Sampling of Indicator Microorganisms and Interpretation

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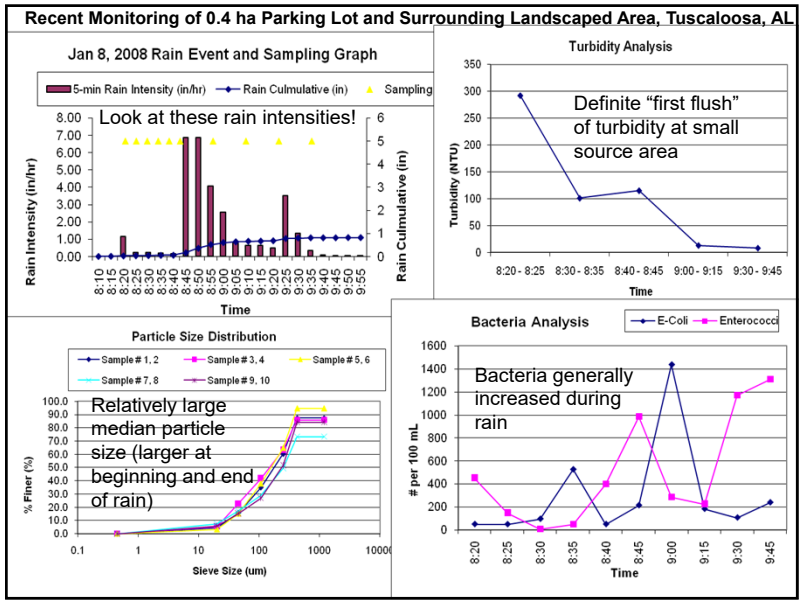

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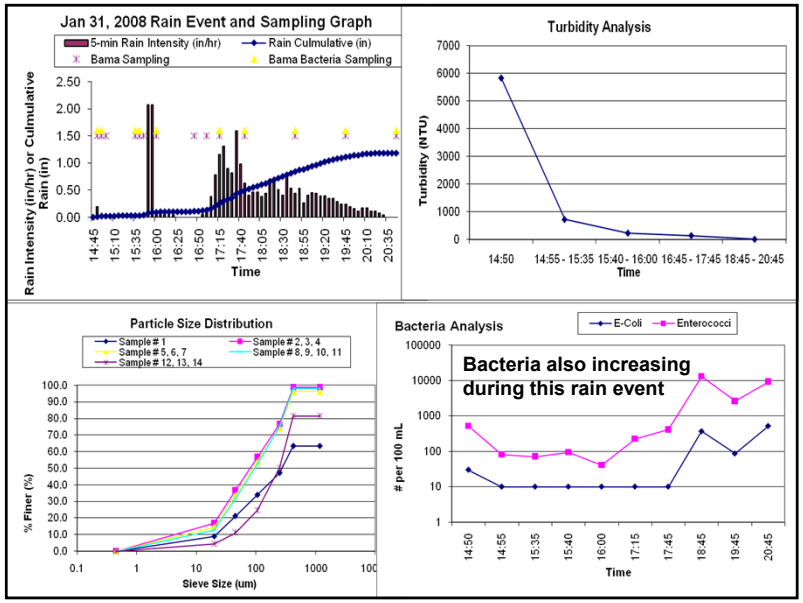

