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Contech Engineered Solutions LLC
200 Enterprise Drive
Scarborough, ME 04074
Phone: (207) 885-9830
Fax: (207) 885-9825
www.ContechES.com

November 5, 2012

District Dept. of the Environment
Attn: Rebecca Stack
Natural Resources Administration
1200 First St. NE, 5th Floor
Washington, D.C. 20002

RE: Comments on proposed "Stormwater Guidebook".

General Comments

- How/why was 60% TSS chosen as the performance standard when treatment must be provided? This benchmark is lower than what most jurisdictions require. Also, the TSS ratings given to the treatment BMPs identified in the manual are also quite low compared with ratings for the same BMPs in other areas. It would be helpful to understand how these decisions were made.

- How were what we consider to be particularly conservative TSS ratings for treatment BMPs established? It is important that a consistent evaluation process be identified so that future BMP submissions are evaluated and rated in the same manner. We suggest adding this information as an appendix to ensure it is readily available and understood

- Since a number of the BMPs in the manual are rated at <60% TSS, will BMPs need to be used in treatment trains to achieve 60% TSS ?

- Can pretreatment devices be added? We recommend creating a process to review and approval acceptable pretreatment practices such as hydrodynamic separators that is less costly than the process required for standalone treatment. We suggest consideration of a single field study rather than 3 field studies or 3 years of data for pretreatment devices.

RWH Chapter 3.2

- Page 41: Figure 3.2.1 shows a sample rainwater harvesting system that has a proprietary pretreatment "Vortex" Filter shown. It would be more appropriate to depict the pretreatment component in a generic manner since there are a number of different pretreatment components used for RWH. The same diagram also calls out a stainless steel smoothing inlet. It should not matter the material choice, just the function of the smoothing or calming inlet. We suggest removing the reference to stainless steel and only call out a smoothing/calming inlet. The figure does not call out an access riser, but this is a key component of the cistern. Lastly the detail shows a pressure tank, which is often not needed for simple RWH systems. We suggest identifying the pressure tank as optional as needed.

- Page 44-45: Indicates that first flush diversion is mandatory and requires a 95% filter efficiency. The language only addresses first flush diverters that are combined with pretreatment systems, but not all first flush diversion systems are combined with the pretreatment system. Many RWH systems have a separate first flush diverter and pretreatment system. The language should be updated such that both types of designs are acknowledged.

- Page 46: Call for the use of a proprietary "Vortex" Filter. Specific products should not be suggested. Instead more generic language should be used like "pretreatment filter or hydrodynamic separator".

- Page 47: The Storage Tank section says that cistern capacities range from 250 to over 30,000 gallons. It is now common for cisterns to be as large as 100,000 gallons on larger projects. We suggest updating the range accordingly. Also, bullet 3 requires access to the cistern be provided but does not specify a minimum size. We suggest mandating a 30" minimum access opening.

- Page 49: Table 3.2.2 – again references a proprietary "Vortex" filter instead of generic pretreatment wording. We suggest changing to a generic reference to pretreatment devices

- If the intent is to maximize runoff reduction for the life of a project we recommend that all cisterns have a design life equal to that of the building. Many cisterns rely on liners that are only rated for a 20yr life. DDOE should consider whether it considers a 20yr liner life acceptable and if not develop language that dictates the acceptable life of a cistern.

Biofiltration Chapter 3.5

- Chapter 3.5 identifies "engineered tree pits" as viable treatment systems. A number of companies now offer engineered tree pit biofilters in proprietary configurations. Will these proprietary tree pit biofilters be acceptable for use or will they be required to go through the proprietary practice approval process described in appendix T?

Stormwater Infiltration Chapter 3.7

- Chapter 3.7 recognizes various types of underground infiltration systems including both perforated pipes and chambers surrounded by stone. A list of applicable pretreatment practices is also provided that must be utilized for all infiltration system. Many of these practices are not well suited to underground infiltration systems. We suggest establishing a list of appropriate pretreatment practices for underground infiltration systems. It is common to pretreat these systems with hydrodynamic separators which capture coarser sediments and debris or underground filtration systems that achieve a higher level of performance. We suggest establishing a means of vetting these technologies for use as pretreatment to infiltration facilities.

Storage Practices Chapter 3.11

- Can hydrodynamic seperators be used as pretreatment to underground storage facilities. These types of systems provide excellent removal of coarse solids, trash and debris etc. We encourage inclusion of this type of technology for pretreatment of underground storage practices and a consistent sizing methodology based on documented performance for a given technology.

