Field Sampling

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Objective

- Introduction to sampling
- Various methods of sampling
- Sampling importance in Stormwater Management
- QA and QC to be followed in sampling
- Field sampling case study
- Conclusions
- Reference: Stormwater Effects Handbook
  - G. Allen Burton, Robert E. Pitt

Introduction

- To find information about a subject of interest
- Methods used to get information are Census, experimentation and sampling
- Census is generally carried out over the entire population. Costly, time consuming and often not possible.

Introduction

- Sampling is a way to obtain information about a large group by examining a smaller, randomly chosen selection (the sample) of group members.
- Sample collected should be a *representative* sample.

Methods of Sampling

- Haphazard sampling
- Judgment sampling
- Probability sampling
- Search sampling

Probability Sampling

- Simple random sampling
- Stratified random sampling
- Multistage sampling - Commonly used and is associated with the required sub sampling of samples obtained in the field
- Cluster sampling
- Systematic sampling

Sampling Importance in Stormwater Management

- To determine the quality of stormwater
- The effect of urbanization on stormwater.

  Eg : Street runoff, roof runoff

  Eg of pollutants: Suspended solids, Nutrients, bacteria, heavy metals, Organic matter
- To find the inappropriate discharges to storm drains
- Effectiveness of control devices
- To formulate regulations for stormwater runoff Eg: NPDES Phase I, and II

Issues in Sampling

- Before sampling
- While sampling
- After sampling

Before Sampling

- Determine the objectives of sampling
- Experimental Design
- Number of samples required
- Site characteristics
- Data monitoring/logging equipment
- Determine appropriate sample volume
- Selecting right field equipment with minimal effect on sample characteristics

  Eg: Samplers, flow meters

Table 5.7 Potential Sample Contamination from Sampler Material

Material	Contaminant
PVC – threaded joints	Chloroform
PVC – cemented joints	Methylethyl ketone, toluene, acetone, methylene chloride, benzene, ethyl acetate, tetrahydrofuran, cyclohexanone, organic tin compounds, and vinyl chloride
Teflon	Nothing
Polypropylene and polyethylene	Plasticizers and phthalates
Fiberglass-reinforced epoxy material (FRE)	Nothing
Stainless steel	Chromium, iron, nickel, and molybdenum
Glass	Boron and silica

Data from Cowgill, U.M. Sampling waters, the impact of sample variability on planning and confidence levels, in *Principles of Environmental Sampling*. Edited by L.H. Keith. ACS Professional Reference Book. American Chemical Society. pp. 171–189. 1988.

Source: Stormwater Effects Handbook

Number of Samples

$$n = [COV(Z_{1-\alpha} + Z_{1-\beta})/(error)]^2$$

where

- n = number of samples needed
- α = false positive rate ($1 - \alpha$ is the degree of confidence. A value of α of 0.05 is usually considered statistically significant, corresponding to a $1 - \alpha$ degree of confidence of 0.95, or 95%)
- β = false negative rate ($1 - \beta$ is the power. If used, a value of β of 0.2 is common, but it is frequently ignored, corresponding to a β of 0.5)
- $Z_{1-\alpha}$ = Z score (associated with area under normal curve) corresponding to $1 - \alpha$. If α is 0.05 (95% degree of confidence), then the corresponding $Z_{1-\alpha}$ score is 1.645 (from

Source: Stormwater Effects Handbook

standard statistical tables).

- $Z_{1-\beta}$ = Z score corresponding to $1 - \beta$ value. If β is 0.2 (power of 80%), then the corresponding $Z_{1-\beta}$ score is 0.85 (from standard statistical tables). However, if power is ignored and β is 0.5, then the corresponding $Z_{1-\beta}$ score is 0.
- error = allowable error, as a fraction of the true value of the mean
- COV = coefficient of variation (sometimes noted as CV), the standard deviation divided by the mean. (Data set assumed to be normally distributed.)

