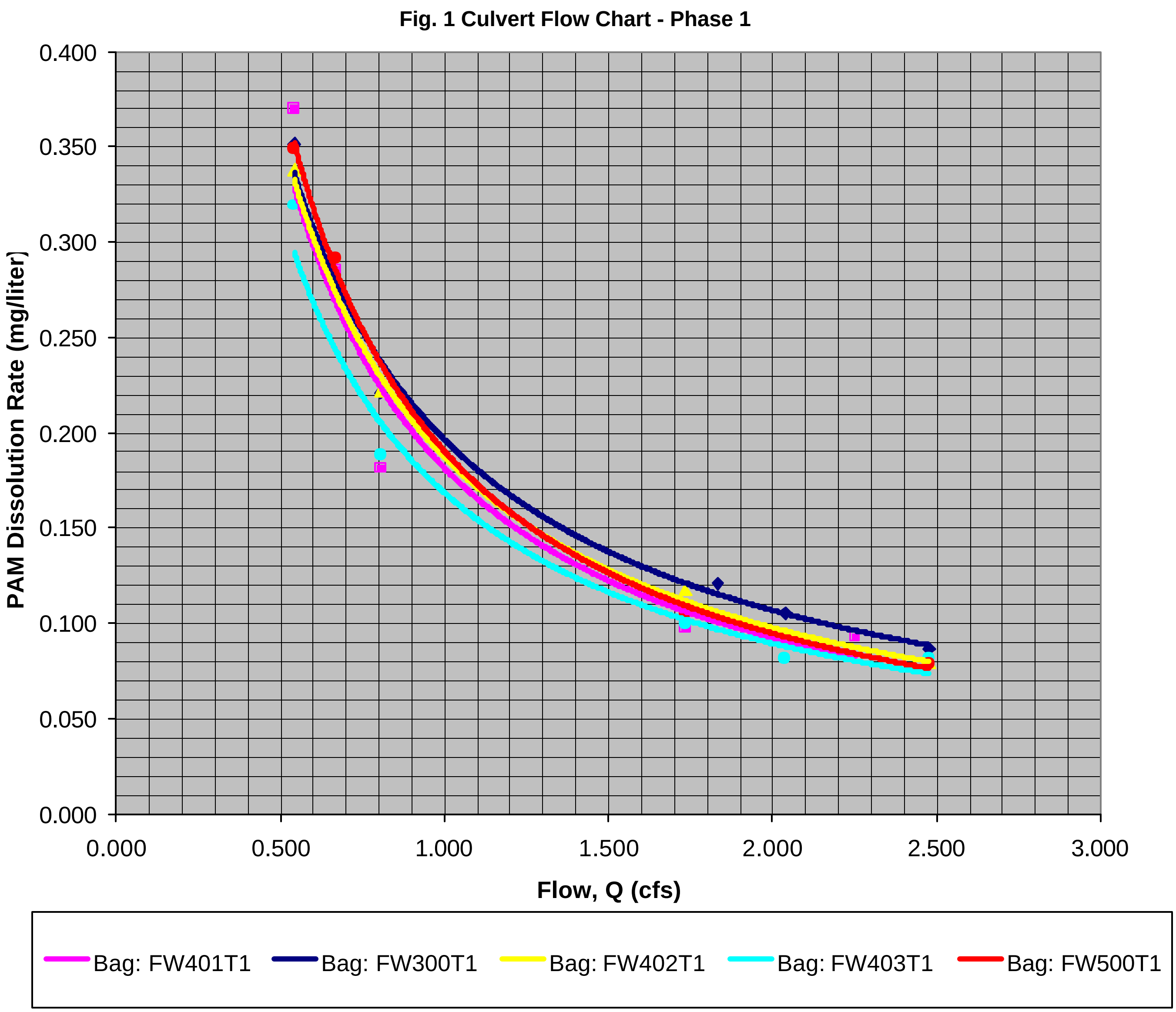


Fig. 1 Culvert Flow Chart - Phase 1
PAM Dissolution Rate (mg/liter)
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.000
0.500
1.000
1.500
2.000
2.500
3.000
Flow, Q (cfs)
Bag: FW401T1
Bag: FW300T1
Bag: FW402T1
Bag: FW403T1
Bag: FW500T1

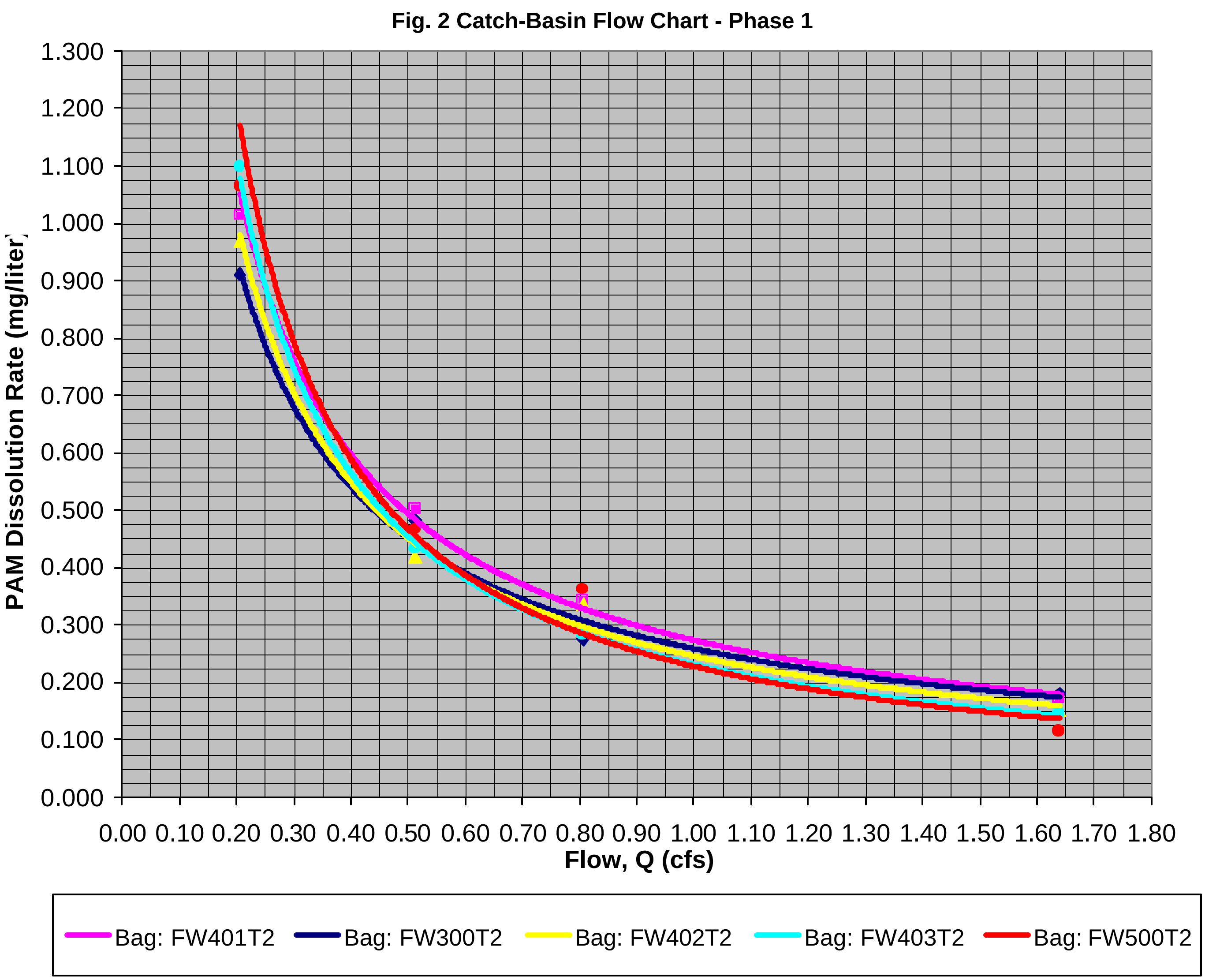


Fig. 2 Catch-Basin Flow Chart - Phase 1
PAM Dissolution Rate (mg/liter)
1.300
1.200
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10 1.20 1.30 1.40 1.50 1.60 1.70 1.80
Flow, Q (cfs)
Bag: FW401T2
Bag: FW300T2
Bag: FW402T2
Bag: FW403T2
Bag: FW500T2

PHASE 2 - PAM COMPARISONS

Testing

In Phase 2, the variation in dissolution rate with flow was determined for 4 additional PAM types (5 PAM types in all, including the 9905N PAM used in Phase I). It was found in Phase 1 that D-Rate varies only slightly with geotextile fabric type; therefore, only 1 geotextile type was used in Phase 2: type FW500.

The flow rates tested were:

Culvert Flow: .2, .5, .8, 1.6, 2.0 and 2.5 cfs;
Catch basin: .2, .5, .8 and 1.6 cfs.

Results

The data points and regressed curves of D-Rate vs. Flow are presented graphically in the Culvert Flow Chart - Phase 2 (Fig. 3) and the Catch-Basin Flow Chart - Phase 2 (Fig. 4). The curves clearly show 2 results from the testing:

1. D-Rate decreases with increasing flow.
2. D-Rate varies only slightly between PAM types.

Discrete regressed values of D-Rate vs. Flow are presented in Tables 3 and 4 for the culvert and catch basin configurations, respectively. The regressed values of D-Rate ranged from .083 to 1.172 mg/liter for culvert flow, and from .150 to 1.407 mg/liter for catch basin flow.

TABLE 3

PHASE 2 - PAM COMPARISONS

REGRESSED D-RATES FOR CULVERT FLOWS

FLOW (cfs)	CORRESP. VELOCITY (ft/s)	D-RATE (mg/liter) by PAM TYPE				
		9905N*	9832A	9835A	9836A	9837A
.2	0.31	---	1.152	1.172	1.073	.993
.5	0.64	.383	.469	.475	.435	.404
1.0	1.08	.190	.237	.240	.220	.205
1.5	1.43	.127	.159	.161	.148	.137
2.0	1.73	.095	.120	.121	.111	.104
2.5	1.99	.076	.096	.097	.089	.083

TABLE 4

PHASE 2 - PAM COMPARISONS

REGRESSED D-RATES FOR CATCH-BASIN FLOWS

FLOW (cfs)	CORRESP. VELOCITY (ft/s)	D-RATE (mg/liter) by PAM TYPE				
		9905N*	9832A	9835A	9836A	9837A
.2	0.31	1.208	1.157	1.221	1.407	1.053
.5	0.64	.467	.491	.507	.534	.456
1.0	1.08	.228	.257	.261	.257	.242
1.5	1.43	.150	.176	.177	.167	.167