Proprietary Practices Chapter 3.12

- Chapter 3.12 acknowledges that proprietary practices that do not provide volume storage must be sized based on a peak flow rate. However, there is not clear guidance on how to calculate an appropriate flow rate to be treated by water quality practices. We encourage providing said guidance and specifying the level of performance expected at the design treatment rate. For example, you might consider requiring that proprietary practices be sized to treat the peak flow generated from the water quality storm 1.2in in 24hrs or in instances when treatment is only required for a portion of the water quality volume a storm

depth proportional to the volume needing treatment could be used to calculate the treatment flow. Example, when treatment is required for 50% of the SWRv the treatment flow could be calculated by determining the peak flow for a 0.6 in 24hr storm. We suggest the method used by Maryland and many other states to convert volume to flow. Here is a link to Appendix D10 of the Maryland Stormwater Manual:
http://www.mde.state.md.us/programs/Water/StormwaterManagementProgram/MarylandStormwaterDesignManual/Documents/www.mde.state.md.us/assets/document/sedimentstormwater/Appnd_D10.pdf

Approval of Proprietary Practices Appendix T

- Once approved will proprietary practices and applicable sizing criteria be added to the manual? We believe it will be helpful to have all approved devices and applicable sizing posted in the manual similar to other BMPs.

- Proprietary Practices Approval process is referenced as Appendix X in Chapter 2 of the guidebook but appears as Appendix T. This should be addressed such that any references cite the correct Appendix.

- Section T.0 lists 1.7in as the design storm for proprietary practices. We believe the appropriate design storm is 1.2in event. This should be changed to ensure consistency for all BMPs

- Appendix T needs to describe how data from 3 different studies will be compiled into a single TSS rating and how this equates to the rating process for land based systems. The TSS rating process needs to be consistent for all BMPs.

- We feel strongly that DDOE should create an approval path for pretreatment systems such as hydrodynamic separators that is not as stringent as the approval process for proprietary practices seeking full treatment credit. It is unlikely that many of the viable pretreatment practices available will be subjected to 3 TARP level studies. We suggest a lower barrier to entry for devices seeking pretreatment credit such as 1 TARP study

- Language in section T.1 has multiple references to Table X.1 etc. These should be corrected to Table T.1 etc.

Respectfully,

Derek M. Berg
Regulatory Manager- Stormwater

CONTECH Engineered Solutions LLC
200 Enterprise Drive | Scarborough, ME 04074
T: 207.885.6174 F: 207.885.9825
DBerg@conteches.com
www.ContechES.com

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

James H. Lenhart, PE, D.WRE, CONTECH Stormwater Solutions

ABSTRACT

Many regulatory agencies throughout the United States are faced with the issue of having to review BMP performance data for the purpose of acceptance and design. This paper outlines a simple method of analyzing qualified performance data relative to the defined performance expectations established by the agency.

Current issues surrounding BMP performance evaluation are whether to use percent removal or effluent based guidelines. For percent removal guidelines the question is whether to use concentration or load based reduction.

This method addresses all of these concerns, allows the reviewer to set criteria to meet effluent limits, concentration and load reduction goals.

This method includes the establishment of a Performance Expectation Function (PEF) which is based on both target effluent concentrations, percent removals, and load reductions. Performance data from BMP monitoring which have been collected to an established monitoring protocol are then compared to the PEF on both a percent removal and load basis. Analysis of residuals allows for the establishment of confidence limits in the BMP meeting the designated performance expectations.

This method can be used for pollutants such as TSS, TP, Ortho-P, TN and metals.

INTRODUCTION

Many regulatory agencies are struggling with how to set simple yet realistic goals for Best Management Practice (BMP) performance. Many regulations provide for simple removal rates of pollutants such as an 80% TSS removal or a total annual TSS load reduction of 80%. Some agencies use other parameters such a 65% Total Phosphorus removal requirement. What is problematic is that these simple requirements do not reflect the reality of how BMP's actually perform in the field.

In efforts to get away from percent removal requirements, other attempts at setting flat effluent standards for BMP's (e.g. 20 mg/l TSS effluent) are also problematic in that the level of treatment required to constantly meet these standards is very high. To some degree, by definition, the performance of a BMP is probabilistic and presumptive and therefore it has not been deemed practicable to constantly expect performance levels that meet effluent standards. There are also concerns that the cost of this level of treatment and associated maintenance are too high and that setting a fixed effluent standard may introduce complexities in terms of monitoring and compliance.

