BMP Performance Expectation Functions- A Simple Method for Evaluating Stormwater Treatment BMP Performance Data

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Background

- Many agencies are struggling with processes on reviewing and approving BMPs
- Treatment guidelines are simplistic and create confusion as to how to evaluate BMP performance
- The end result can be misuse (or no use) of BMPs

Typical Guidelines

- Percent Removal
- Load Reduction
- Effluent based guidelines

80% TSS 60% TP 40% TN

Percent Removal

- High percent removals do not guarantee good performance
  - 90% oil removal
- Low percent removals do not necessarily mean poor performance
  - 20 mg/l in and 20 mg/l out is a zero percent removal yet does not mean bad performance

Effluent Based Guidelines

- It is reasonable to expect passive BMP's to meet strict standards?
  - Wastewater Treatment Plants
- Do effluent based guidelines imply higher levels of monitoring and compliance?

Annual Load Reduction

- A high annual load reduction does not necessarily mean clean water
  - One storm transports a massive load while EMC's remain high
- A low annual load reduction does not necessarily mean poor performance
  - Clean Sites

Baseline Concentrations

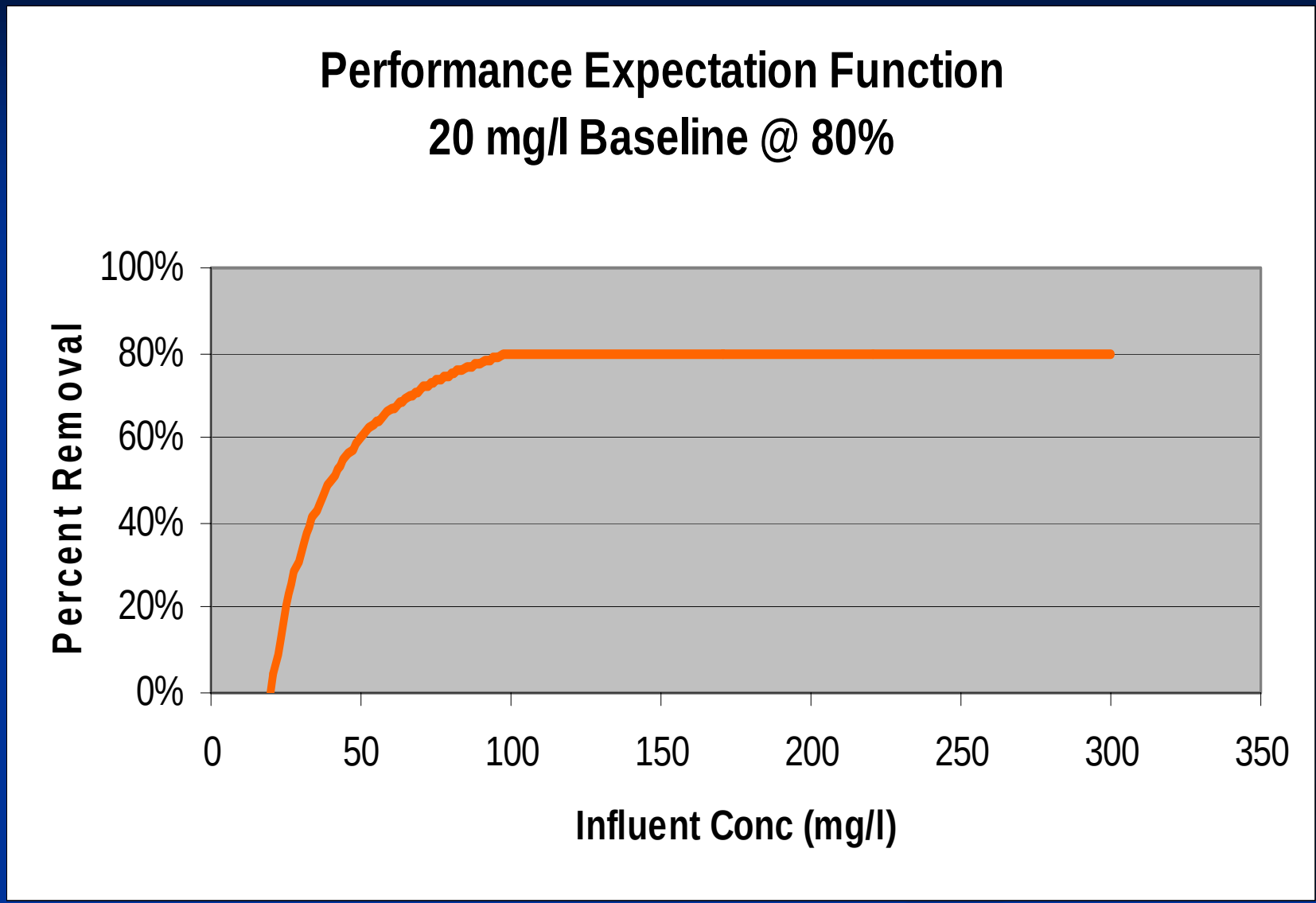
- Many water quality professional recognize that there are irreducible concentrations
  - 20 mg/l is frequently recognized
- Should this be considered a baseline concentration?