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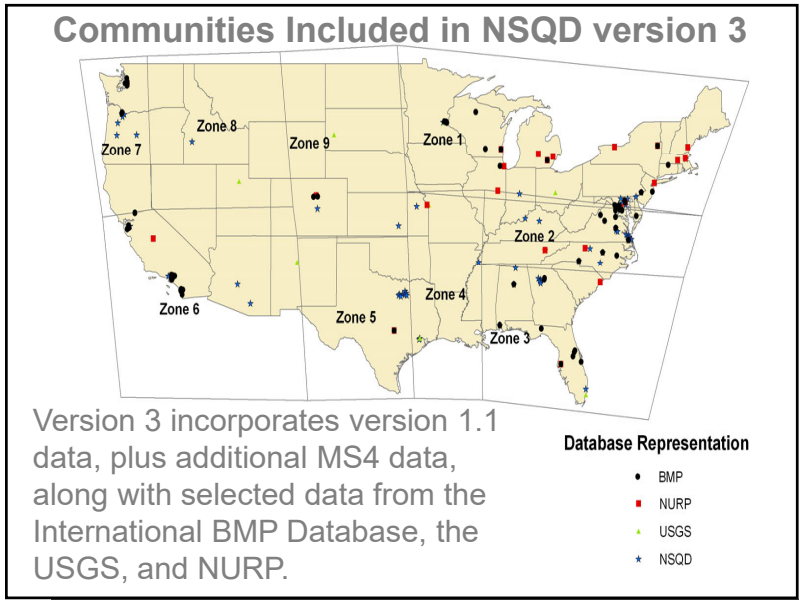

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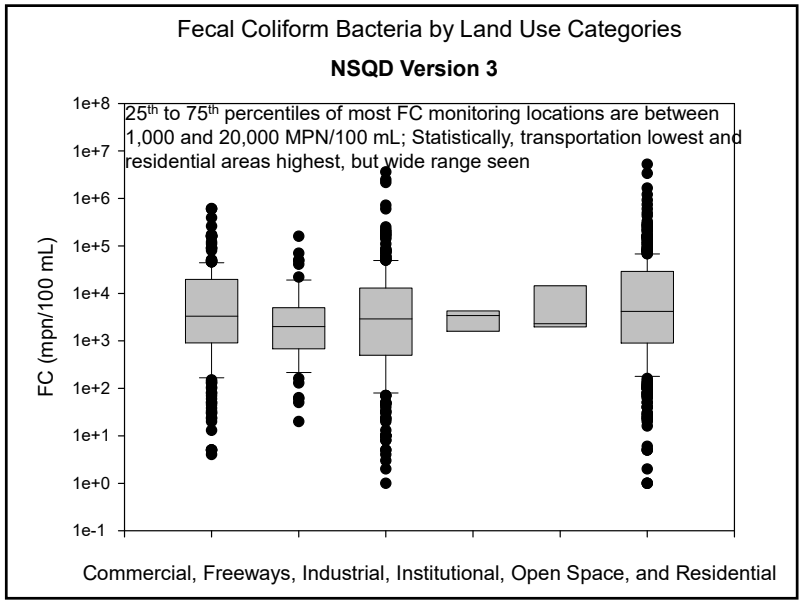
Fecal Coliform Bacteria by Land Use Categories
NSQD Version 3
25th to 75th percentiles of most FC monitoring locations are between 1,000 and 20,000 MPN/100 mL; Statistically, transportation lowest and residential areas highest, but wide range seen
FC (mpn/100 mL)
1e+8
1e+7
1e+6
1e+5
1e+4
1e+3
1e+2
1e+1
1e+0
1e-1
Commercial, Freeways, Industrial, Institutional, Open Space, and Residential

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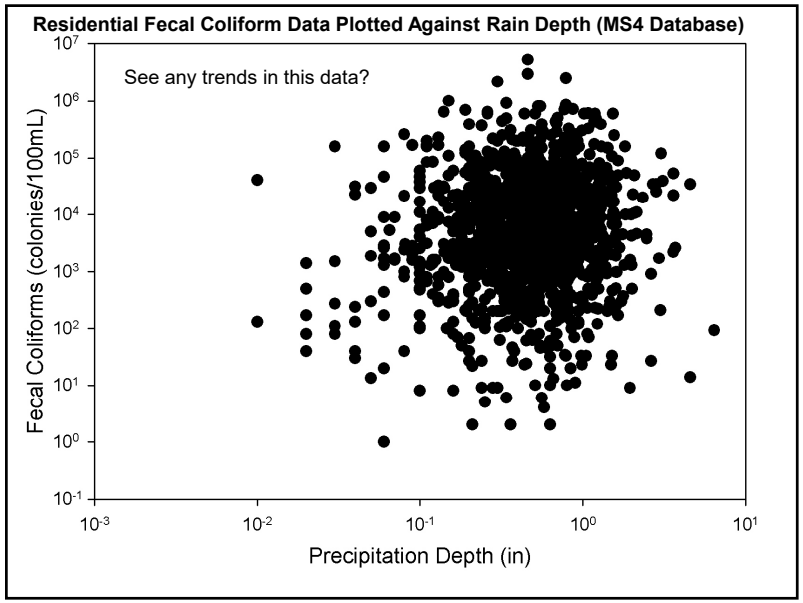
Residential Fecal Coliform Data Plotted Against Rain Depth (MS4 Database)
See any trends in this data?
Fecal Coliforms (colonies/100mL)
Precipitation Depth (in)