Clearly both of the approaches are problematic yet have beneficial aspects that perhaps could be combined to form a simple, realistic, and achievable performance standard for BMP's that can add a level of confidence the BMP is going to meet the standards though analysis of field data. BMP performance claims should be based and verified with the confidence that a percent removal or effluent concentration or load reduction will occur given a range of influent concentrations and/or particle size distributions.

THE TROUBLE WITH PERCENT REMOVAL

From a purely analytical perspective the simplistic 80% removal requirement has some serious flaws. First, lets assume that influent concentrations are extremely low, say 20 mg/l. For an 80% reduction the effluent would need to be 4 mg/l, which is often below the probable quantitative limits (PQL) set by commercial laboratories. In other words, with a PQL of 5 mg/l the best any technology could ever achieve is 75% removal.

Another issue, which is even more significant, is the notion that there are irreducible concentrations (Schueler, 1996). This is predicated on the notion that given the operation of BMPs that there is no expectation that the effluent will be below some amount. Many stormwater professionals accept that the irreducible concentration is at 20 mg/l (or greater) for TSS. In fact, advanced wastewater treatment regulations typically set effluent guidelines at 20 mg/l of TSS. Why, would we expect a relatively simple stormwater BMPs to outperform a plant with primary treatment, secondary treatment, automation, intensive maintenance and operators?

The irreducible concentration could also be viewed as a baseline effluent concentration. As an extreme example, say that water with zero mg/l of TSS enters a wetland. More than likely the effluent will not be zero and could easily be 20 mg/l. Though there is a net export of mass, at these concentrations this type of BMP behavior should not be a surprise.

So, using the example above, given an influent concentration of 20 mg/l and a 20 mg/l irreducible concentration, the expectation for percent removal is zero. Clearly this is far from the 80% rule, yet given the practical reality of BMP performance, is acceptable.

Data analysis using percent removal is typically not an accepted practice. The arithmetic averaging of percent removal, though sometimes used, is generally not accepted because it can be deceptive. For example, a series of small storms with small runoff volumes may yield higher removals due to long term settling of displaced water. Less frequent, higher magnitude storms yield low removal rates but have much greater volumes of water being discharged. Simple arithmetic averaging could yield a result that the BMP worked well when in fact in terms of mass load the BMP did not work well at all.

On the other hand if influent concentrations are continuously low, the average percent removal is low, and the BMP judged not to work, when in fact, given irreducible concentrations, all that could really be concluded is that the site has a low pollutant load and the function of the BMP is indeterminate.

Another issue, which has been discussed, is the plotting of percent removal vs. influent concentration. Typically, when plotted a characteristic curve is the result. The nature of the curve shows removal efficiency increasing with increasing influent concentrations. It has been shown that error plays a part in the characteristic (de Ridder et.al., 2002). The error is most pronounced at low concentrations due to analytical resolution. However, are there are other influences on the curve characteristic that may have a direct bearing on BMP performance?

One major influence can be particle size distribution. Lehman and de Ridder (2005) showed a direct correlation between intensity and TSS concentration. In general, as storm intensity increased, influent TSS concentration increased as well. This finding is consistent with physically based models in which increased intensity results in more detachment energy, higher peak flows and transport energy. Though not applicable in all cases, it leads to the hypothesis that higher removal efficiencies at higher concentrations is the product of transporting larger particles, which are easy to remove.

So it appears that there are both advantages and disadvantages in using concentration alone to evaluate BMP performance. But clearly, given these issues, simple percent removal as a standalone measure of performance should not be done.

LOAD VS. CONCENTRATION

Many will argue that the sum of loads or mass load calculations are the only way to evaluate BMP performance. Others will argue that concentration is most important.

Mass load reduction is also a simple concept. Basically mass load reduction is done by calculating the event mean concentration (EMC) of a storm times the runoff volume to yield the total mass of the influent and effluent. The percent reduction of the mass load is calculated from there.

While this method seems straight forward, there are issues with this method as well (Strecker et. al., 2004). Say, for example, a BMP gets a series of small storms with EMCs of about 100 mg/l. The EMCs of the effluent are at about 70 mg/l which yields a 30% removal of TSS. However a large storm transports a huge amount of mass (possibly consisting of large volumes of sand) at a concentration of 1000 mg/l with an effluent of 100 mg/l for a percent removal of 90%. When the sum of loads is conducted, the amount of mass and high removal of the one storm outweighs the others and leads to the conclusion that the BMP achieved an 80% reduction of mass load, therefore is was working.