Source: Stormwater Effects Handbook

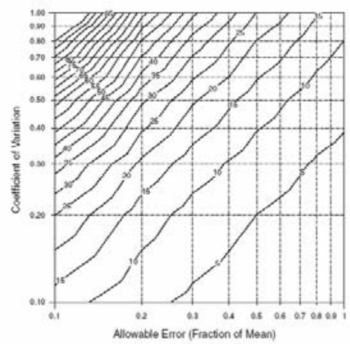


Figure 5.3 Sample requirements for confidence of 95% ($\alpha = 0.05$) and power of 80% ($\beta = 0.20$). (From Pitt, R. and K. Parmer. *Quality Assurance Project Plan: Effects, Sources, and Treatability of Stormwater Toxicants*. Contract No. CR819573. U.S. Environmental Protection Agency, Storm and Combined Sewer Program, Risk Reduction Engineering Laboratory, Cincinnati, OH. February 1995.)

Data Quality Objectives

- When designing a plan, one should look at the study objectives and ask:
  - How will the data be used to arrive at conclusions?
  - What will the resulting actions be?
  - What are the allowable errors be?

While and After Field Sampling

- Documentation is very important during and after the field sampling
- Collection and preservation of samples
- Analyzing the samples for pollutants by priority
- Cleaning sample bottles as per ASTM standards

Table 5.9- Summary of Special Sampling and Handling Requirements for Water and Wastewater Samples[a]

Determination	Container[b]	Minimum Sample Size (mL)	Sample Type[c]	Preservation[d]	Maximum Storage Recommended/ Regulatory[e]
Acidity	P, G(B)	100	g	Refrigerate	24h/14d
Alkalinity	P, G	200	g	Refrigerate	24h/14d
BOD	P, G	1000	g, c	Refrigerate	6h/48h
Boron	P (PTFE) or quartz	100	g, c	None required	28d/6months
Bromide	P, G	100	g, c	None required	28d/28d
Carbon, organic, total	G	100	g, c	Analyze immediately; or refrigerate and add H_3PO_4 or H_2SO_4 to pH<2	7d/28d
Carbon dioxide	P, G	100	g	Analyze immediately	0.25h/N.S.
COD	P, G	100	g, c	Analyze as soon as possible, or add H_2SO_4 to pH<2; refrigerate	7d/28d
Chloride	P, G	50	g, c	None required	28d
Chlorine, total, residual	P, G	500	g	Analyze immediately	0.25h/0.25h
Chlorine, dioxide	P, G	500	g	Analyze immediately	0.5 h/N.S.
Chlorophyll	P, G	500	g, c	Unfiltered, dark, 4°C Filtered, dark, –20°C (Do not store in frost-free refrigerator)	28d/–
Color	P, G	500	g, c	Refrigerate	48h/48h
Conductivity	P, G	500	g, c	Refrigerate	28d/28d
Cyanide: Total	P, G	1000	g, c	Add NaOH to pH>12, refrigerate in dark	24h/14d;24h if sulfide present
Fluoride	P	100	g, c	None required	28d/28d
Hardness	P, G	100	g, c	Add HNO_3 to pH<2	6 months/6months
Iodine	P, G	500	g, c	Analyze immediately	0.5h/N.S.
Metals, general	P(A), G(A)	1000	g, c	For dissolved metals filter immediately, add HNO_3 to pH<2	6months/6months
Chromium VI	P(A), G(A)	1000	g	Refrigerate	24h/24h
Mercury	P(A), G(A)	1000	g, c	Add HNO_3 to pH<2, 4°C, refrigerate	28d/28d
Nitrogen:					
Ammonia	P, G	500	g, c	Analyze as soon as possible or add H_2SO_4 to pH<2, refrigerate	7d/28d
Nitrate	P, G	100	g, c	Analyze as soon as possible or refrigerate	48h/48h (28d for chlorinated samples)
Nitrate + nitrite	P, G	200	g, c	Add H_2SO_4 to pH<2, refrigerate	1–2d/28d
Nitrite	P, G	100	g, c	Analyze as soon as possible refrigerate	None /48h
Organic, Kjeldahl	P, G	500	g, c	Refrigerate; add H_2SO_4 to pH<2	7d/28d
Oil and grease	G,wide-mouth calibrated	1000	g, c	Add HCl to pH<2, refrigerate	28d/28d
Organic compounds:		200			
MBAS	P, G	250	g, c	Refrigerate	48h/N.S.
Pesticides	G(S), PTFE-lined cap	1000	g, c	Refrigerate; add 1000 mg ascorbic acid/L if residual chlorine present	7d/7d until extraction 40d after extraction
Phenols	P, G PTFE-lined cap	500	g, c	Refrigerate add H_2SO_4 to pH<2	*/28d until extraction