* PAM type 9905N was tested in Phase I

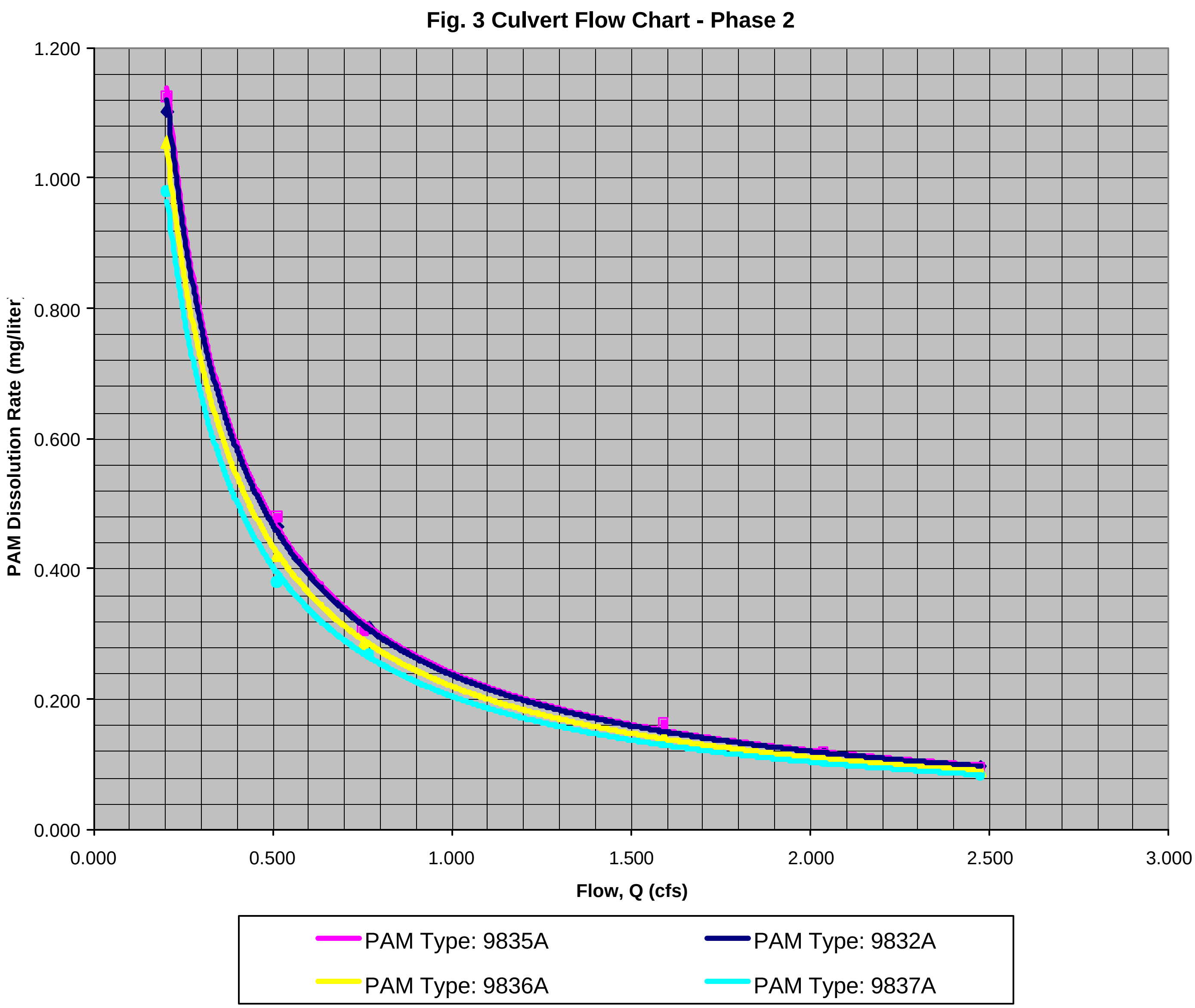
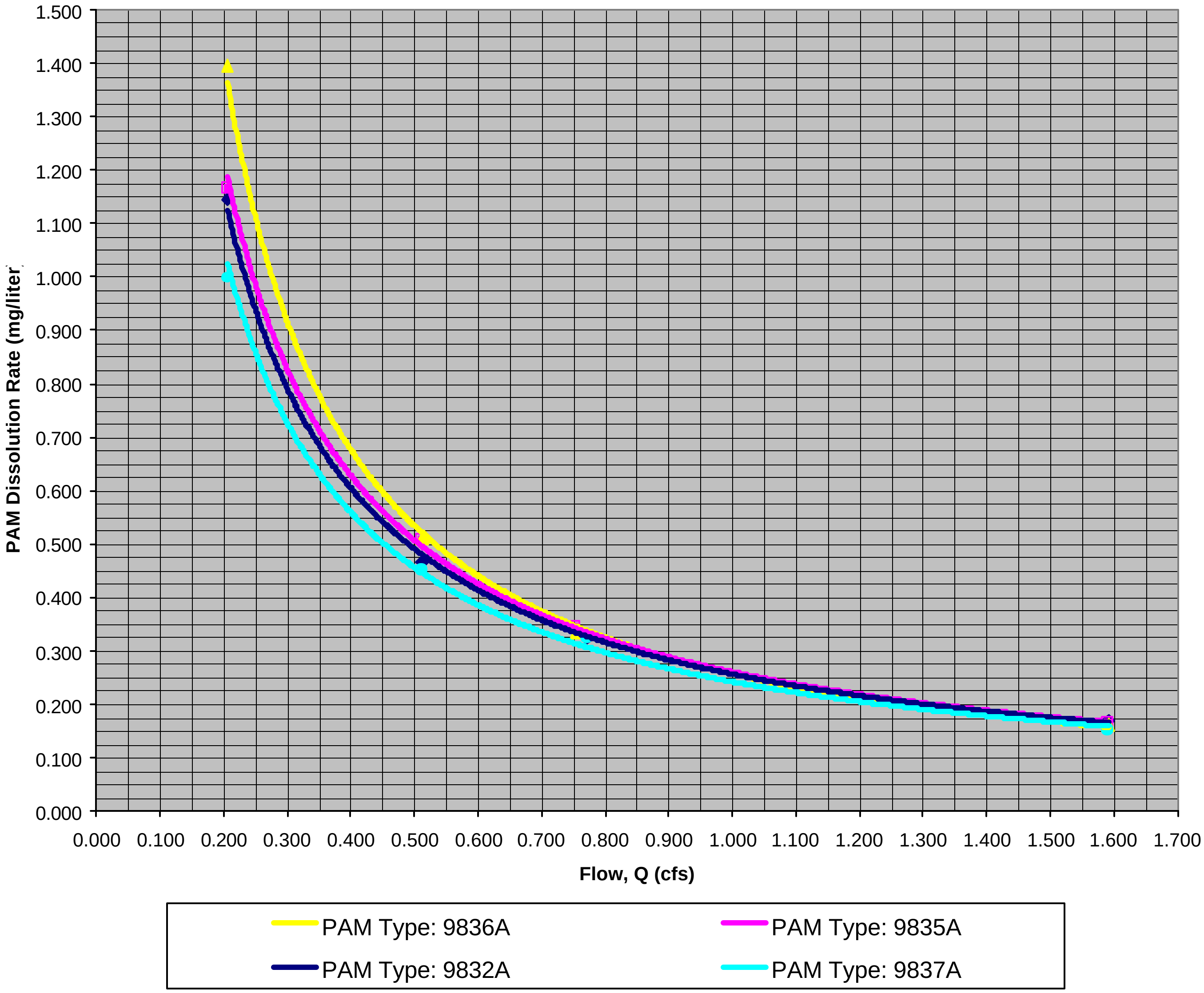


Fig. 3 Culvert Flow Chart - Phase 2
PAM Dissolution Rate (mg/liter)
1.200
1.000
0.800
0.600
0.400
0.200
0.000
0.000
0.500
1.000
1.500
2.000
2.500
3.000
Flow, Q (cfs)
PAM Type: 9835A
PAM Type: 9832A
PAM Type: 9836A
PAM Type: 9837A

Fig. 4 Catch-Basin Flow Chart - Phase 2



PHASE 3 - ALTERNATIVE CONFIGURATIONS

Testing

In Phase 3, the variation in dissolution rate with flow was determined for several alternative configurations. The alternative configurations tested were:

Culvert Flow:	1 bag turned "edgewise" to flow (Photo 22)
	1 bag flat on the bottom (Photo 22)
	2 bags flat on the bottom (Photo 20)
	4 bags flat on the bottom (Photo 21)
	3-inch x 3-foot "snake" bag (Photo 20)
Catch-Basin:	2-bags in Streamguard insert
	4-bags in Streamguard insert
	PAM "chunks" in insert (Photo 19)

Geotextile-type FW401 and PAM-type 9836A were used for all the configurations in Phase III. The flow rates tested were:

Culvert Flow: .2, .8 and 2.5 cfs;
Catch Basin: .2, .5 and .8 cfs.

Results

The data points and regressed curves of D-Rate vs. Flow are presented graphically in the Culvert Flow Chart - Phase 3 (Fig. 5) and the Catch-Basin Flow Chart - Phase 3 (Fig. 6).

Discrete regressed values of D-Rate vs. Flow are presented in Tables 5 and 6 for the culvert and catch basin configurations, respectively. The regressed values of D-Rate ranged from .083 to 4.003 mg/liter for culvert flow, and from .231 to 4.197 mg/liter for catch basin flow.

TABLE 5

PHASE 3 - ALTERNATIVE CONFIGURATIONS

REGRESSED D-RATES FOR CULVERT FLOWS

FLOW (cfs)	CORRESP. VELOCITY (ft/s)	D-RATE (mg/liter)				
		1 BAG ON "EDGE:	1 BAG ON BOTTOM	2 BAGS ON BOTTOM	4 BAGS ON BOTTOM	SNAKE BAG
.2	0.31	1.044	1.066	2.201	4.003	3.837
1.0	1.08	.210	.210	.409	.813	.741
1.5	1.99	.084	.083	.161	.327	.291

TABLE 6

PHASE 3 - ALTERNATIVE CONFIGURATIONS

REGRESSED D-RATES FOR CATCH-BASIN FLOWS

FLOW (cfs)	CORRESP. VELOCITY (ft/s)	D-RATE (mg/liter)		
		2 BAGS IN INSERT	4 BAGS IN INSERT	CUBES IN INSERT
.2	0.31	2.256	4.197	.917
.5	.64	.881	1.685	.547
1.5	1.08	.433	.845	.231

Fig. 5 Culvert Flow Chart - Phase 3

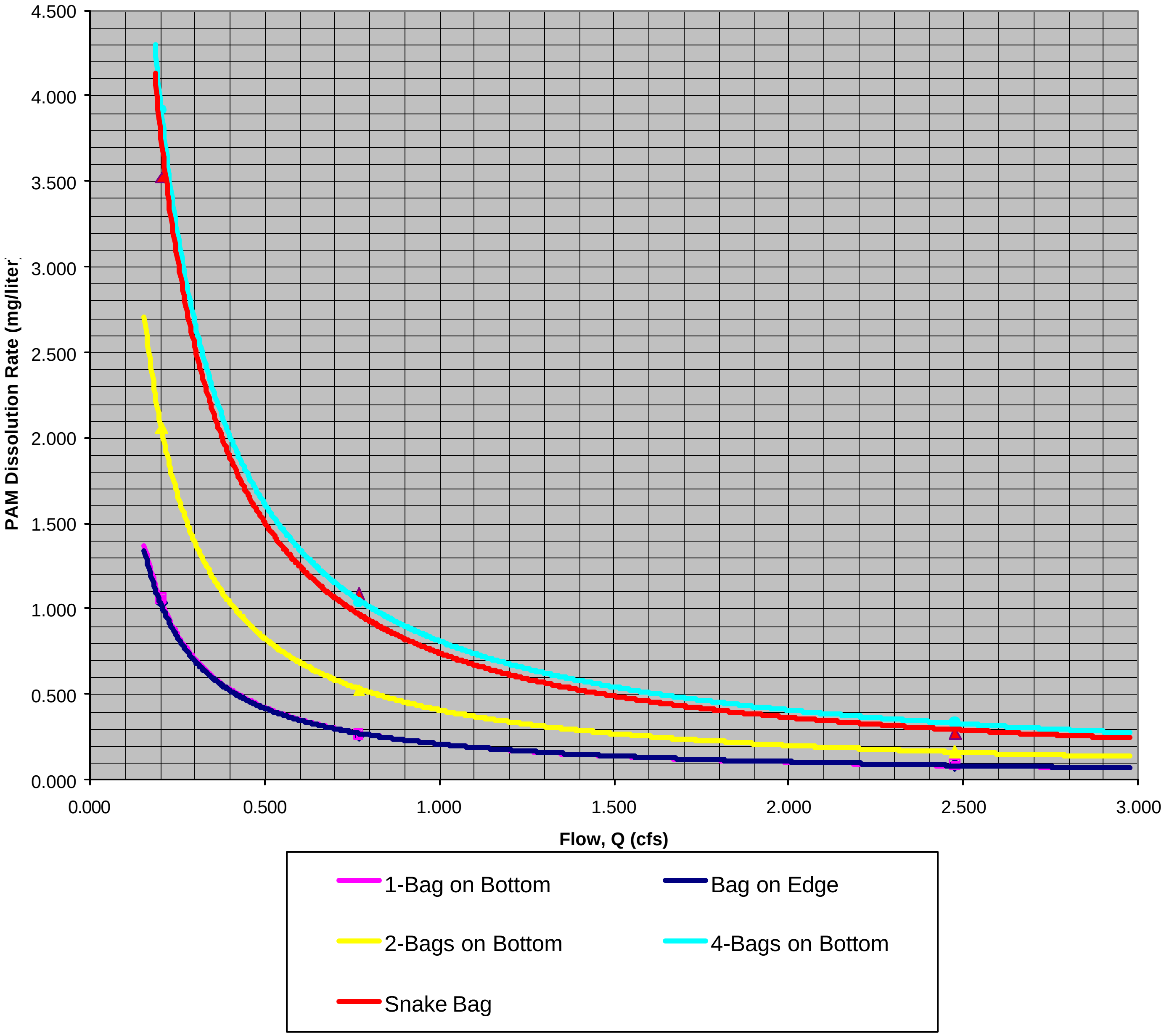
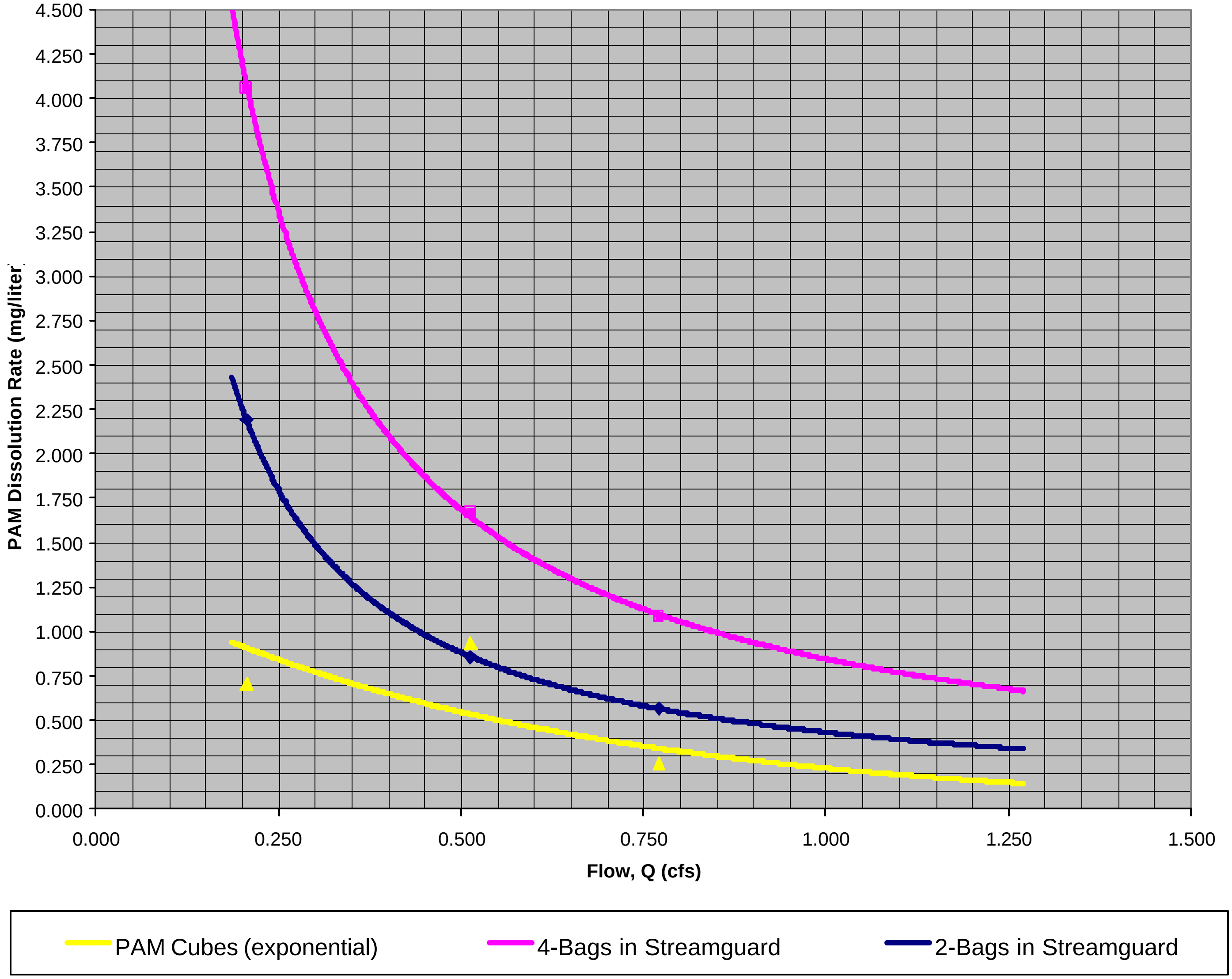