Performance Expectation Functions

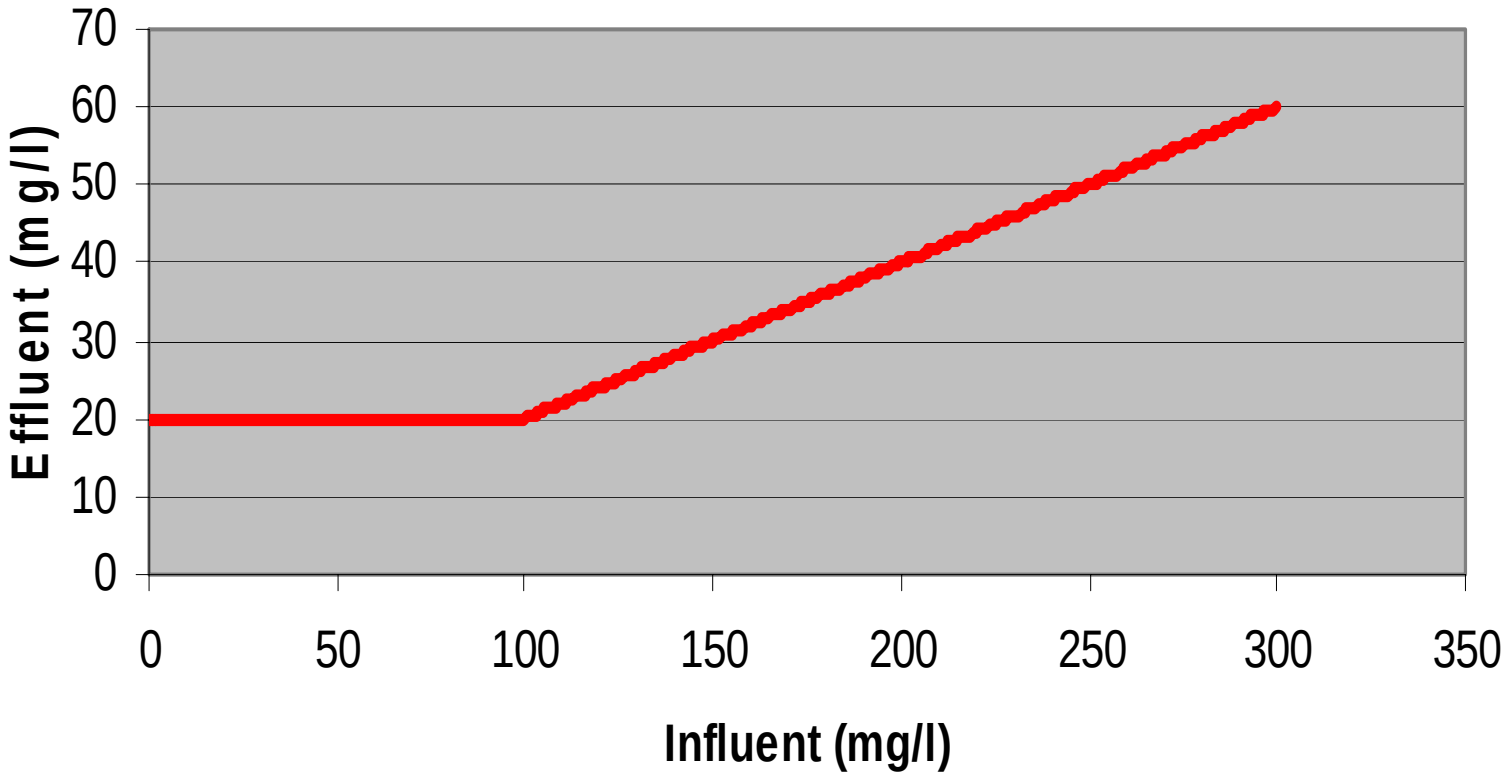
- Allows for a regulatory definition of the how a BMP should perform for a pollutant parameter
- Recognizes baseline concentrations
- Allows for both percent removal and load based review of BMP performance
- Unlike regression, this method tests how well the data fit the line vs. how the line fits the data