Source: Stormwater Effects Handbook

QA/QC

- All samples are chilled on ice or in a refrigerator at 4°C (except for the HNO3-preserved samples for heavy metal analyses) and analyzed within the holding times shown below:
- Immediately after sample collection or upon arrival in the laboratory: pH and microorganisms
- Within 24 hours: toxicity, ions, color, and turbidity
- Within 7 days: GC extractions, solids, and conductivity
- Within 40 days: GC analyses
- Within 6 months: heavy metal digestions and analyses

Samplers

Table 5.14 The Advantages and Disadvantages of Manual and Automatic Sampling

Type	Advantages	Disadvantages
Manual	Low capital cost Not a composite Point-in-time characterization Compensate for various situations Note unusual conditions No maintenance Can collect extra samples in short time when necessary	Probability of increased variability due to sample handling Inconsistency in collection High cost of labor[a] Repetitious and monotonous task for personnel
Automatic	Consistent samples Probability of decreased variability caused by sample handling Minimal labor requirement for sampling Has capability to collect multiple bottle samples for visual estimate of variability and analysis of individual bottles	Considerable maintenance for batteries and cleaning; susceptible to plugging by solids Restricted in size to the general specifications Inflexibility Sample contamination potential Subject to damage by vandals

[a] High cost of labor assumes that several samples are taken daily, large distances between sampling sites, and labor is used solely for sampling.

From EPA. *Handbook for Sampling and Sample Preservation of Water and Wastewater*, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH, EPA 600/4-82/029. 1982.

Source: Stormwater Effects Handbook

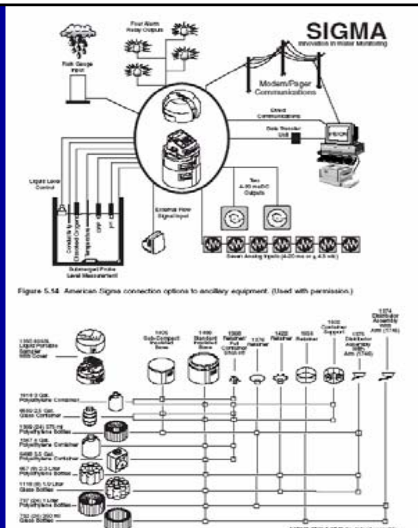


Figure 5.14 American Sigma connection options to ancillary equipment. (Used with permission.)

Figure 5.15 American Sigma sample bottle options. (Used with permission.)

Source: Stormwater Effects Handbook

Sampler Issues

- Required sample line velocities to minimize particle sampling errors
  - Typical sample lines are Teflon-lined polyethylene and are 10mm in dia

Table 5.15 Losses of Particles in Sampling Lines

	30 cm/s Flow Rate		100 cm/s Flow Rate	
% Loss	Critical Settling Rate (cm/s)	Size range (μm, for ρ = 1.5 to 2.65 g/cm³)	Critical Settling Rate (cm/s)	Size Range (μm, for ρ = 1.5 to 2.65 g/cm³)
100	30	2000–5000	100	8000–25,000
50	15	800–1500	50	3000–10,000
25	7.5	300–800	25	1500–3000
10	3.7	200–300	10	350–900
1	0.37	50–150	1	100–200

Source: Stormwater Effects Handbook

Sampler Issues

- Automatic sampler line flushing
  - First, sample line is back flushed to minimize sample cross over and to clear debris from the sample intake
  - Sample is collected
  - Finally, the sample is back flushed again before going into sleep mode to await next sampling instruction
- Time or flow composite sampling

- Eg: A volume of 1850ml fills a 10mm (3/8in) dia sample line that is 7.5m or 25ft long. If a sample volume of 350ml is to be collected for each sample interval, what is the total volume of water pumped by the sampler for each sample instruction?