Fig. 6 Catch-Basin Flow Chart - Phase 3



DISCUSSION and CONCLUSIONS

Geotextile Type

It was determined in the Phase 1 testing that dissolution rates for the different tested varies by only about 10 to 20-percent. In the culvert flows, geotextile type FW500 exhibited the highest dissolution rates at low flow (.5 cfs), whereas FW300 showed the highest rates at higher flows. In the catch-basin flows, again type FW500 gave the highest rates at low flow (.2 cfs), with FW401 the winner at higher flow rates.

Because dissolution rates do not vary by large amounts in the different geotextile fabrics, the performance of the bags during handling emerged as a more significant factor in selecting a fabric to recommend for general field use. In all the bags types except FW500, it was difficult to keep from losing PAM granules, which tended to "sift" out of the bags during handling.

It appears that the more flexible the geotextile fabric is, the better it retains the PAM during handling. In this regard, fabric type FW500 is the most flexible and favorable of those tested.

PAM Type

It was determined during Phase 2 testing that PAM-type 9835A had the highest rate in the culvert at all flow rates, as well as in the catch-basin at flows of 1.0 cfs and higher. However, PAM type 9836A had higher dissolution rates under low flows in the catch basin (see Tables 3 and 4, and Figures 3 and 4).

PAM types 9832A, 9835A and 9836A had comparable dissolution rates, in the range of 10 to 25-percent higher than the PAM 9905N used in Phase I. However, PAM type 9837A had dissolution rates only slightly higher than the 9905N.

Culvert Flow Configurations

When the dissolution rate is normalized to the amount of PAM introduced into the stream flow (i.e., D-Rate per pound of PAM), it is clear that the various configurations (multiple bags, bag orientation or snake bag) do not have very much effect on the dissolution rate. This can be seen in Table 7 and in Figure 7.

TABLE 7

REGRESSED D-RATES PER POUND OF PAM

FOR CULVERT FLOW CONFIGURATIONS

FLOW (cfs)	D-RATE (mg/liter) per POUND of PAM					
	1 BAG "FLAT-WISE"	1 BAG ON "EDGE:	1 BAG ON BOTTOM	2 BAGS ON BOTTOM	4 BAGS ON BOTTOM	SNAKE BAG
.2	1.049	1.029	1.051	1.045	.984	.970
.5	.428	.415	.419	.413	.397	.387
1.0	.217	.209	.209	.204	.200	.193
1.5	.146	.140	.139	.135	.134	.129
2.0	.110	.105	.105	.101	.101	.096
2.5	.089	.084	.084	.081	.081	.077

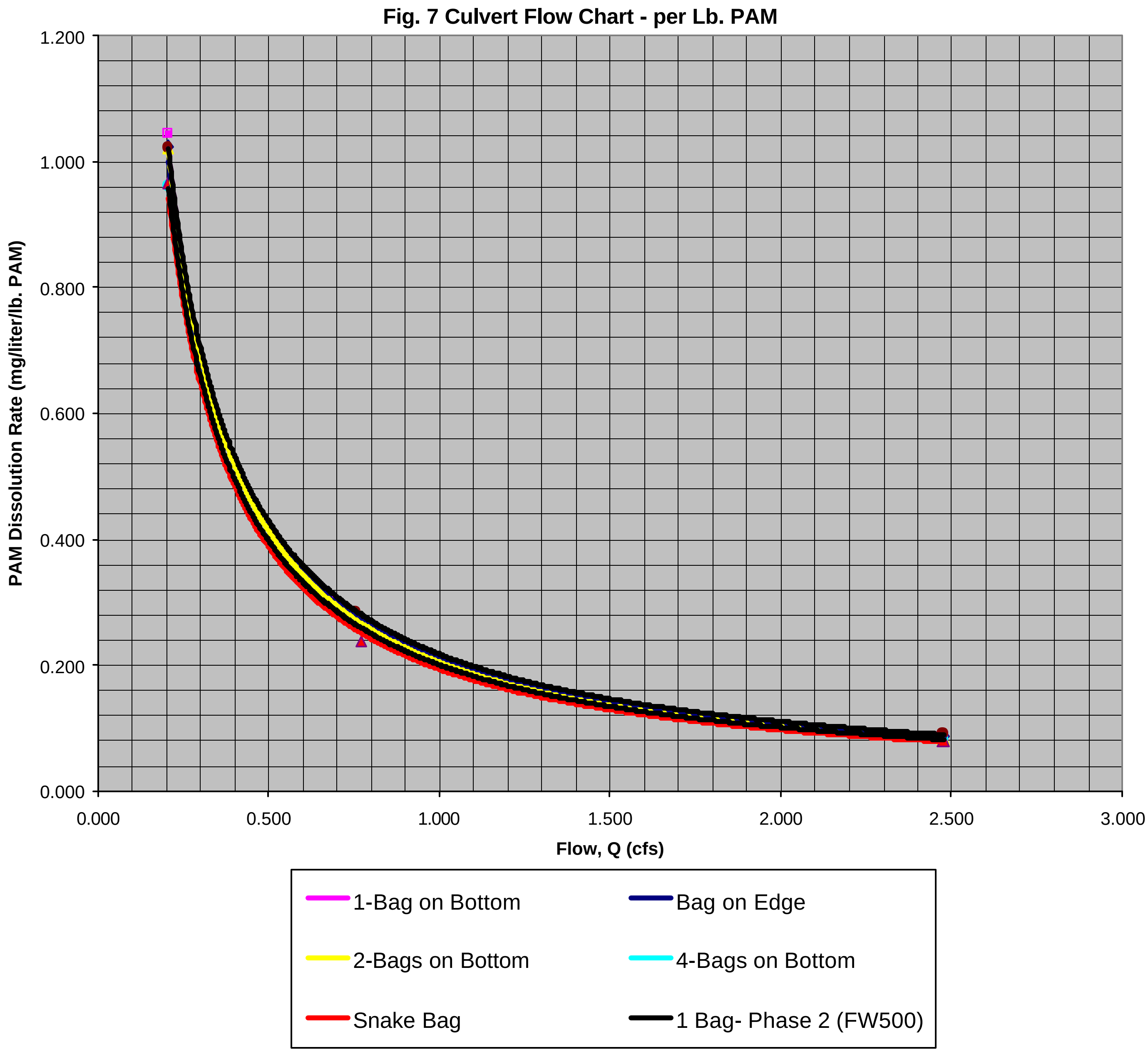


Fig. 7 Culvert Flow Chart - per Lb. PAM
PAM Dissolution Rate (mg/liter/lb. PAM)
1.200
1.000
0.800
0.600
0.400
0.200
0.000
0.000
0.500
1.000
1.500
2.000
2.500
3.000
Flow, Q (cfs)
1-Bag on Bottom
Bag on Edge
2-Bags on Bottom
4-Bags on Bottom
Snake Bag
1 Bag- Phase 2 (FW500)

Catch-Basin Configurations

Similar to the culvert flow, when the dissolution rates from catch-basin flows are normalized to the total weight of PAM introduced into the flow, there is not much variation between the different configurations (except for the "PAM cubes" configuration). This is shown in Table 8 and Figure 8.

TABLE 8

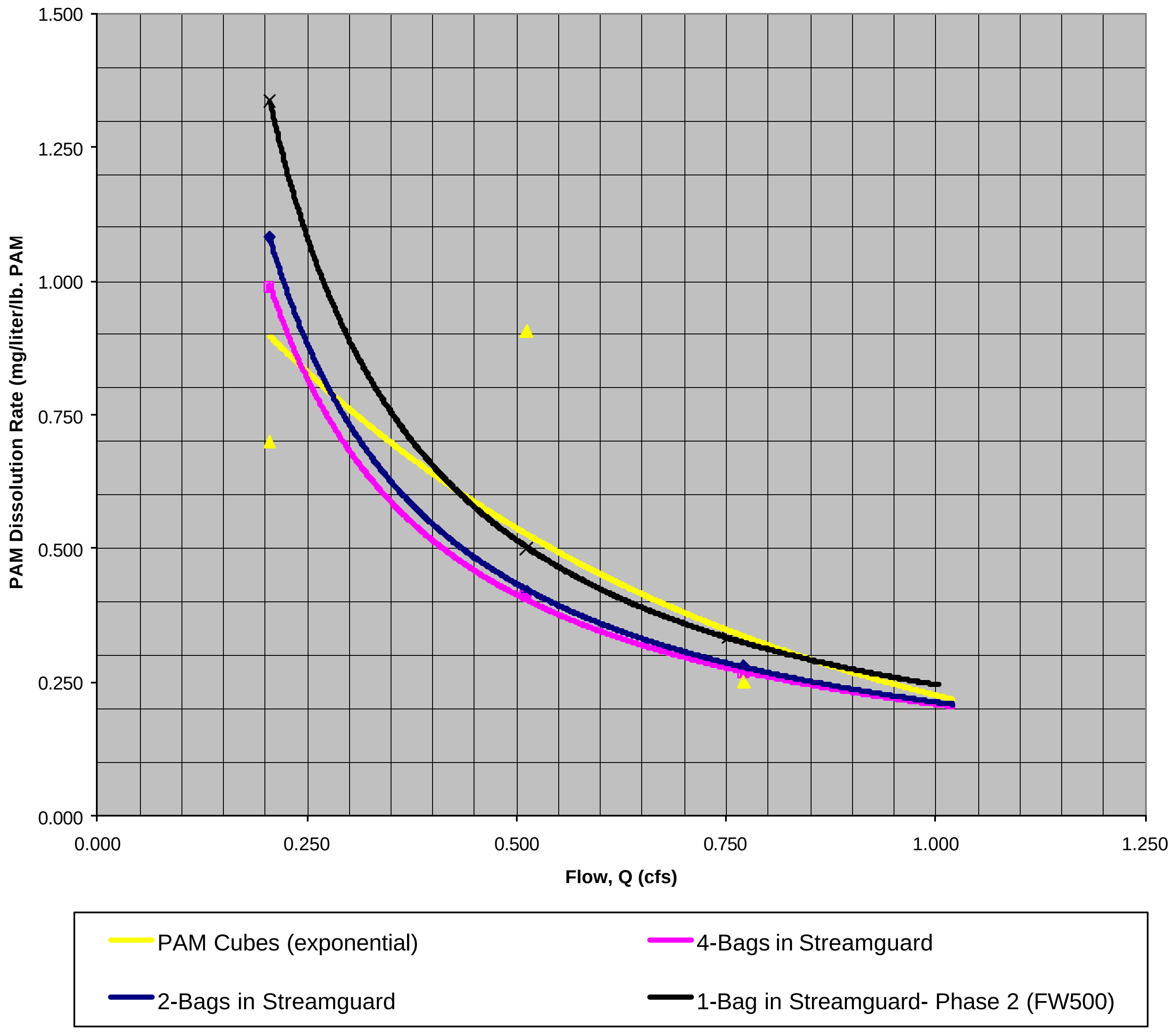
REGRESSED D-RATES PER POUND OF PAM

FOR CATCH-BASIN FLOW CONFIGURATIONS

FLOW (cfs)	D-RATE (mg/liter) per POUND of PAM			
	1 BAG IN INSERT	2 BAGS IN INSERT	4 BAGS IN INSERT	CUBES IN INSERT
.2	1.377	1.112	1.021	.906
.5	.516	.434	.413	.538
1.0	.245	.213	.208	.226

The "PAM cubes" configuration showed a different, and more erratic, dissolution rate vs. flow rate pattern. In addition, the chunks become a "gooey blob" in the Streamguard insert --- this will make it difficult to clean debris out of the insert in field use.