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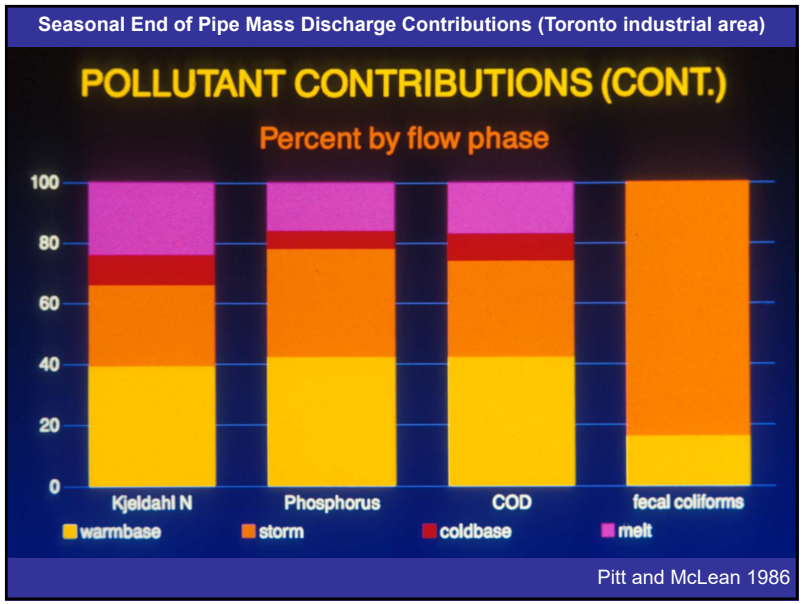
Seasonal End of Pipe Mass Discharge Contributions (Toronto industrial area)
POLLUTANT CONTRIBUTIONS (CONT.)
Percent by flow phase
100
80
60
40
20
0
Kjeldahl N
Phosphorus
COD
fecal coliforms
warmbase
storm
coldbase
melt
Pitt and McLean 1986

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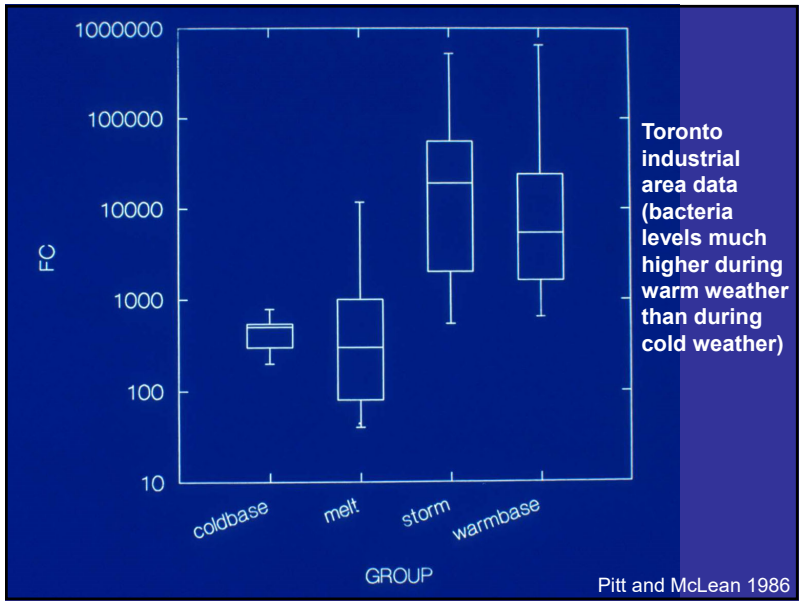
1000000
100000
10000
1000
100
10
FC
coldbase
melt
storm
warmbase
GROUP
Toronto industrial area data (bacteria levels much higher during warm weather than during cold weather)
Pitt and McLean 1986