- Back flush line 1850 mL
- Fill tube 1850 mL
- Collect sample 350 mL
- Back-flush line 1850 mL

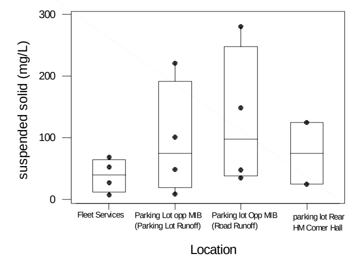
Field Sampling Case Study

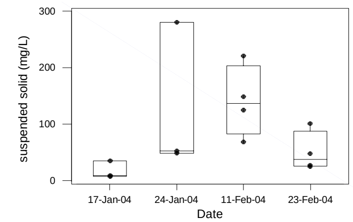
- Research Objectives
  - Test Upflow Filter™ for treatment of stormwater
  - Test the performance of Upflow Filter™ at various flow rates and at different sediment concentration loads
  - Develop and demonstrate effectiveness of upflow filtration setups for the treatment of stormwater runoff

Preliminary Site Analysis

Conclusion of Priliminary Site Analysis

- The statistical tests showed that the variability of the stormwater concentrations was much more varied between the storms than for between the sampling locations.
- Supports experimental design to install the inlet tests at a site that has the desired physical properties and to include many events for analyses.





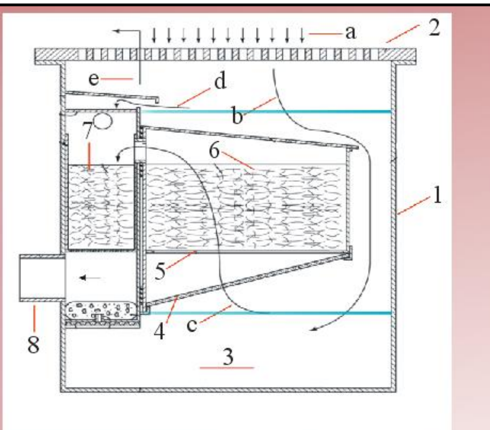
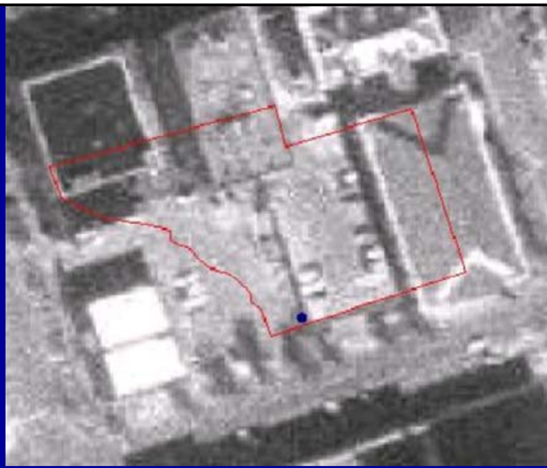
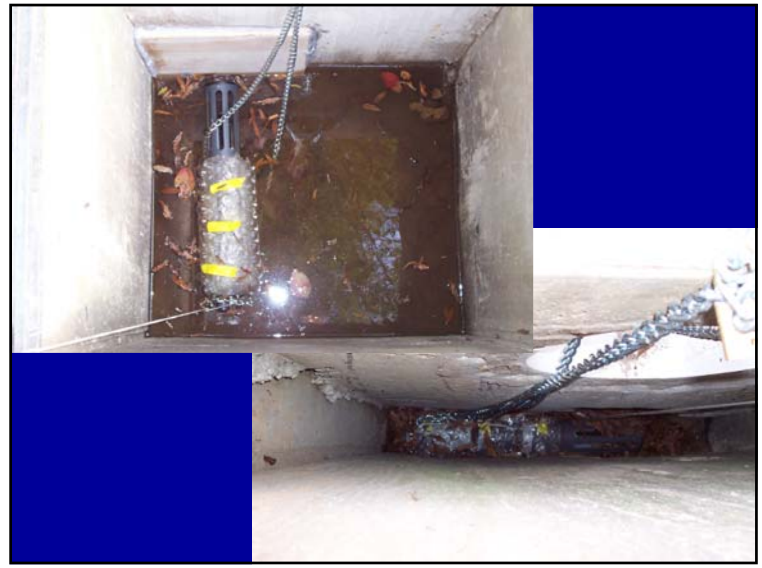


Fig 1: Upflow Stormwater Filter™ (patent pending)
1. Catch basin 2. Grate inlet cover 3. Sump 4. Screen 5. Screen 6 and 7. Filter media 8. Effluent pipe.
a, b and c are showing the flow path inside the filter.
d and e are showing the over flow path.