Fig. 8 Catch-Basin Flow Chart - per Lb. PAM



RECOMMENDATIONS

In our opinion, the present testing program has produced enough information to begin field trials. The next step should be to monitor the proposed application of PAM as a stormwater flocculent on several trial construction projects. To this end, the following recommendations are made for the first field trials.

1. For the tea bags, geotextile fabric FW500 will result in the least amount of PAM spilled during handling.
2. Similar results will be obtained by using PAM type 9832A, 9835A or 9836A. Lower dissolution rates would result from using either PAM 9905N or 9837A.
3. In the culvert flow configuration, Figure 7 may be used to estimate the required amount of PAM required in the flow stream. For example, if a concentration of 2 mg/liter was desired in stormwater expected to flow at 0.5 cfs, the amount of PAM required for dosing can be approximated as:

$$\text{PAM} = \frac{\text{desired concentration}}{\text{D-RATE per POUND PAM}} = \frac{2}{0.4} = 5 \text{ lbs.}$$

   The desired concentration will probably be obtained by using either multiple tea bags, or a "snake-bag".

4. In the catch-basin configuration, the same calculation may be made, using Figure 8. We recommend that tea bags be used in the Streamguard insert. We do not recommend that PAM cubes be placed directly in the insert. The insert should not be used for flows over 0.8 cfs.

REFERENCES

Kindsvater, C.E., and Carter, R.W., "Discharge Characteristics of Rectangular Thin-Plate Weirs," ASCE Transactions, No. 124, 1959.

Washington State Department of Transportation (WSDOT), "Polyacrylamides for Soil Erosion Control and Flocculation of Stormwater Detention Ponds at Highway Construction Sites," FHWA-PTP Program Federal Aid Project Number PTP-1996 (003), 1996.

APPENDIX

A. Photographs

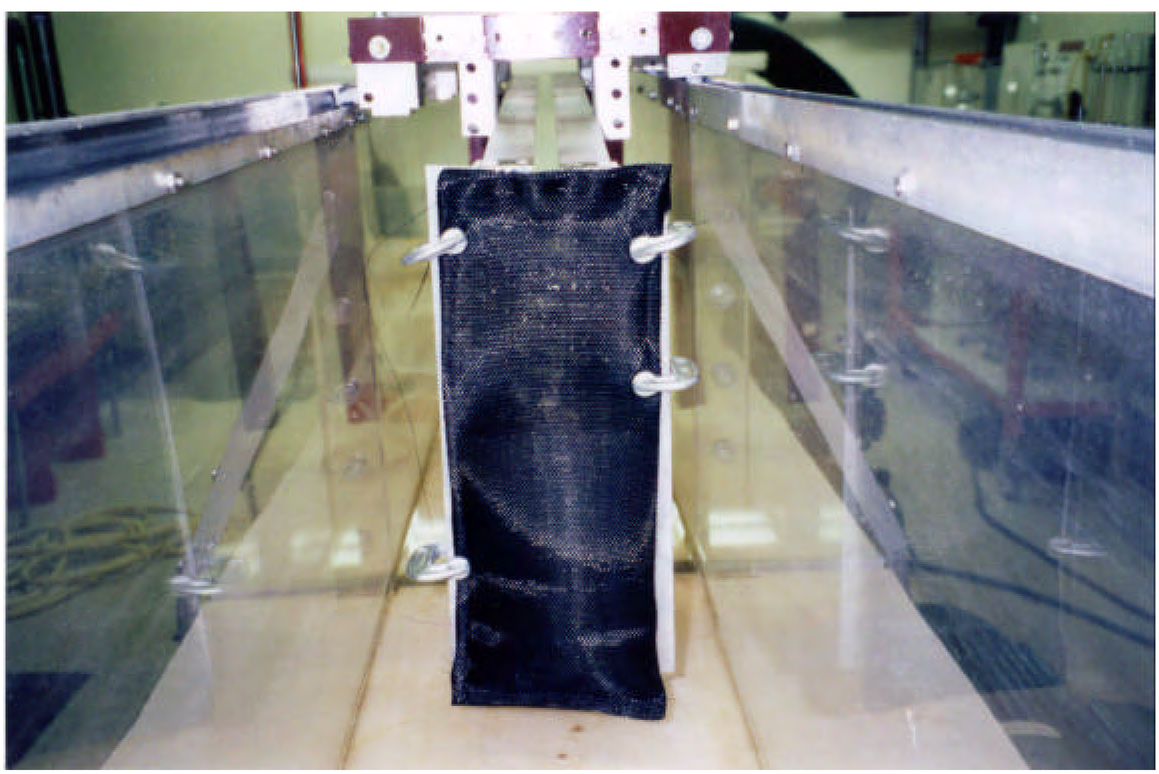
B. Procedure and Test Data

APPENDIX A

Photographs

Photo 1.
Frame for simulated culvert test.

Photo 2.
Frame for simulated culvert test positioned in flume with geotextile bag in place.



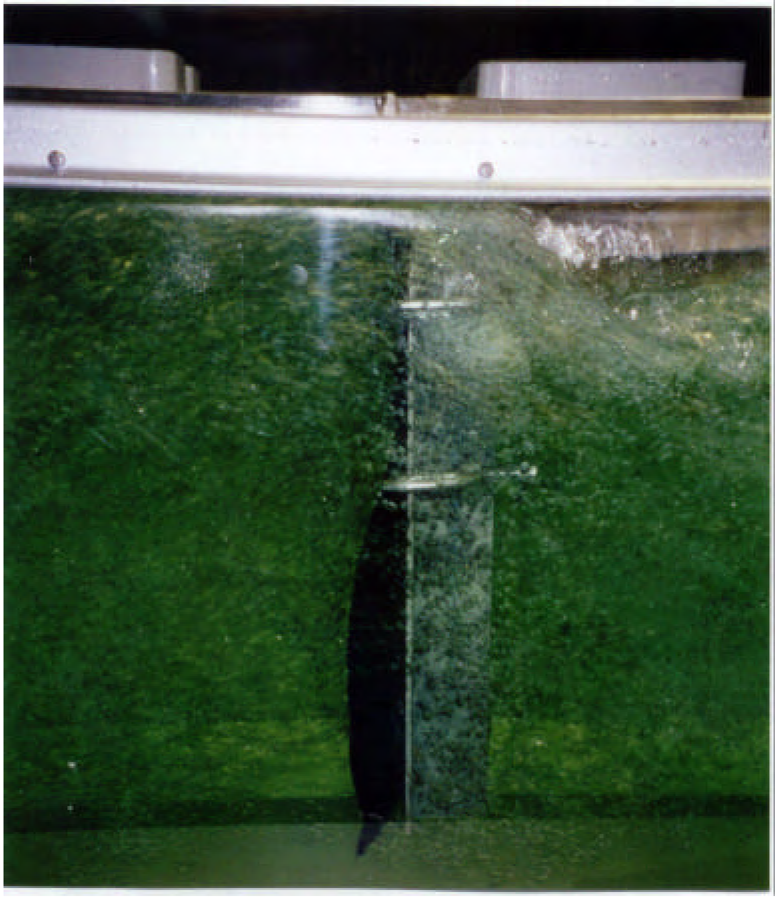
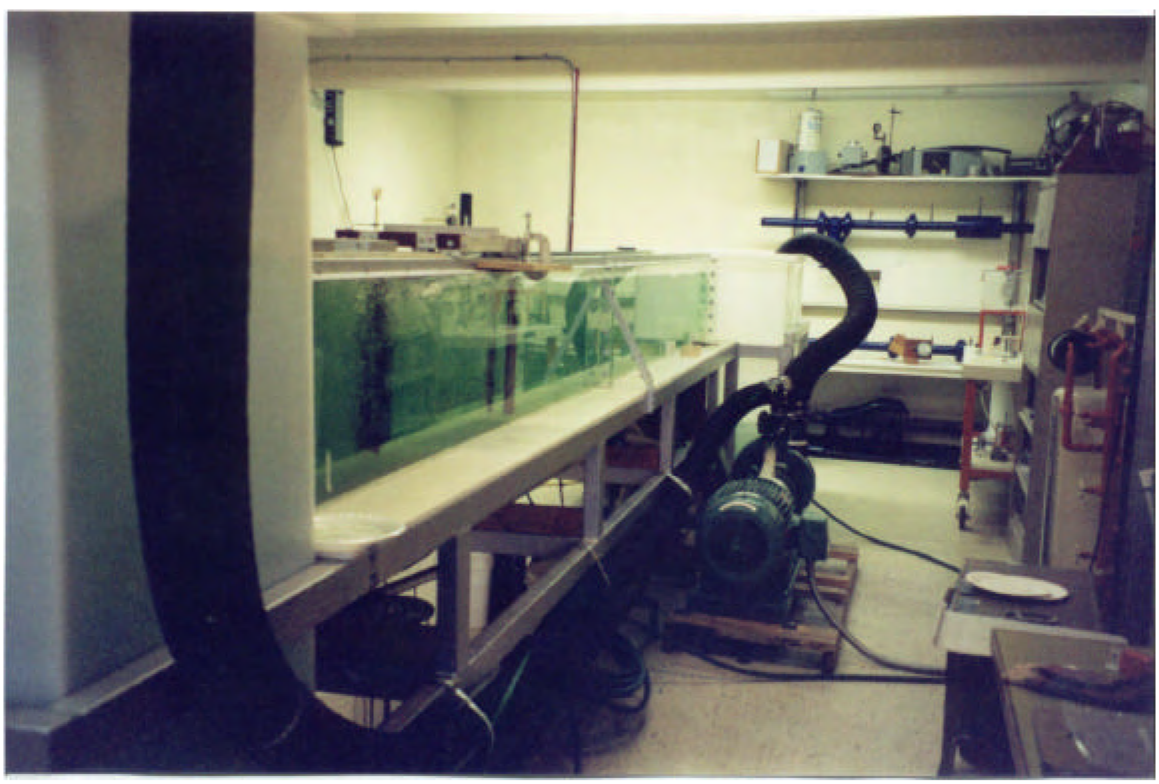
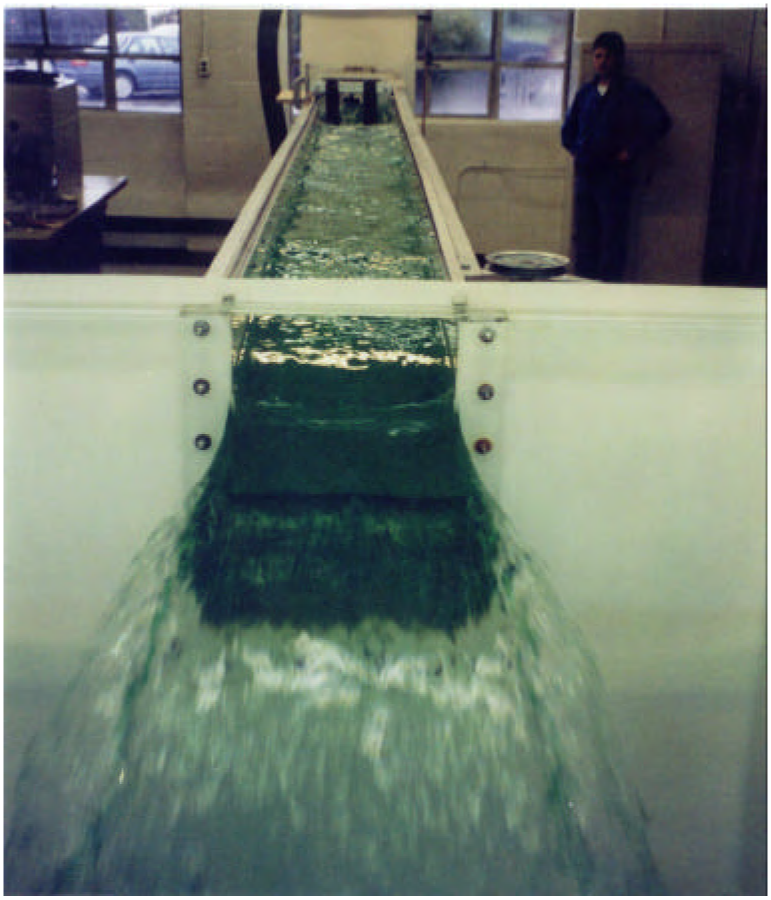


Photo 3.
Close up of culvert flow test in progress. (Direction of flow is left to right.)