What is problematic is that even though an 80% mass load reduction was achieved, the effluent concentrations were high and still exhibit significant water quality impacts. So in this case one might accept a BMP that really does not meet water quality needs.

On the other hand, lets say that a BMP has influent EMCs of 50 mg/l and Effluent EMCs of 20 mg/l for 5 storms and one storm at 120 mg/l in and 24 mg/l out. The sums of loads removal is calculated to be about a 66% removal. This result may lead to the conclusion that it does not meet the 80% goal and is rejected even though, given the concentrations, the BMP actually performed very well. Clearly, more data with higher concentrations may be needed to be conclusive, but these data are not sufficient to reject the BMP for low performance.

These situations lead to the conclusion that, to understand the operation of the BMP, <u>one must look at both load and concentration for making decisions on performance.</u>

PERFORMANCE EXPECTATION FUNCTIONS

From the discussions above it should be evident that simplistic percent removals on either a concentration or mass load basis do not allow for proper evaluation of BMP performance and effluent guidelines are not practicable. However one may consider combining the two into a method which is simple, flexible, measurable, considers both concentration and mass load, and most importantly is achievable by many BMPs.

A Performance Expectation Function (PEF) can achieve these goals. The basis of the PEF is that the regulatory agency defines the PEF based on their specific water quality goals. The agency defines the irreducible or baseline concentration (typically 20 mg/l for TSS) that constitutes an effluent guideline for concentration below a threshold amount. Then, for influent concentrations above the threshold, percent removal (typically 80%) is used.

For example with a baseline concentration of 20 mg/l an agency would set an effluent guideline of 20mg/l for influent concentration of 100 mg/l or less. For concentrations greater than 100 mg/l the performance expectation is 80%. Put simply, the PEF would be "for concentrations less than or equal to100 mg/l the expected effluent is 20 mg/l and for influent concentrations greater than 100 mg/l the expected effluent is 80% of the influent.

Figures 1 and 2 show how the PEF can be illustrated in two ways. The first is a plot of influent vs. percent removal and the second is of influent vs. effluent.

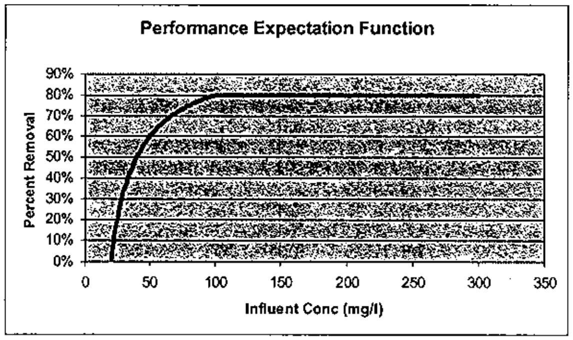
This curve now defines the performance expectation of the BMP. Since the BMP performance is probabilistic one would expect that some of the data points will be above the line and some will be below the line.

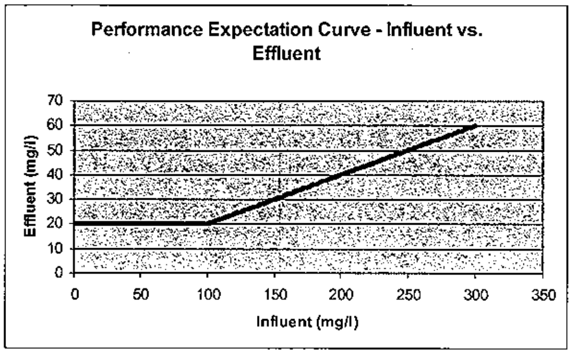
It is important to realize that the PEF can be used for other pollutants such a phosphorus and metals or can be more complex. For example, the city of Portland wants the concentration percent removal to rise to 90% at concentrations exceeding 280 mg/l

USING THE PEF TO EVALUATE BMP PERFORMANCE

Once a PEF is defined by the regulatory agency, observed performance data from a qualified BMP monitoring project can be used to compare how the observed performance meet the expected performance as defined by the PEF.