Example Using TSS

- Use a baseline concentration of 20 mg/l
- For concentrations less than or equal to100 mg/l the effluent guideline is 20 mg/l
- For concentrations greater than 100 mg/l the expected effluent is 80% of the influent.


Performance Expectation Function
20 mg/l Baseline @ 80%
Percent Removal
100%
80%
60%
40%
20%
0%
0
50
100
150
200
250
300
350
Influent Conc (mg/l)

Performance Expectation Curve - Influent vs. Effluent

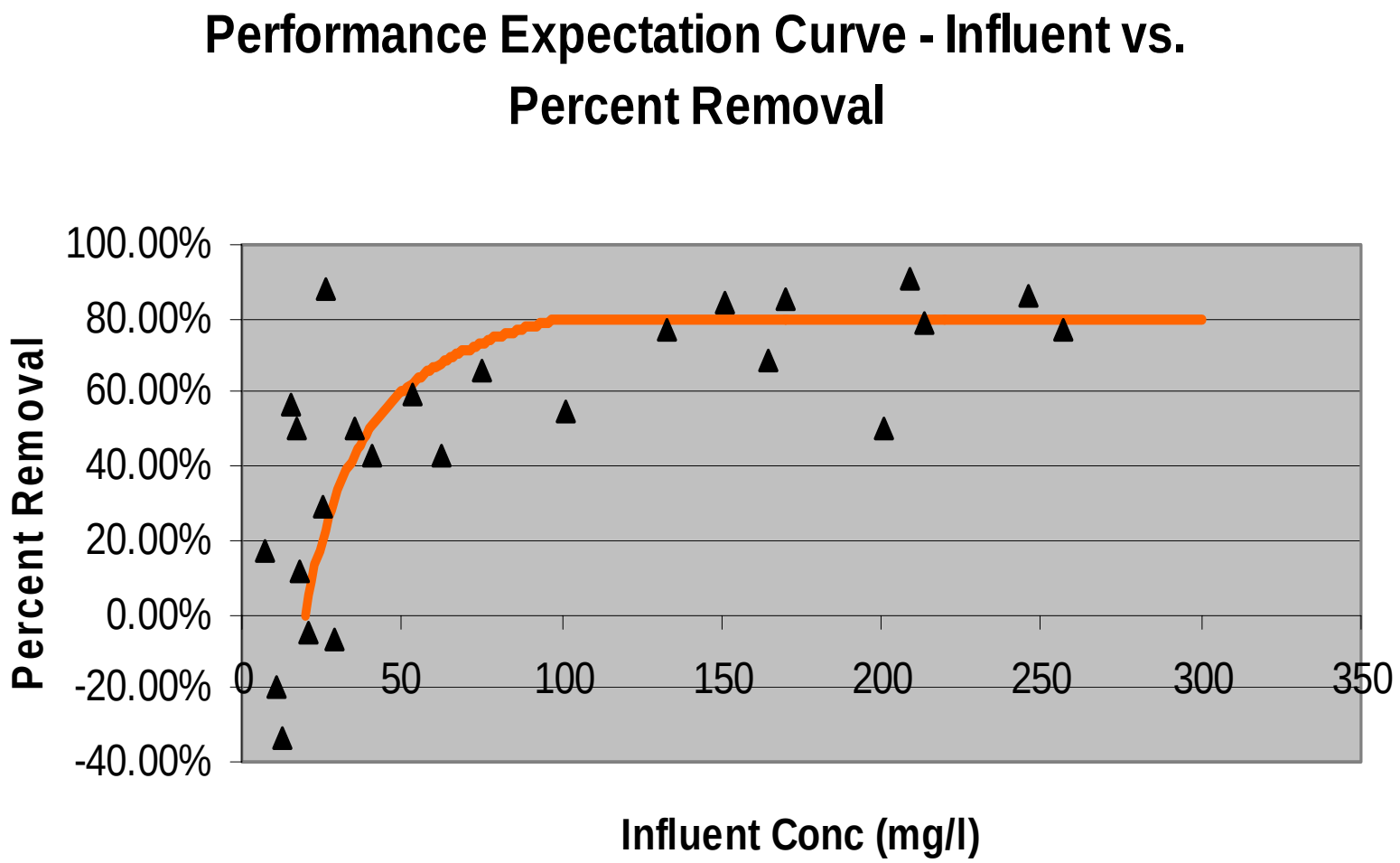


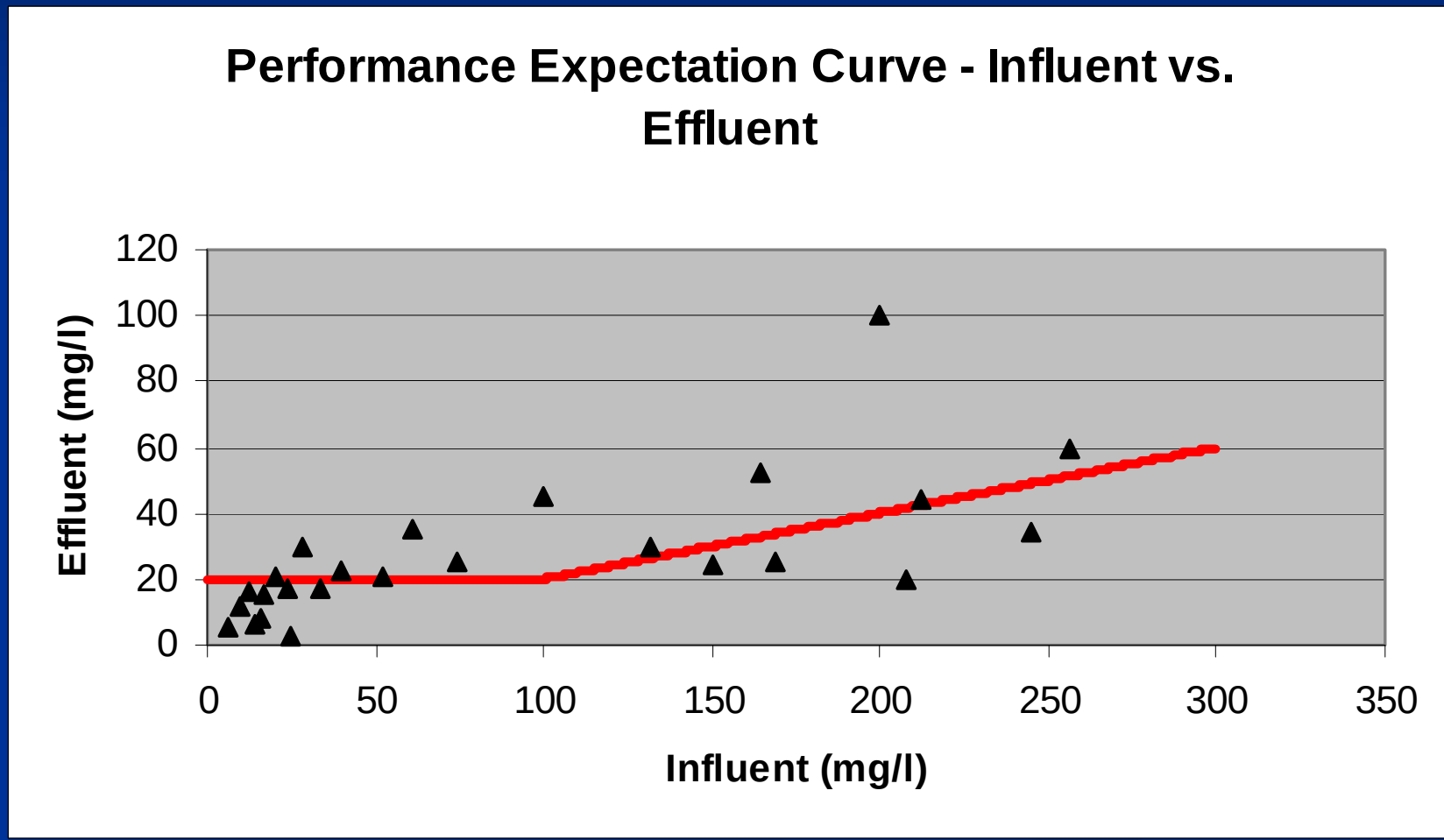
Data Set

- Example Data Only

Influent	Expected Effluent	Expected Percent removal	Observed Effluent	Observed Percent Removal
6	20	0.00%	5	16.67%
10	20	0.00%	12	-20.00%
12	20	0.00%	16	-33.33%
14	20	0.00%	6	57.14%
16	20	0.00%	8	50.00%
17	20	0.00%	15	11.76%
20	20	0.00%	21	-5.00%
24	20	16.67%	17	29.17%
25	20	20.00%	3	88.00%
28	20	28.57%	30	-7.14%
34	20	41.18%	17	50.00%

Data Set


Performance Expectation Curve - Influent vs. Percent Removal
Percent Removal
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
-20.00%
-40.00%
0
50
100
150
200
250
300
350
Influent Conc (mg/l)