Photo 4.
Culvert flow test in progress. (Bag at left end of flume. Auxiliary pump is visible.)





<u>Photo 5.</u>
Culvert flow test in progress. (Frame and bag in back, weir in front.)

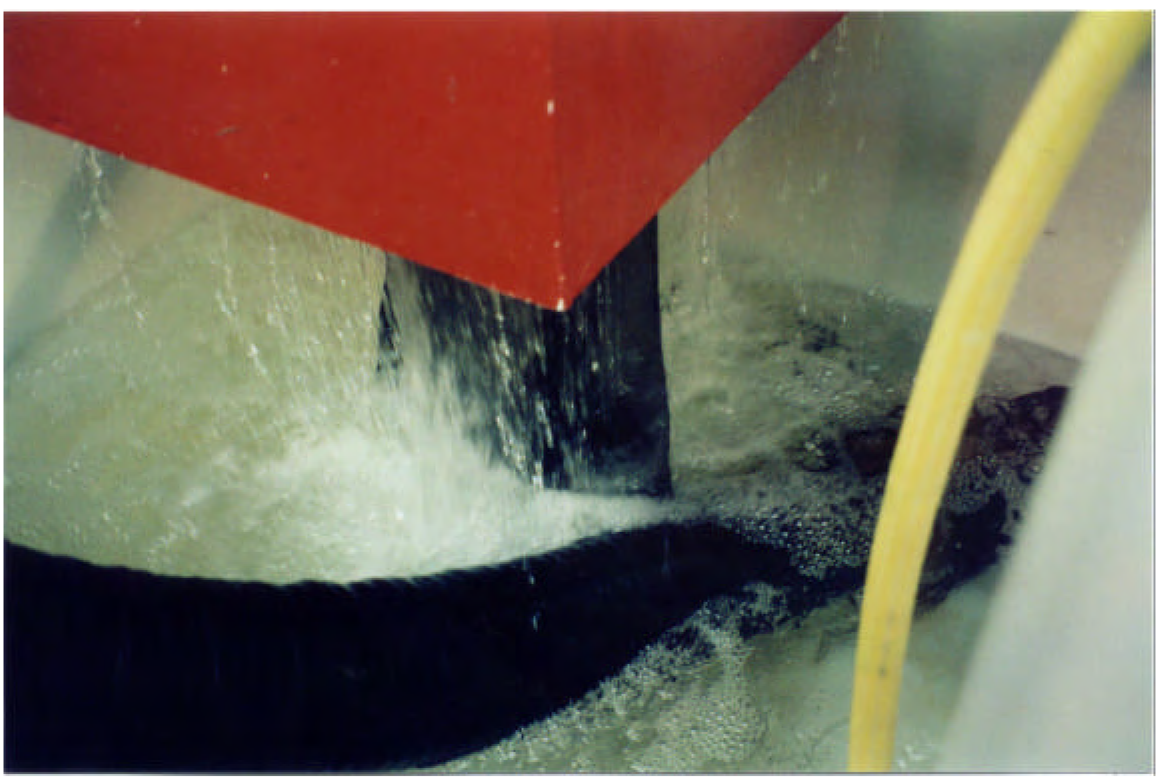
<u>Photo 6.</u>
Permanent flume pumps.

Photo 7.
Streamguard® mounted in simulated 18x24 catch basin.

Photo 8.
View of Streamguard® insert from below.

Photo 9.
Top view of the simulated catch basin grate. (Test in progress, looking downstream)

Photo 10.
Catch basin test in progress. (Drainage view)



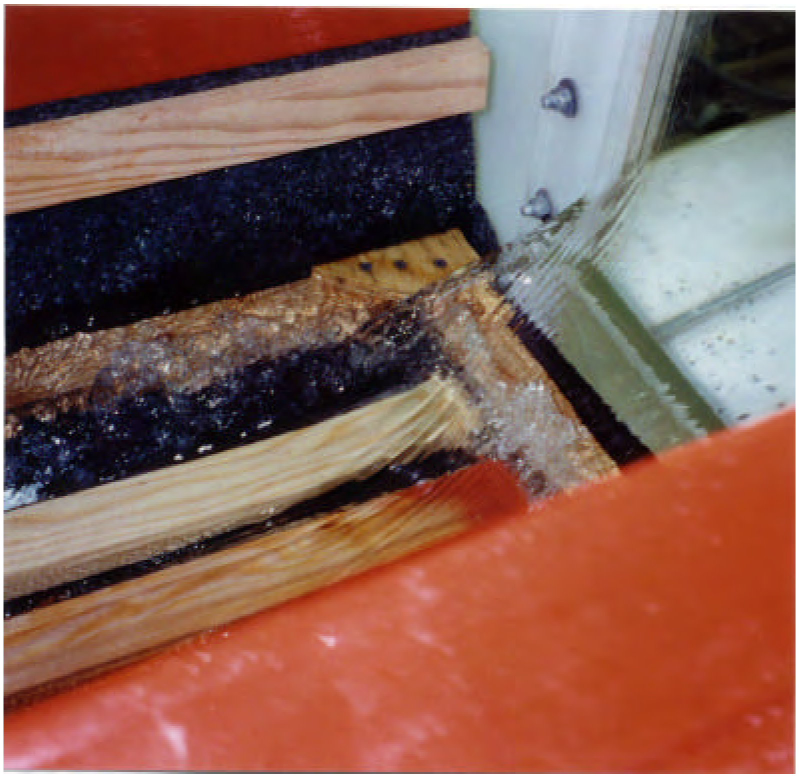
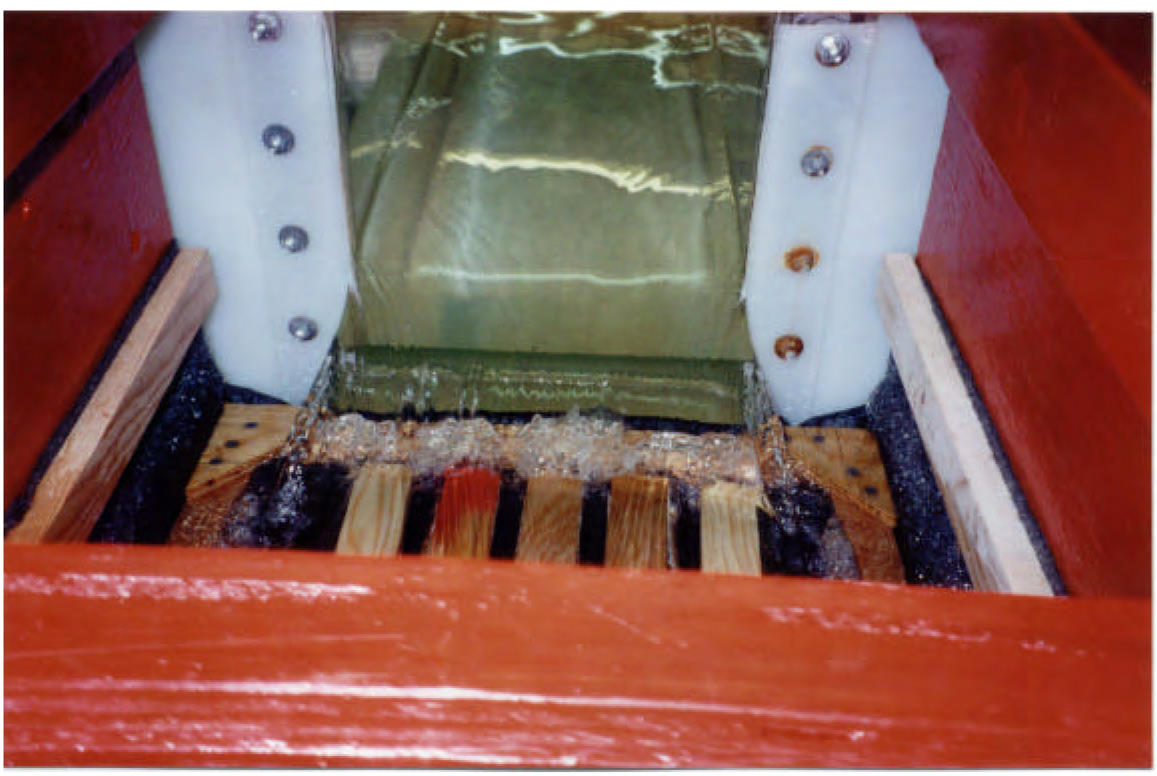


Photo 11.
Close up of catch basin flow test in progress.

Photo 12.
Close up of catch basin flow test in progress.



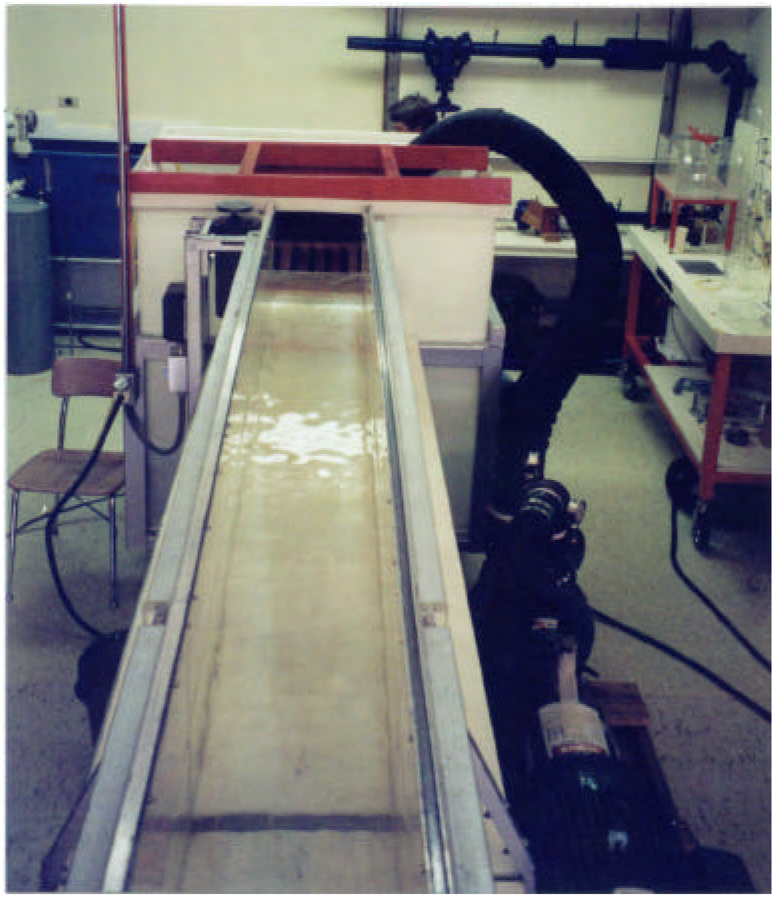
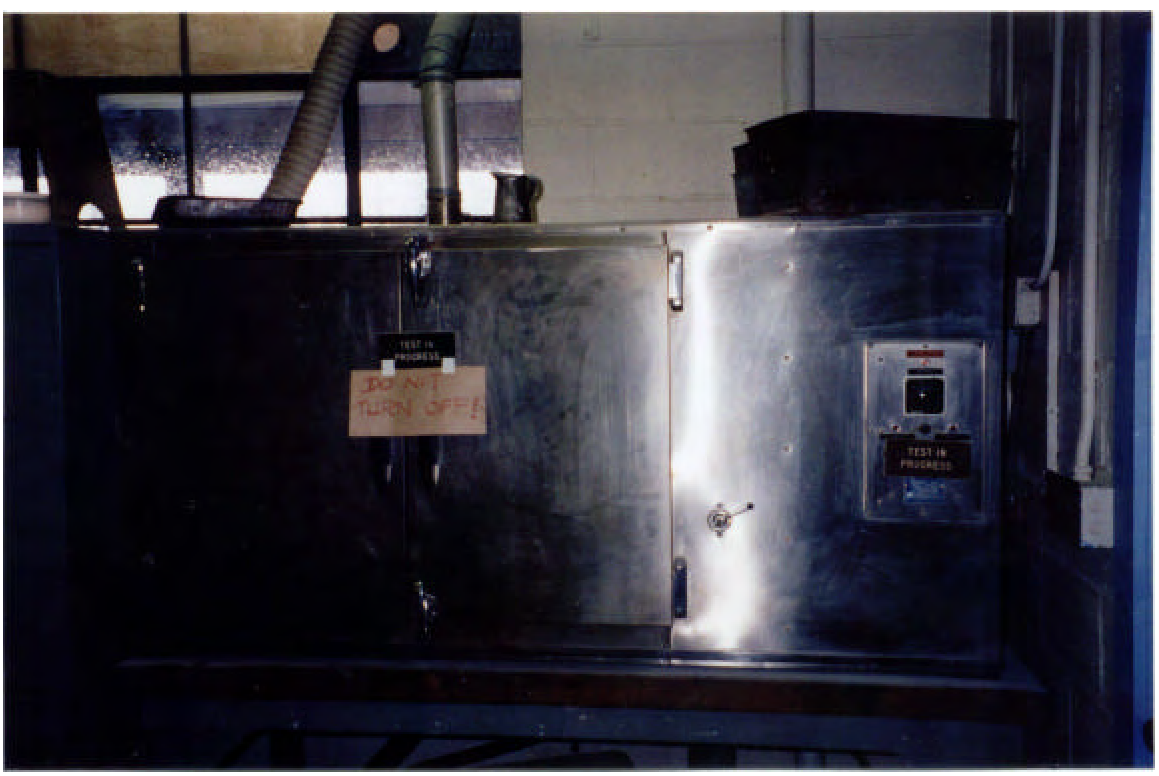


Photo 13.
Catch basin flow test in progress. (Looking downstream)

Photo 14.
Modern Lab Equipment oven, model 657-SS, used to dry sample bags after test.