For the sake of illustration a hypothetical data set was constructed and is shown in Table 1. The sample





Figures 1 and 2. Sample PEF Functions expressed as influent vs. Percent removal and influent vs. effluent

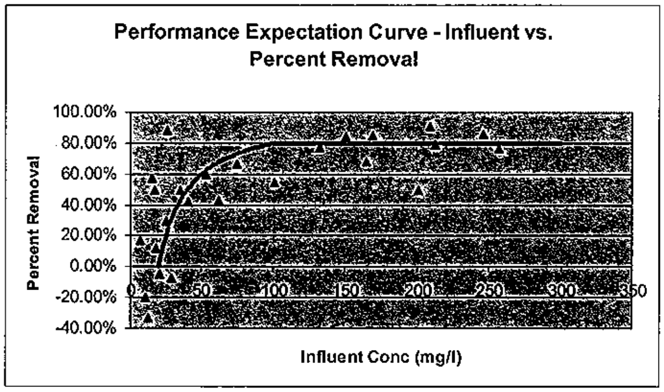
population is 25, which for a field monitoring population would be considered substantial.

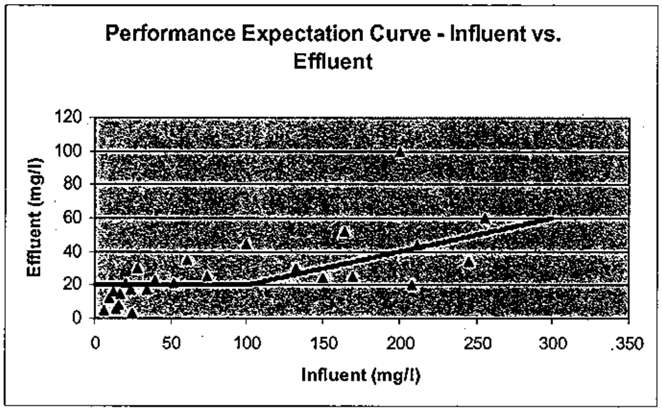
These data can then be plotted against the PEF to gain a visual perspective on performance. Figures 3 and 4 present the data in a graphical format with the PEF.

Table 1: Hypothetical Data Set for Example Analysis

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%
40	20	50.00%	23	42.50%
52	20	61.54%	21	59.62%
61	20	67.21%	35	42.62%
74	20	72.97%	25	66.22%
100	20	80.00%	45	55.00%
132	26.4	80.00%	30	77.27%
150	30	80.00%	24	84.00%
164	32.8	80.00%	52	68.29%
169	33.8	80.00%	25	85.21%
200	40	80.00%	100	50.00%
208	41.6	80.00%	20	90.38%
212	42.4	80.00%	44	79.25%
245	49	80.00%	34	86.12%
256	51.2	80.00%	60	76.56%

Once the data are plotted against the PEF, one can begin with a numerical and visual analysis of the data. Though both graphs are presenting the same data, the influent vs. % removal seems to convey more information. Looking at the influent vs. the effluent it seems, that in viewing the points that the question of what fraction (percent) is removed is always asked. Some additional visual aspects are:





Figures 3 and 4. Performance Expectation Functions vs. Observed Data

1. **Spread of the data points**. Do the data points have a tendency to group or scatter? Data points that form tighter groups should represent a more robust and predictable technology. Scattered points indicate a lot of variance in the performance characteristics.
2. **Position of the points about the line.** For percent removal, points above the line are exceeding expectations whereas points below the line are not meeting expectations. If the majority of the points are tightly clustered and above the line this is a good indicator that the technology is meeting or exceeding expectations. Clusters below the line indicate the technology is not meeting expectations. Finally, clusters about the line may be visually indeterminate.
3. **Outliers.** Note that in the example there are two points which may represent outliers. For the analysis one may decide to include or exclude the points.

DATA ANALYSIS – OBSERVED VS. EXPECTED

It is important to understand that the PEF is defined by the "user" and the observed data points are plotted about the line. Therefore the PEF is not the outcome from a regression analysis of the points but are a defined performance standard from which one can compare observed vs. expected.

One method of comparison is the sign test. This is a simple nonparametric statistical test to estimate if the scatter of the points about the line, represent the same population or a population which rests above or below the line. For example, if the BMP performance characteristic did follow the PEF, it would be reasonable to expect that 50% of the points would rest above the line and 50% below. If higher frequencies of occurrence lied either above or below the line then this may indicate that the BMP is either outperforming or underperforming expectations.