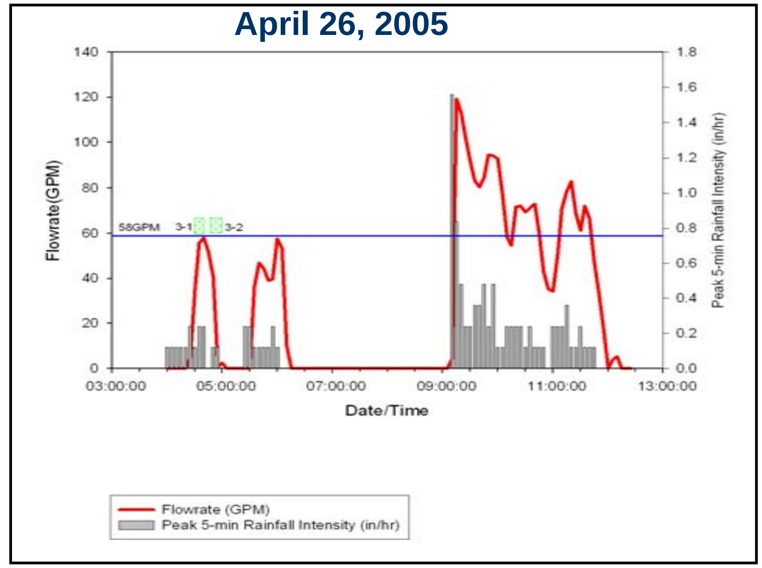


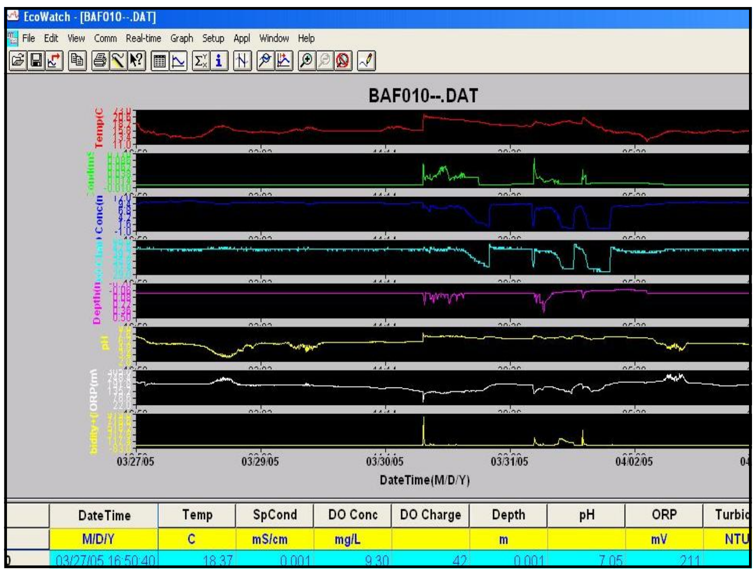
SBIR2 field test site, Tuscaloosa, AL, City Hall and public works vehicle parking area, 0.8 acres.