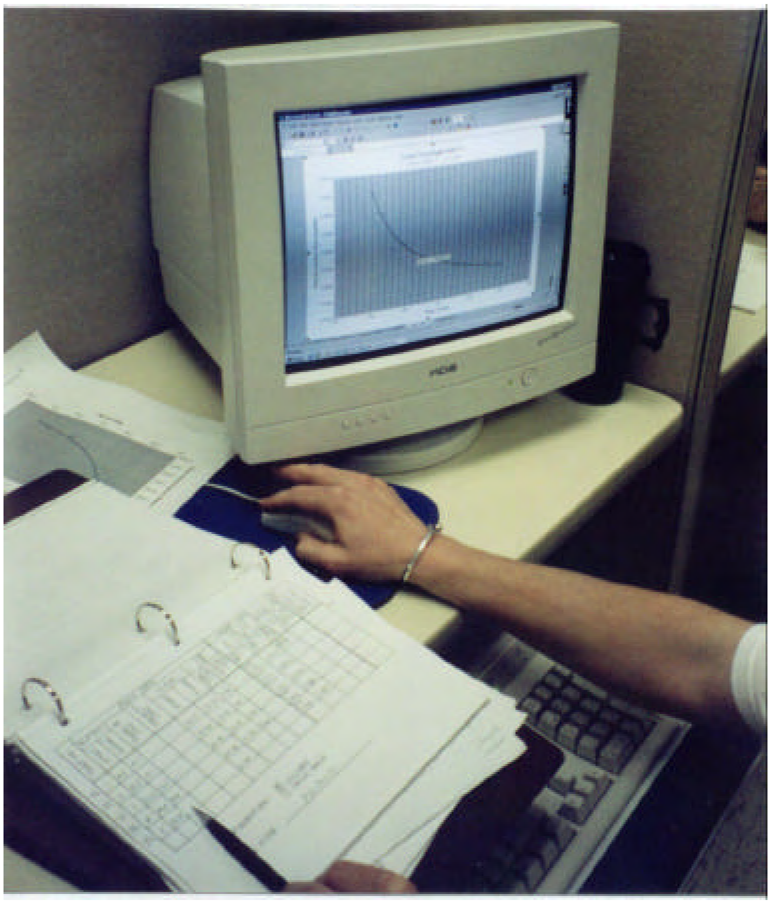
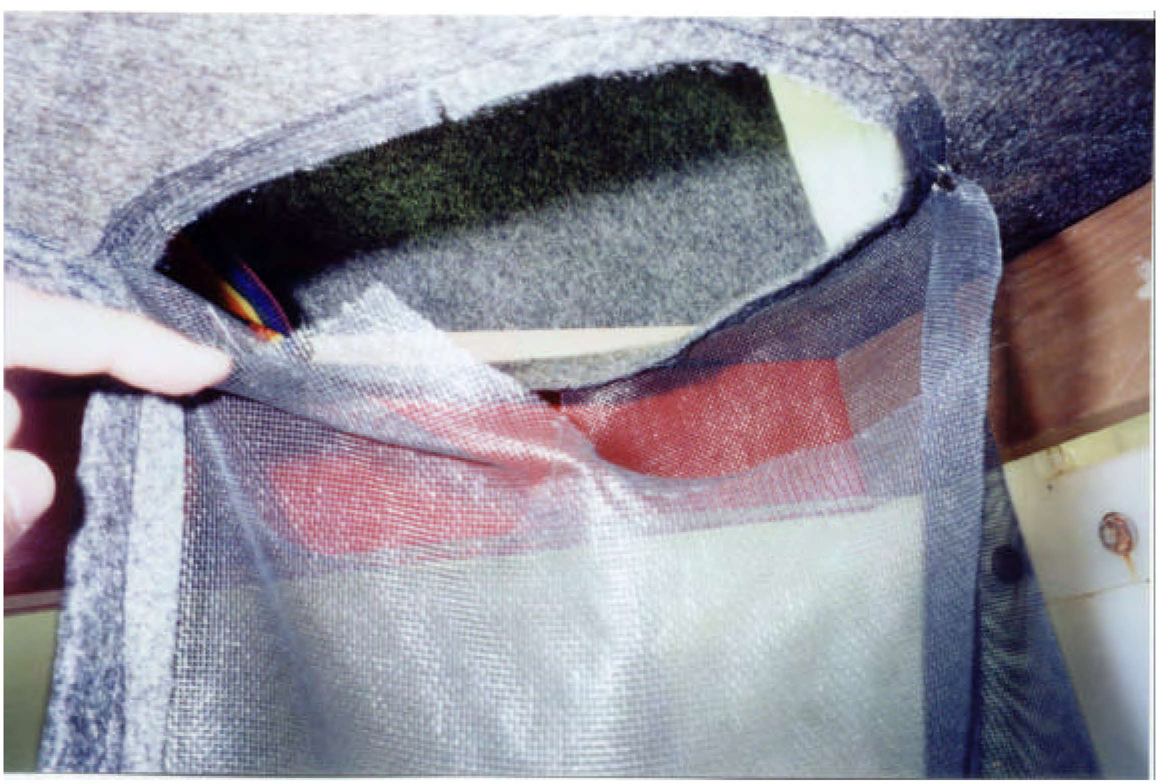


Photo 15.
Test results modeled by computerized curve fitting.

Photo 16.
Bag samples weighed on Ohaus 700 triple-beam balance.

Photo 17.
Failed catch basin insert after removal.

Photo 18.
Failed catch basin insert in place. (View from below)



<u>Photo 19.</u>
PAM chunks in catch basin insert.

<u>Photo 20.</u>
Snake-bag and 2-bags flat on bottom of flume during test.

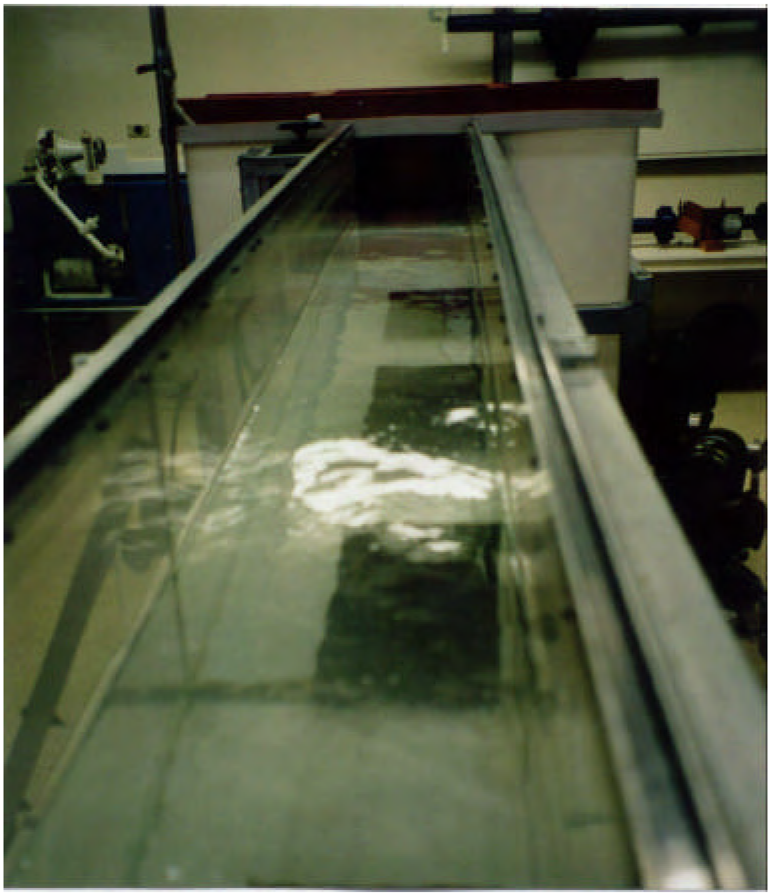
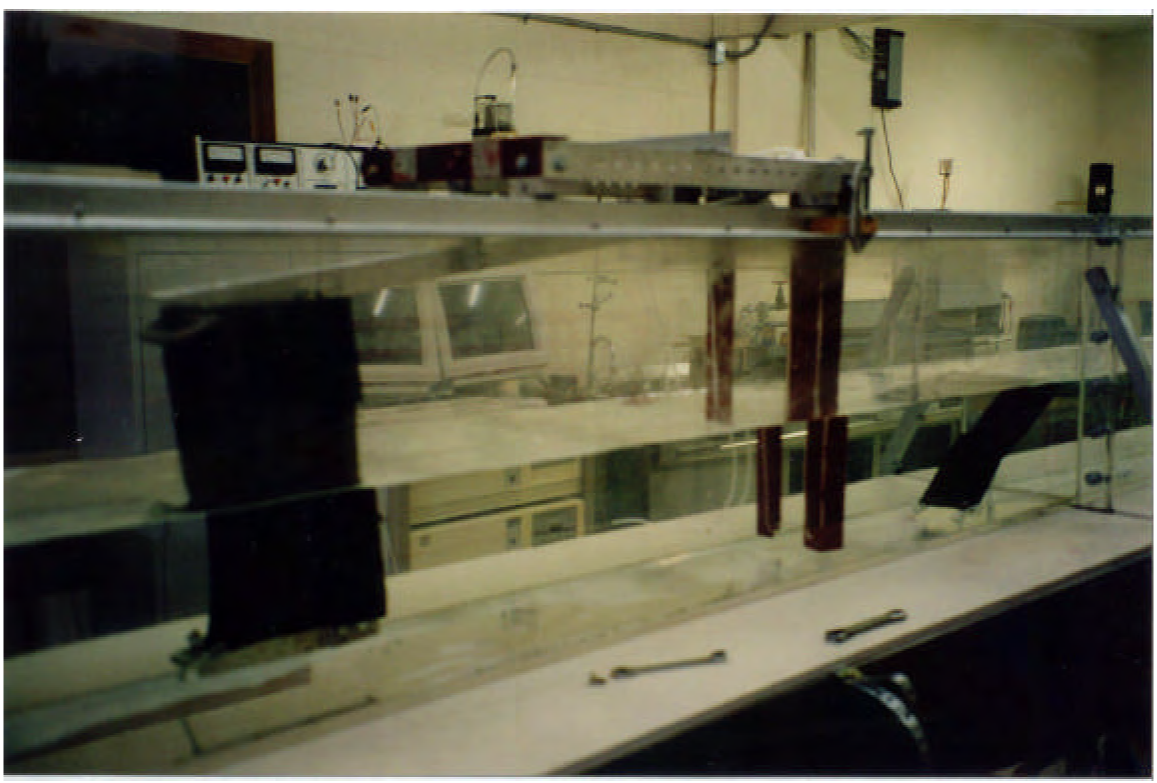


Photo 21.
4-bags flat on bottom of flume during test.

Photo 22.
Bag on "edge" and 1-bag flat on bottom of flume.



APPENDIX B

Procedure and Test Data

Polyacrylamide PAM Flocculent Dissolution Rate Testing
For An Experimental Passive Dosing System

Procedure:

Weighing:

1- Zero the scale. Weigh the plate. Record.
2- Weigh the plate and bag for the test. Record.
3- Weigh out about 1 pound (453.6 g) of PAM and pour into the porous bag. Staple top closed and weigh plate + bag filled with PAM. Record.