SIGN TEST

The Sign Test is a nonparametric test that may be of use when it is only necessary to know if observed differences between two conditions are significant. That is to say, with appropriate use of the sign test, it would be possible to determine if X is really "more" than Y, or however the conditions are arranged. The sign test is structured so that plus (+) and minus (-) "signs" are used to denote change in magnitude, as opposed to a quantitative measurement.

In a sign test the concentration differences are calculated by subtracting the observed from the expected. Positive number are then assigned a plus sign and negative numbers are assigned a negative sign. Differences of zero (i.e. Observed = Expected) are omitted. The outcome of the number of points above and below the line are compared to a population when it is expected that half the points are above the line and half are below. Using a binomial distribution the probability that the number of occurrences above (or below) the line, as explained by chance, is calculated. The probability is then evaluated to decide if the samples do or do not represent the PEF. There are three outcomes from this test.

1. The probability is high that the observed data match the expected
2. The probability is high that the observed do not match the expected and are greater (+)
3. The probability is high that the observed do not match the expected and are lesser (-)

With outcomes 1 and 2, the hypothesis that the BMP meets or exceeds expectations would be accepted, at least on a concentration basis. Outcome 3 indicates the BMP is below expectations and should be rejected.

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

Where:

P(S)	The symbol for the probability of success (+)
P(F)	The symbol for the probability of failure (-)
p	The numerical probability of a success (use 0.5)
q	The numerical probability of a failure (use 0.5) (P(S) = p and P(F) = 1- p = q)
n	The number of trials
X	The number of successes (positives)

So in the example there are a total of 25 samples. Of the 25 samples, 13 are above the line(+) and 12 are below (-). This indicates a 50% probability of occurrence which clearly indicates this BMP is meeting expectations. As an example however, lets assume that of the 25 pairs, there were 17 below the line and 8 above then there is about a 5% chance of this occurring which would lead to the conclusion that the BMP was not meeting performance expectations. (http://home.clara.net/sisa/pairwise.htm)

MASS LOAD BALANCE CALCULATIONS

As mentioned above simply looking at the influent vs. percent removal or influent vs. effluent does not tell the whole story. These graphs convey no information on load reduction.

Load reduction evaluation is a quantitative method based on calculating both the expected load removal (expected concentration times the actual runoff volume) and the observed load removal. The difference between these two values represents a residual that can then be further analyzed. Table 2 shows these calculations.

Table 2 – 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
28	20	28.6%	30	-7%	350	9.80E+03	1.05E+04	7.00E+03	3.50E+03
34	20	41.2%	17	50%	800	2.72E+04	1.36E+04	1.60E+04	-2.40E+03
40	20	50.0%	23	43%	1100	4.40E+04	2.53E+04	2.20E+04	3.30E+03
52	20	61.5%	21	60%	5000	2.60E+05	1.05E+05	1.00E+05	5.00E+03
61	20	67.2%	35	43%	2000	1.22E+05	7.00E+04	4.00E+04	3.00E+04
74	20	73.0%	25	66%	5000	3.70E+05	1.25E+05	1.00E+05	2.50E+04
100	20	80.0%	45	55%	2000	2.00E+05	9.00E+04	4.00E+04	5.00E+04
132	26.4	80.0%	30	77%	1600	2.11E+05	4.80E+04	4.22E+04	5.76E+03
150	30	80.0%	24	84%	9000	1.35E+06	2.16E+05	2.70E+05	-5.40E+04
164	32.8	80.0%	52	68%	3000	4.92E+05	1.56E+05	9.84E+04	5.76E+04
169	33.8	80.0%	25	85%	1800	3.04E+05	4.50E+04	6.08E+04	-1.58E+04
200	40	80.0%	100	50%	800	1.60E+05	8.00E+04	3.20E+04	4.80E+04
208	41.6	80.0%	20	90%	5000	1.04E+06	1.00E+05	2.08E+05	-1.08E+05
212	42.4	80.0%	44	79%	30000	6.36E+06	1.32E+06	1.27E+06	4.80E+04
245	49	80.0%	34	86%	9000	2.21E+06	3.06E+05	4.41E+05	-1.35E+05
256	51.2	80.0%	60	77%	2000	5.12E+05	1.20E+05	1.02E+05	1.76E+04

Table 3 summarizes the outcome from Table 2.