Performance Expectation Curve - Influent vs. Effluent
Effluent (mg/l)
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
Influent (mg/l)

Sign Test

- Use a simple binomial test to establish the probability of the data being:
  - On the line
  - Above the line
  - Below the line
- Assume 50% of the points above and 50% below

$$P(X) = \frac{n!}{(n-X)!X!} \cdot p^X \cdot q^{n-X}$$

Sign Test Applied to Example

- 13 points above the line, 12 below
- Probability of occurrence is 50%, therefore accept that BMP meets the PEF
- If 17 below and 8 above there is only a 5% chance of occurrence, therefore reject that the BMP meets the line

Mass Load Balance Calculations

Influent mg/l	Expected Effluent Mg/l	Expected Percent removal	Observed Effluent Mg/l	Observed Percent Removal	Volume (liters)	Mass IN (mg)	Effluent Mass Observed	Effluent Mass Expected	Mass Remove Observed - Expected
6	20	0.0%	5	17%	2000	1.20E+04	1.00E+04	4.00E+04	-3.00E+04
10	20	0.0%	12	-20%	500	5.00E+03	6.00E+03	1.00E+04	-4.00E+03
12	20	0.0%	16	-33%	300	3.60E+03	4.80E+03	6.00E+03	-1.20E+03
14	20	0.0%	6	57%	500	7.00E+03	3.00E+03	1.00E+04	-7.00E+03