Flume:

[Culvert Setup]

4- Turn on pump combination to achieve desired flow. Measure the height of the water in the flume to get the flow rate. Record. Turn off pumps.
5- Attach the bag filled with PAM to the "culvert simulator " frame. Place frame in the flume and secure.
6- Turn on the same combination of pumps to achieve the desired flow. Record the start time. Measure the height of water flowing in the flume to verify the previous measurement. If different, record this new height.
7- Run the simulated culvert flow regime for 2 hours. During this time check the height of the water every 30 minutes. Record any change.
8- After 2 hours turn off the pump(s). Remove the bag, place in drying pan, and place in the drying oven. (Skip to drying procedures)

[Catch Basin Setup]

4- Turn on pump combination to achieve desired flow. Measure the height of the water in the flume to get the flow rate. Record.
5- Place the bag filled with PAM into the Streamguard™ insert. Then place the grate over the opening and push the "catch basin" into position just after the weir (at end of flume).
6- Record the start time. Measure the height of water flowing in the flume to verify the previous measurement. If different, record this new height.
7- Run this simulated catch basin regime for 2 hours. During this time check the height of the water every 30 minutes. Record any change.
8- After 2 hours turn off the pump(s). Remove the bag, place in drying pan, and place in the drying oven.

Drying:

9- The oven setting is 180° F.
10- Rotate the bag (w/PAM) after 12 hours of drying.
11- Remove the bag (w/PAM) after 72 hours of drying time. Zero the scale. Weigh and record.
12- Return the bag (w/PAM) to the oven.
13- Remove after 12 additional hours of drying time. Weigh and record.
14- Compute the difference between the weights (previous – current) divided by the previous weight. If this value is greater than 1.5% then the bag (w/PAM) is returned to the oven and procedure 13 and 14 are repeated until the value is equal to or less than 1.5%.

Equipment Used:

Scale: OHAUS Triple Balance Scale 700 series

Dryer: Modern Lab Equip. Model# 657-SS

Calculations:

Flow: $Q=K\sqrt{2g}\,LH^{3/2}$ where: $K=0.40 + 0.05\frac{H}{P}$ (**flow coef. of the weir)

g= 32.2 ft./s

L= 1ft (width of flume)

H= height of water above weir

P= height of weir= 6"

** Based on experimental work by Kindsvater, Carl E., R.W. Carter "Discharge Characteristics of Rectangular Thin-Plate Weirs." *Trans.* ASCE, 124 (1959)

Velocity: $V=\frac{Q}{A}$ where: Q= flow (cfs)

A= height of water x 1ft (width of flume)

Discharge: Total volume discharged (ft.^{3})= QT $\left(\frac{1hr}{3600\sec}\right)$

where: Q= flow (cfs)

T= time (hrs.)

Dissolution:

D-Rate $\left(\frac{mg}{liter}\right)$= $\dfrac{\text{(wt. of PAM before test – wt. of dry PAM after test)(1000mg/g)}}{\text{(Total volume Discharged)(28.316 liter/ft}^3\text{)}}$

Culvert - Phase 1

Culvert Test
Type of Bag: FW300T1

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Plate (g)	Bag + Plate (g)	Bag+PAM Plate (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
5/3/99	1	9.5	9.5	0.6853	0.5425	10:53	12:53	2.0	3905.894	20.9	59.2	510.8	451.0	38.9	0.35171	1
5/5/99	2	10.5	10.5	0.9214	0.8062	11:03	13:03	2.0	5804.975	20.8	59.3	530.2	473.1	36.3	0.22084	2
5/6/99	3	13.5	13.5	1.6301	1.8339	14:14	16:14	2.0	13204.05	20.6	59.6	529.9	464.2	45.1	0.12063	3
5/7/99	4	14	14	1.7473	2.0385	9:39	11:39	2.0	14677.27	28.1	69.5	524.1	452.3	43.7	0.10515	4
5/7/99	5	15	15	1.9807	2.4759	11:54	13:54	2.0	17826.29	20.6	59.4	521.9	457.5	43.8	0.08677	5

Culvert Test
Type of Bag: FW401T1

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Plate (g)	Bag + Plate (g)	Bag+PAM Plate (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
4/2/99	1	9.5	9.5	0.6853	0.5425	8:27	10:27	2.0	3906.0	16.5	46.5	495.3	437.9	40.9	0.36979	1
4/15/09	4	10	10	0.8031	0.6692	13:45	15:55	2.167	5220.1	27.8	56.6	507.5	437.6	42.1	0.28482	4
4/5/99	3	10.5	10.5	0.9214	0.8062	13:23	15:23	2.0	5805.0	16.5	45.3	488.9	442.6	29.8	0.18129	3
4/2/99	2	13.25	13.25	1.5714	1.7351	10:50	12:50	2.0	12492.9	16.5	45.7	494.8	443.8	34.5	0.09753	2
4/19/99	5	14.5	14.5	1.8641	2.2525	11:05	13:05	2.0	16218.1	28.0	56.4	509.9	439.3	42.6	0.09276	5

Culvert Test
Type of Bag: FW402T1

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Plate (g)	Bag + Plate (g)	Bag+PAM Plate (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
4/20/99	1	9.5	9.5	0.6853	0.5425	15:15	17:15	2.0	3905.894	28.0	58.6	520.5	466.1	37.4	0.33815	1
4/23/99	3	10.5	10.5	0.9214	0.8062	8:30	10:40	2.167	6288.723	20.7	52.3	506.2	446.0	39.5	0.22182	3
4/21/99	2	13.25	13.25	1.5714	1.7351	11:00	13:00	2.0	12492.85	28.0	60.6	532.9	463.4	41.5	0.11732	2
4/26/99	4	14	14	1.7473	2.0385	10:53	12:53	2.0	14677.27	27.7	59.1	524.0	457.3	39.0	0.09384	4
5/1/99	5	15	15	1.9807	2.4759	8:35	10:35	2.0	17826.29	20.8	51.8	516.8	456.1	39.9	0.07905	5

Culvert Test
Type of Bag: FW403T1

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Plate (g)	Bag + Plate (g)	Bag+PAM Plate (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
4/20/99	1	9.5	9.5	0.6853	0.5425	15:15	17:15	2.0	3906.0	28.0	65.4	522.0	458.7	35.3	0.31916	1
4/23/99	3	13.25	13.25	1.5714	1.7351	14:53	16:53	2.0	12492.9	28.0	65.5	520.1	456.8	35.3	0.09979	3
4/23/99	2	10.5	10.5	0.9214	0.8062	8:30	10:40	2.0	5805.0	20.7	58.8	511.2	469.6	30.9	0.18799	2
5/4/99	5	14	14	1.7473	2.0385	15:10	17:15	2.08	15264.4	28.2	64.9	521.8	458.5	35.1	0.08121	5
5/1/99	4	15	15	1.9807	2.4759	10:50	12:50	2.0	17826.3	20.1	57.6	511.3	449.9	41.3	0.08182	4

Culvert Test
Type of Bag: FW500T1

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Plate (g)	Bag + Plate (g)	Bag+PAM Plate (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
5/3/99	5	9.5	9.5	0.6853	0.5425	10:53	12:53	2.0	3906.0	20.9	54.0	511.8	452.3	38.6	0.34900	5
4/15/99	1	10	10	0.8031	0.6692	13:45	15:55	2.0	4818.5	27.8	59.5	513.6	446.0	39.8	0.29170	1
4/21/99	2	13.25	13.25	1.5714	1.7351	11:00	13:00	2.0	12492.9	28.0	60.8	514.3	449.2	37.1	0.10488	2
4/24/99	4	14	14	1.7473	2.0385	11:00	13:00	2.0	14677.3	20.8	53.1	536.0	476.6	38.6	0.09288	4
4/23/99	3	15	15	1.9807	2.4759	11:00	13:00	2.0	17826.3	20.8	54.5	525.2	464.8	39.6	0.07845	3

Catch-Basin - Phase 1

Catch-Basin Test
Type of Bag: FW300T2

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Plate (g)	Bag + Plate (g)	Bag+PAM Plate (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
5/14/99	1	7.875	7.875	0.3139	0.2060	8:18	10:28	2.167	1606.8	13.8	47.8	500.7	445.5	41.4	0.90991	1
5/14/99	2	9.375	9.375	0.6559	0.5125	15:05	17:05	2.0	3689.6	14.0	45.0	505.6	441.1	50.5	0.48336	2
5/15/99	3	10.5	10.5	0.9214	0.8062	7:08	9:08	2.0	5805.0	7.0	38.7	502.2	450.0	45.2	0.27498	3
6/8/99	4	13	13	1.5126	1.6387	20:46	22:46	2.0	11798.6	13.8	46.4	512.6	438.5	60.3	0.18049	4

Catch-Basin Test
Type of Bag: FW401T2

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Plate (g)	Bag + Plate (g)	Bag+PAM Plate (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
5/28/99	3	7.875	7.875	0.3139	0.2060	8:35	10:35	2.0	1483.2	13.8	39.8	498.0	441.6	42.6	1.01431	3
5/18/99	2	9.375	9.375	0.6559	0.5125	17:32	19:32	2.0	3689.6	14.0	39.9	514.2	447.7	52.5	0.50251	2
5/15/99	1	10.5	10.5	0.9214	0.8062	9:08	11:08	2.0	5805.0	13.9	38.6	496.8	426.7	56.2	0.34190	1
6/3/99	4	13	13	1.5126	1.6387	19:30	21:30	2.0	11798.6	7.1	32.2	486.4	421.8	57.5	0.17211	4

Catch-Basin Test
Type of Bag: FW402T2

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Plate (g)	Bag + Plate (g)	Bag+PAM Plate (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
5/28/99	3	7.875	7.875	0.3139	0.2060	10:35	12:35	2.0	1483.2	13.9	40.9	498.3	443.7	40.7	0.96907	3
5/22/99	2	9.375	9.375	0.6559	0.5125	10:06	12:06	2.0	3689.6	13.9	41.3	499.3	441.6	43.8	0.41923	2
5/15/99	1	10.5	10.5	0.9214	0.8062	11:08	13:08	2.0	5805.0	13.7	42.2	520.6	451.7	55.2	0.33582	1
6/3/99	4	13	13	1.5126	1.6387	21:31	23:31	2.0	11798.6	7.0	32.9	488.2	430.9	50.3	0.15056	4

Catch-Basin Test
Type of Bag: FW403T2

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Plate (g)	Bag + Plate (g)	Bag+PAM Plate (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
5/28/99	3	7.875	7.875	0.3139	0.2060	12:36	14:36	2.0	1483.2	7.1	40.0	497.1	443.9	46.1	1.09764	3
5/22/99	2	9.375	9.375	0.6559	0.5125	12:07	14:07	2.0	3689.6	7.1	42.6	502.2	449.9	45.2	0.43264	2
5/22/99	1	10.5	10.5	0.9214	0.8062	6:05	8:05	2.0	5805.0	6.9	43.1	501.6	448.2	46.5	0.28289	1
6/5/99	4	13	13	1.5126	1.6387	5:50	7:50	2.0	11798.6	7.0	41.3	495.0	439.5	48.5	0.14517	4

Catch-Basin Test
Type of Bag: FW500T2

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Plate (g)	Bag + Plate (g)	Bag+PAM Plate (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
5/29/99	3	7.875	7.875	0.3139	0.2060	6:42	8:42	2.0	1483.2	13.9	41.0	507.6	449.0	44.7	1.06431	3
5/28/99	2	9.375	9.375	0.6559	0.5125	6:35	8:35	2.0	3689.6	7.0	36.1	503.5	447.7	48.8	0.46709	2
5/22/99	1	10.5	10.5	0.9214	0.8062	8:05	10:05	2.0	5805.0	6.9	37.5	495.1	428.6	59.6	0.36259	1
6/5/99	4	13	13	1.5126	1.6387	7:51	9:51	2.0	11798.6	7.2	35.0	490.6	444.9	38.5	0.11524	4

Culvert - Phase 2

Culvert Test
Type of PAM: 9832A

	Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bag (g)	Bag+PAM (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
1	8/23/99	1	7.875	7.875	0.3139	0.2060	14:50	16:53	2.0	1483.225	32.7	493.4	447.1	46.3	1.10241	1
2	8/26/99	2	9.375	9.375	0.6559	0.5125	12:00	14:00	2.0	3689.647	33.8	496.2	447.6	48.6	0.46518	2
3	9/13/99	3	10.375	10.375	0.8918	0.7710	8:09	10:09	2.0	5551.54	32.8	512.2	463.5	48.7	0.30980	3
4	9/24/99	4	12.875	12.875	1.4832	1.5914	9:27	11:27	2.0	11457.92	32.8	497.0	448.6	48.4	0.14918	4
5	9/24/99	5	14.0	14.0	1.7473	2.0385	16:48	18:48	2.0	14677.27	31.9	499.9	450.9	49.0	0.11790	5
6	9/25/99	6	15.0	15.0	1.9807	2.4759	9:05	11:05	2.0	17826.29	32.9	496.2	447.4	48.8	0.09668	6