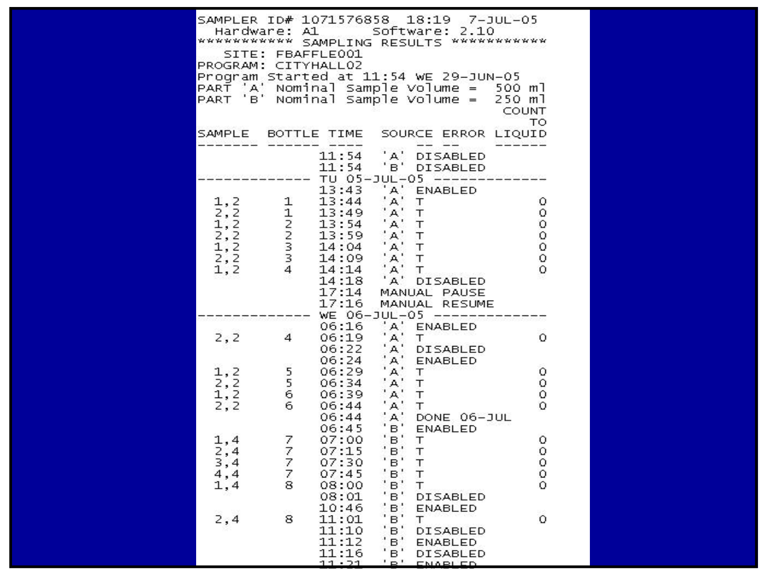

Test area drainage
area characteristics,
Tuscaloosa, AL



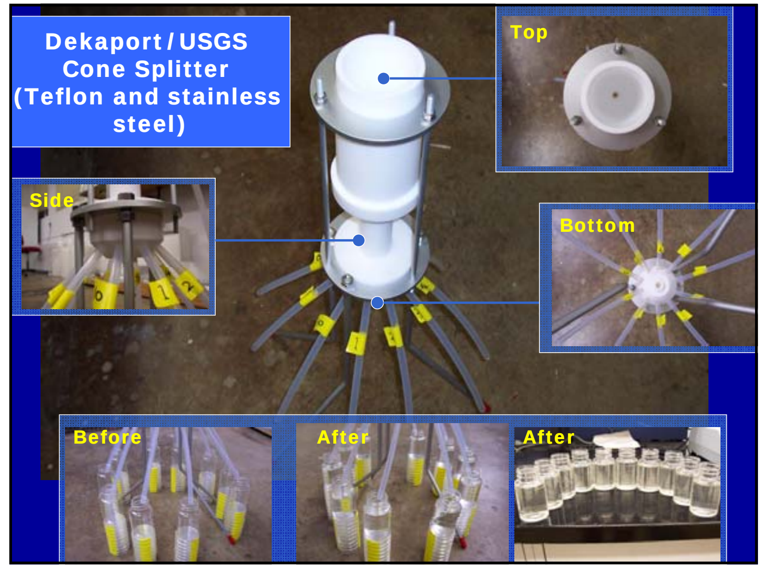

ALABAMA
GREENLEE





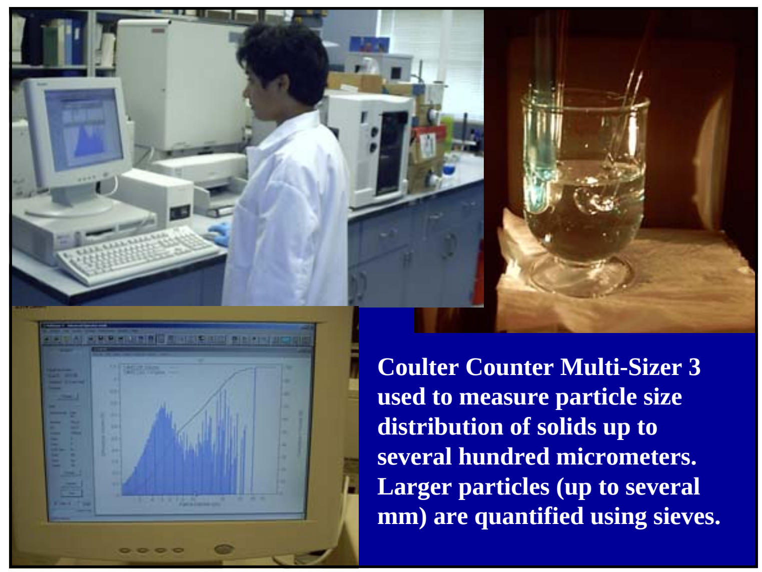


```
SAMPLER ID# 1071576858  18:19  7-JUL-05
  Hardware: A1        Software: 2.10
*********** SAMPLING RESULTS ***********
   SITE: FBAFFLE001
PROGRAM: CITYHALL02
Program Started at 11:54 WE 29-JUN-05
PART 'A' Nominal Sample Volume =  500 ml
PART 'B' Nominal Sample Volume =  250 ml
                                   COUNT
                                      TO
SAMPLE  BOTTLE TIME   SOURCE ERROR LIQUID
------- ------ ----      -- --    ------
               11:54  'A' DISABLED
               11:54  'B' DISABLED
------------- TU 05-JUL-05 -------------
               13:43  'A' ENABLED
  1,2     1    13:44  'A' T             0
  2,2     1    13:49  'A' T             0
  1,2     2    13:54  'A' T             0
  2,2     2    13:59  'A' T             0
  1,2     3    14:04  'A' T             0
  2,2     3    14:09  'A' T             0
  1,2     4    14:14  'A' T             0
               14:18  'A' DISABLED
               17:14  MANUAL PAUSE
               17:16  MANUAL RESUME
------------- WE 06-JUL-05 -------------
               06:16  'A' ENABLED
  2,2     4    06:19  'A' T             0
               06:22  'A' DISABLED
               06:24  'A' ENABLED
  1,2     5    06:29  'A' T             0
  2,2     5    06:34  'A' T             0
  1,2     6    06:39  'A' T             0
  2,2     6    06:44  'A' T             0
               06:44  'A' DONE 06-JUL
               06:45  'B' ENABLED
  1,4     7    07:00  'B' T             0
  2,4     7    07:15  'B' T             0
  3,4     7    07:30  'B' T             0
  4,4     7    07:45  'B' T             0
  1,4     8    08:00  'B' T             0
               08:01  'B' DISABLED
               10:46  'B' ENABLED
  2,4     8    11:01  'B' T             0
               11:10  'B' DISABLED
               11:12  'B' ENABLED
               11:16  'B' DISABLED
               11:21  'B' ENABLED
```