16	20	0.0%	8	50%	1500	2.40E+04	1.20E+04	3.00E+04	-1.80E+04
17	20	0.0%	15	12%	150	2.55E+03	2.25E+03	3.00E+03	-7.50E+02
20	20	0.0%	21	-5%	2000	4.00E+04	4.20E+04	4.00E+04	2.00E+03
24	20	16.7%	17	29%	800	1.92E+04	1.36E+04	1.60E+04	-2.40E+03
25	20	20.0%	3	88%	1900	4.75E+04	5.70E+03	3.80E+04	-3.23E+04

Total Mass In (KG)	Total Mass Out (KG)	Total Mass Out Expected (KG)	Observed – Expected (KG)
13.83	2.93	3.04	-.011

- Therefore, the BMP meets the load reduction expectation

More work is needed

- Tie storm frequency to storms collected
  - Too many small or big storms
- Analysis of outliers
  - Residuals are normally distributed
- Other Pollutants
  - Soluble vs. particulate
- Tie the PEF to particle size distribution?

Conclusion

- Use of the PEF allows for a regulatory defined function that can be coupled with water quality goals
- Dispenses with the problematic simple percent removal
- Avoids issues associated with low influent and effluent concentrations and loads by using both
- Used in conjunction with a rigorous review program can lead to the successful use of many BMPs