Culvert Test
Type of PAM: 9835A

	Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bag (g)	Bag+PAM (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
1	8/23/99	1	7.875	7.875	0.3139	0.2060	14:50	16:53	2.0	1483.2	31.8	494.6	447.4	47.2	1.12384	1
2	8/26/99	2	9.375	9.375	0.6559	0.5125	12:00	14:00	2.0	3689.6	33.2	498.9	448.9	50.0	0.47858	2
3	9/15/99	3	10.25	10.375	0.8770	0.7537	7:50	9:50	2.0	5426.5	32.4	489.9	443	46.9	0.30522	3
4	9/24/99	4	12.875	12.875	1.4832	1.5914	11:30	13:30	2.0	11457.9	32.9	531.5	478.8	52.7	0.16243	4
5	9/24/99	5	14.0	14.0	1.7473	2.0385	16:48	18:48	2.0	14677.3	33.5	492.9	443.6	49.3	0.11862	5
6	9/27/99	6	15.0	15.0	1.9807	2.4759	7:27	9:27	2.0	17826.3	33.5	487.6	440	47.6	0.09430	6

Culvert Test
Type of PAM: 9836A

	Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bag (g)	Bag+PAM (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
1	8/23/99	1	7.875	7.875	0.3139	0.2060	12:11	14:11	2.0	1483.225	32.8	501.0	456.7	44.3	1.05479	1
2	9/1/99	2	9.375	9.375	0.6559	0.5125	8:34	10:34	2.0	3689.647	33.4	494.0	450.0	44.0	0.42115	2
3	9/15/99	3	10.25	10.375	0.8770	0.7537	10:05	12:05	2.0	5426.521	32.4	484.5	440.9	43.6	0.28375	3
4	9/24/99	4	12.875	12.875	1.4832	1.5914	14:13	16:13	2.0	11457.92	32.2	492.1	445.6	46.5	0.14332	4
5	9/25/99	5	14.0	14.0	1.7473	2.0385	7:00	9:00	2.0	14677.27	34.4	484.5	439.7	44.8	0.10780	5
6	9/27/99	6	15.0	15.0	1.9807	2.4759	9:50	11:50	2.0	17826.29	33.1	488.6	443.1	45.5	0.09014	6

Culvert Test
Type of PAM: 9837A

	Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bag (g)	Bag+PAM (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
1	8/23/99	1	7.875	7.875	0.3139	0.2060	12:11	14:11	2.0	1483.2	33.5	495.7	454.6	41.1	0.97859	1
2	9/8/99	2	9.375	9.375	0.6559	0.5125	7:14	9:14	2.0	3689.6	32.0	497.0	457.4	39.6	0.37903	2
3	9/15/99	3	10.376	10.375	0.8918	0.7710	12:20	14:20	2.0	5551.5	32.6	492.0	450.0	42.0	0.26718	3
4	9/24/99	4	12.875	12.875	1.4832	1.5914	14:13	16:13	2.0	11457.9	32.5	487.9	444.8	43.1	0.13284	4
5	9/25/99	5	14.0	14.0	1.7473	2.0385	7:00	9:00	2.0	14677.3	34.9	495.6	453.1	42.5	0.10226	5
6	9/27/99	6	15.0	15.0	1.9807	2.4759	12:17	14:17	2.0	17826.3	32.0	482.0	440.3	41.7	0.08261	6

Catch-Basin - Phase 2

Catch-Basin Test

Type of PAM: 9832A

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bag (g)	Bag+PAM (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
8/26/99	1	7.875	7.875	0.3139	0.2060	9:35	11:35	2.0	1483.2	29.7	492.4	444.3	48.1	1.14627	1
8/26/99	2	9.375	9.375	0.6559	0.5125	11:47	13:47	2.0	3689.6	28.0	484.7	435.9	48.8	0.46709	2
9/13/99	3	10.375	10.375	0.8918	0.7710	7:58	9:58	2.0	5551.5	30.5	490.5	439.5	51.0	0.32443	3
10/6/99	4	12.875	12.875	1.4832	1.5914	7:42	9:42	2.0	11457.9	30.9	492.6	437.8	54.8	0.16891	4

Catch-Basin Test

Type of PAM: 9835A

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bag (g)	Bag+PAM (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
8/23/99	1	7.875	7.875	0.3139	0.2060	16:16	18:17	2.0	1483.2	27.1	501.5	452.5	49.0	1.16669	1
8/26/99	2	9.375	9.375	0.6559	0.5125	13:52	15:52	2.0	3689.6	29.7	492.4	439.2	53.2	0.50921	2
9/15/99	3	10.25	10.375	0.8770	0.7537	7:45	9:45	2.0	5426.5	29.8	493.8	441.0	52.8	0.34362	3
10/6/99	4	12.875	12.875	1.4832	1.5914	10:45	0:45	2.0	11457.9	30.0	485.9	432.5	53.4	0.16459	4

Catch-Basin Test

Type of PAM: 9836A

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bag (g)	Bag+PAM (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
8/23/99	1	7.875	7.875	0.3139	0.2060	12:10	14:10	2.0	1483.2	30.0	503.7	445.1	58.6	1.39527	1
9/1/99	2	9.375	9.375	0.6559	0.5125	8:34	10:34	2.0	3689.6	30.2	494.1	440.7	53.4	0.51112	2
9/15/99	3	10.25	10.375	0.8770	0.7537	10:02	12:02	2.0	5426.5	31.4	486.9	435.5	51.4	0.33451	3
10/8/99	4	12.875	12.875	1.4832	1.5914	13:54	15:54	2.0	11457.9	30.1	481.1	428.5	52.6	0.16212	4

Catch-Basin Test

Type of PAM: 9837A

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bag (g)	Bag+PAM (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rate (mg/liter)	Test #
8/23/99	1	7.875	7.875	0.3139	0.2060	14:11	16:13	2.0	1483.2	29.8	492.9	451.0	41.9	0.99764	1
9/8/99	2	9.375	9.375	0.6559	0.5125	7:06	9:06	2.0	3689.6	31.2	500.4	453.3	47.1	0.45082	2
9/15/99	3	10.375	10.375	0.8918	0.7710	12:18	14:18	2.0	5551.5	30.0	489.7	438.5	51.2	0.32571	3
10/9/99	4	12.875	12.875	1.4832	1.5914	12:34	14:34	2.0	11457.9	30.6	487.0	437.7	49.3	0.15195	4

Culvert - Phase 3

Culvert Test
Configuration: Bag on Edge

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bag (g)	Bag+PAM (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rates (mg/liter)	PAM Dissolution Rates (mg/liter)per lb. PAM	Test #
1/15/00	1	7.875	7.875	0.3139	0.2060	11:00	13:00	2.0	1483.2	32.9	492.9	449.3	43.6	1.038	1.024	1
1/17/00	7	10.375	10.375	0.8918	0.7710	7:59	9:59	2.0	5551.5	31.8	487.3	446.7	40.6	0.2583	0.2572	7
1/15/00	10	15.0	15.0	1.9807	2.4759	8:37	10:37	2.0	17826.3	32.9	485.5	441.5	44	0.0872	0.0874	10
FW500																
12/21/99	FW500	10.375	10.375	0.8918	0.7710	7:12	9:12	2.0	5551.5	33.7	487.7	440.5	47.2	0.3003	0.3000	7
12/22/99	FW500	15.0	15.0	1.9807	2.4759	9:31	11:31	2.0	17826.3	33.2	486.5	439.6	46.9	0.0929	0.0930	10

Culvert Test
Configuration: 1 Bag on Bottom

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bag (g)	Bag+PAM (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rates (mg/liter)	PAM Dissolution Rates (mg/liter)per lb. PAM	Test #
1/15/00	1	7.875	7.875	0.3139	0.2060	11:00	13:00	2.0	1483.2	35.5	494.8	450.4	44.4	1.057	1.044	1
1/17/00	7	10.375	10.375	0.8918	0.7710	7:59	9:59	2.0	5551.5	33.0	489.6	448.7	40.9	0.2602	0.2585	7
1/15/00	10	15.0	15.0	1.9807	2.4759	8:37	10:37	2.0	17826.3	32.8	482.7	439.3	43.4	0.0860	0.0867	10
FW500																
12/21/99	FW500	10.375	10.375	0.8918	0.7710	7:12	9:12	2.0	5551.5	34.3	488	440.9	47.1	0.2998	0.2986	7
12/22/99	FW500	15.0	15.0	1.9807	2.4759	9:31	11:31	2.0	17826.3	33	487.4	439.6	47.8	0.0947	0.0945	10

Culvert Test
Configuration: 2 Bags on Bottom

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bags (g)	Bags+PAM (g)	Dried Bags+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rates (mg/liter)	PAM Dissolution Rates (mg/liter)per lb. PAM	Test #
1/15/00	2	7.875	7.875	0.3139	0.2060	13:38	15:38	2.0	1483.2	65.3	978.6	892.2	86.4	2.057	1.022	2
1/17/00	8	10.375	10.375	0.8918	0.7710	10:38	12:38	2.0	5551.5	65.4	969.5	887.3	82.2	0.523	0.2623	8
1/13/00	11	15.0	15.0	1.9807	2.4759	13:22	15:22	2.0	17826.3	65.7	973	890.2	82.8	0.164	0.0820	11

Culvert Test
Configuration: 4 Bags on Bottom

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bags (g)	Bags+PAM (g)	Dried Bags+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rates (mg/liter)	PAM Dissolution Rates (mg/liter)per lb. PAM	Test #
1/25/00	2	7.875	7.875	0.3139	0.2060	12:11	14:11	2.0	1483.2	140.0	1988.8	1824.4	164.4	3.914	0.9604	2
1/21/00	9	10.375	10.375	0.8918	0.7710	10:33	12:33	2.0	5551.5	130.7	1964.6	1801.9	162.7	1.035	0.2560	9
1/13/00	12	15.0	15.0	1.9807	2.4759	10:41	12:41	2.0	17826.3	130.4	1968.0	1800.0	168.0	0.3328	0.0822	12

Culvert Test
Configuration: Snake Bag

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bag (g)	Bag+PAM (g)	Dried Bag+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rates (mg/liter)	PAM Dissolution Rates (mg/liter)per lb. PAM	Test #
1/15/00	2	7.875	7.875	0.3139	0.2060	13:38	15:38	2	1483.2	51.5	1704	1556.1	147.9	3.522	0.9666	2
1/17/00	8	10.375	10.375	0.8918	0.7710	10:38	12:38	2	5551.5	53.7	2133.3	1962.2	171.1	1.088	0.2374	8
1/13/00	11	15.0	15.0	1.9807	2.4759	13:22	15:22	2	17826.3	51.6	1612.2	1473.0	139.2	0.276	0.0802	11

Catch-Basin - Phase 3

Catch-Basin Test
Configuration: 2-Bags in Streamguard

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bags (g)	Bags+PAM (g)	Dried Bags+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rates (mg/liter)	PAM Dissolution Rates (mg/liter)per lb. PAM	Test #
1/15/00	1	7.875	7.875	0.3139	0.2060	11:00	13:00	2	1483.2	54.1	972.7	880.7	92.0	2.191	1.082	1
1/18/00	4	9.375	9.375	0.6559	0.5125	13:00	15:00	2	3689.6	54.3	981.5	892.0	89.5	0.8567	0.4191	4
1/17/00	7	10.375	10.375	0.8918	0.7710	7:59	9:59	2	5551.5	55.4	973.6	884.6	89.0	0.5662	0.2797	7
FW500																
12/21/99	FW500	9.375	9.375	0.6559	0.5125	12:15	14:15	2	3689.6	61.2	967.7	869.4	98.3	0.9409	0.4708	4
12/21/99	FW500	10.375	10.375	0.8918	0.7710	9:31	11:31	2	5552	62.0	969.5	870.3	99.2	0.6311	0.3154	4

Catch-Basin Test
Configuration: 4-Bags in Streamguard

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Bags (g)	Bags+PAM (g)	Dried Bags+PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rates (mg/liter)	PAM Dissolution Rates (mg/liter)per lb. PAM	Test #
1/15/00	2	7.875	7.875	0.3139	0.2060	13:38	15:38	2	1483.2	109.8	1974.3	1804.0	170.3	4.055	0.988	2
1/18/00	5	9.375	9.375	0.6559	0.5125	15:01	17:01	2	3689.6	109.1	1957.0	1782.4	174.6	1.671	0.4102	5
1/17/00	8	10.375	10.375	0.8918	0.7710	10:38	12:38	2	5551.5	113.5	1958.6	1788.4	170.2	1.083	0.2662	8

Catch-Basin Test
Configuration: PAM Cubes

Date	Test #	H+P (in) Start	H+P (in) Finish	Velocity (ft/s)	Flow, Q(cfs)	Clock Start	Clock Finish	Time (hrs)	Volume QxT (Ft^3)	Streamguard (g)	Streamguard plus PAM (g)	Dried Streamguard plus PAM (g)	Amount Of Dissolved PAM (g)	PAM Dissolution Rates (mg/liter)	PAM Dissolution Rates (mg/liter)per lb. PAM	Test #
1/25/00	3	7.875	7.875	0.3139	0.2060	13:10	15:10	2	1483.2	362.4	819.7	790.1	29.6	0.7048	0.699	3
12/24/99	6	9.375	9.375	0.6559	0.5125	12:42	14:42	2	3689.6	364.8	830.8	733.6	97.2	0.9304	0.9056	6
1/21/00	9	10.375	10.375	0.8918	0.7710	10:33	12:33	2	5551.5	307.1	767.4	727.5	39.9	0.2538	0.2501	9