Table 3 – Summary of Table 2

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

Note in this case that a negative number reflects a positive result. In other words, less mass left the BMP than expected. So one could conclude from a mass basis that the BMP met expectations as well.

Note that on a mass basis, the expected percent removal calculates to be 78% and not 80%. Clearly if the water was much cleaner with lower EMC's the mass removal could be say 50% and still meet performance expectations, however, one may ask the question how well the BMP would operate at higher concentrations which would warrant additional samples at higher concentrations.

The load reduction assessment can be further refined if there is an infiltration component. If a fraction of the entire runoff volume is reduced through infiltration or evaporative processes then the expected mass load would be a product of the (influent volume)x(Expected infiltration component)x(expected percent removal) the actual mass load would be the (Effluent volume)x(effluent concentration)

This allows an assessment of how well the infiltration component is working rather than assigning a simple percent which perpetuates the issue. One should use caution however because the infiltration capacity is most likely not constant and reduces over time with progressive loading.

COMPARISON TO THE EXPECTED RAINFALL DISTRIBUTIONS

Another issue about the use of storms is how they are distributed. Another way to misinterpret data is to not evaluate how the unit was sized as compared to the magnitude of the storms or storm flows that occurred. In most areas one can use local rainfall data to construct a cumulative rainfall depth frequency curve or a cumulative flow duration curve. These curves can be used to adjust flow data (or runoff volume data) to normalize what actually happen during the monitoring period vs. what would be expected to happen over a much longer period of time.

In most (if not all) cases one would find that BMP's tend to work better during small storms (especially BMP's that rely on volume storage and settling) and one would also find that the highest frequency of occurrence of storms is smaller storms. So it stands to reason that an additional weight should be added to the data set to provide an adjustment which weights the data to be more representative of what will statistically occur over a period of time vs. what just happened during the sampling period.

ANALYSIS OF OUTLIERS

Analysis of the outliers can be done for both the concentration and load. One method is to analyze the residuals (observed minus expected) to determine if they are normally distributed about the mean, which in this case would be zero. Box and whisker plots can then be used to identify the points outside the second or third standard deviations.

PERFORMANCE EXPECTATION FUNCTIONS FOR OTHER POLLUTANTS

A PEF can be constructed for other pollutants as well. In some cases the PEF may be more complex due to the more complex nature of the pollutant. Total Phosphorus for example has a soluble component to it. Most BMPs do not address Ortho-P and in many cases can generate Ortho-P from the decomposition of organic matter. Typically the reduction of Total-P is associated with the organic and mineral phase of Total-P associated with the TSS. (Wigginton et al, 2000) The soluble component adds a layer of complexity in that; the higher the fraction of Ortho-P to the Total P, the BMP relative performance will significantly drop.

So, in the case of a PEF for Total-P there could be two base lines. The first is the Ortho-P baseline and the second is the fraction of the particulate Total-P associated with the baseline TSS concentration. The PEF for the ortho fraction could be set to zero, and the particulate fraction could be then tied to the TSS removal or some function of the TSS removal.

For example, if an influent sample had 0.3 mg/l of Total P of which 0.10 mg/l was Ortho-P then the remainder could be associated with the TSS. If the influent TSS is at 50 and the expected percent removal of is 60% so (conservatively assuming a linear relation between TSS and TP) the removal expectation for the TSS fraction of the TP is 60% of 0.2 mg/l which is 0.12 mg/l. This gives an expected effluent of (0.10 mg/l + 0.12 mg/l) = 0.22 mg/l. Thus the expected percent removal is only 27%. In this case the observation was 0.21 mg/l, therefore, the BMP was exceeding expectations for TP even though the Ortho-P fraction was elevated on the effluent side.

Table 4 – Summary of Example Total-P Performance Expectation Function

Parameter	Influent (mg/l)	Effluent (mg/l)	% removal	Expected Effluent mg/l
TSS	50	20	60	20
Total P	0.3	0.21	30	0.22
Ortho P	0.10	0.12	-20%	0.10

CONCLUSION

This method of analysis is relatively simple and does not use "heavy statistics". However it does provide a reasonable balance between the need to simply define expected BMP performance while taking into consideration much of the practical reality of how BMP's actually perform. This method takes into account both concentration and load and allows for a realistic comparison to expected performance that is characteristic of most accepted BMPs.

The use of the PEF also allows the regulatory agency to stipulate the expected BMP performance. This allows for a connection between the BMP performance and water quality needed to meet the water quality requirements for the receiving waters.

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