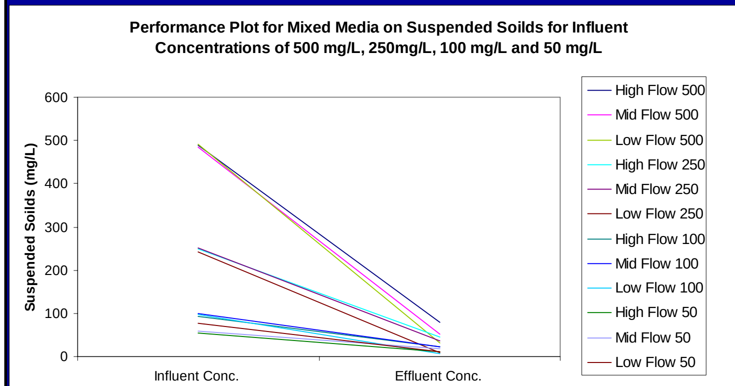


April 1, 2005
(19 gal/min during sampling)

Parameter	Influent	Effluent	% Reduction
Suspended Solids (mg/L)	53	36	32
Turbidity (NTU)	85.6	42.4	51
Total Solids (mg/L)	88	75	15
COD (mg/L)	141	45	68
Ammonia (mg/L)	0.23	0.21	9
Nitrates (mg/L)	0.4	0.4	0
Total Phosphates (mg/L)	0.64	0.6	6
E-Coli (mpn/100 mL)	1390	1076	22



Coulter Counter Multi-Sizer 3 used to measure particle size distribution of solids up to several hundred micrometers. Larger particles (up to several mm) are quantified using sieves.



Summary

- Methods to determine the needed sampling effort, including the number of samples, number of sampling locations.
- Prior knowledge of the conditions to be monitored is needed.
- Phased sampling approach is recommended, allowing some information to be initially collected and used to make preliminary estimates of the sampling effort.

Table 5.19 General Sampling Guidelines[a]

Location

1. Locate stations at sites representative of least and greatest impact from each pollutant source and for the total system, considering each ecosystem component (e.g., substrate, flow, biota).
2. Sample depositional areas and critical habitats such as riffles and spawning areas.
3. Collect replicate samples at each station which characterize the site spatially.
4. Sample during baseflow and various stormflow conditions.
5. Sample during different seasons.
6. Sample during recovery periods (following storm events) noting different periods of disturbance (i.e., storm recurrence period).
7. Note diurnal, weekly, monthly, and seasonal cycles of various ecosystem components-endpoints (e.g., DO, redox, tissue residues, toxicity, life stage).

Type

8. In areas where effects are uncertain, use a "weight-of-evidence" integrated approach (see Chapter 8). Characterize the inputs and receiving water system both physically (e.g., flow, solids, temperature, habitat) and chemically (e.g., oxygen, hardness, organics, metals). Measure key indigenous biological communities (indices), indicators (e.g., trout), and endpoints (e.g., fish abnormalities). Measure toxicity of effluents, waters, and sediments using sensitive and relevant species representing multiple levels of biological organization (e.g., fish, zooplankton, algae, benthic macroinvertebrates). *In situ* toxicity testing is the preferred approach.

Method

9. Process samples quickly (refrigerate and/or preserve immediately upon collection).
10. Reduce sample manipulation whenever possible (e.g., mixing, sieving, aeration, filtration).
11. Maintain sample integrity when possible (e.g., using core rather than grab [dredge] collection).
12. Characterize key components of all sample replicates.
13. Follow proper QA/QC practices.

[a] All sampling issue decisions must be based on the study objectives and their associated data quality objectives.

Source: Stormwater Effects Handbook