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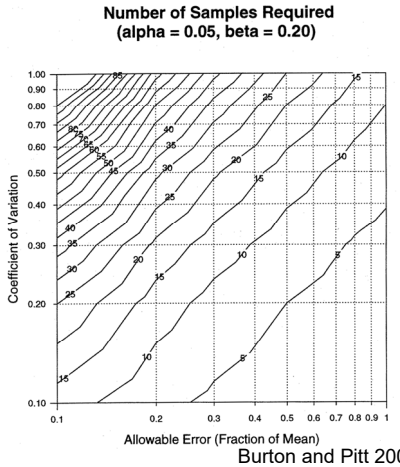
Experimental Design - Number of Samples Needed

The number of samples needed to characterize stormwater conditions for a specific site is dependent on the COV and allowable error. For most constituents and conditions, about 20 to 30 samples may be sufficient for most objectives. Most Phase 1 sites only have about 10 events, but each stratification category usually has much more.



Burton and Pitt 2002

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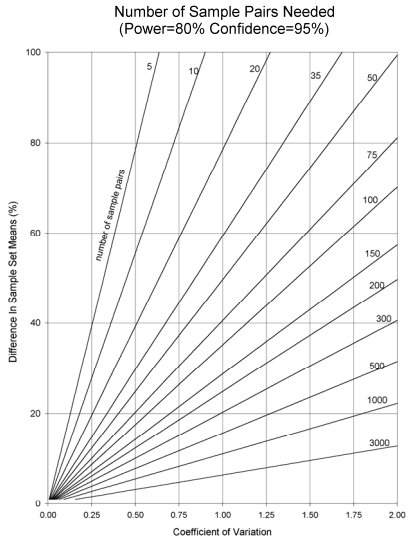

Much information will be needed to confirm performance of stormwater controls for bacteria.

Obviously, easier to confirm removals when the differences between influent and effluent are greatest.

Burton and Pitt 2002

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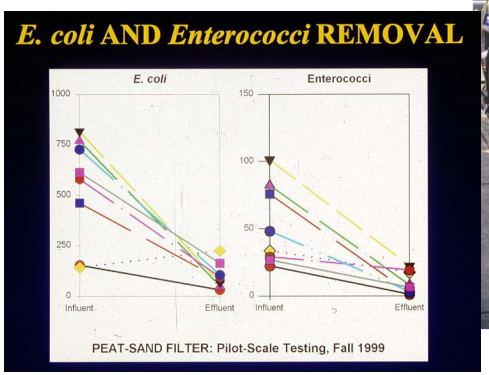
Pilot-scale filters examining many different media.



Significant reductions observed with relatively few pairs of observations due to high levels of reductions observed

Clark 1996 and 2000

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Bacteria Source Area Sampling Effort, Tuscaloosa, AL 2005 (Shergill 2004)

202 wet weather samples analyzed for *E. coli* and enterococci

- 10-12 sample pairs collected from each source area
- 176 source area samples analyzed
- Additional tests investigated effects of different sampling handling conditions (time, refrigeration, and agitation)

278 dry weather samples analyzed for *E. coli* and enterococci

- 142 reference samples (dry weather flow potential sources)
- 136 creek outfall samples analyzed

Total of 480 Samples analyzed using IDEXX methods

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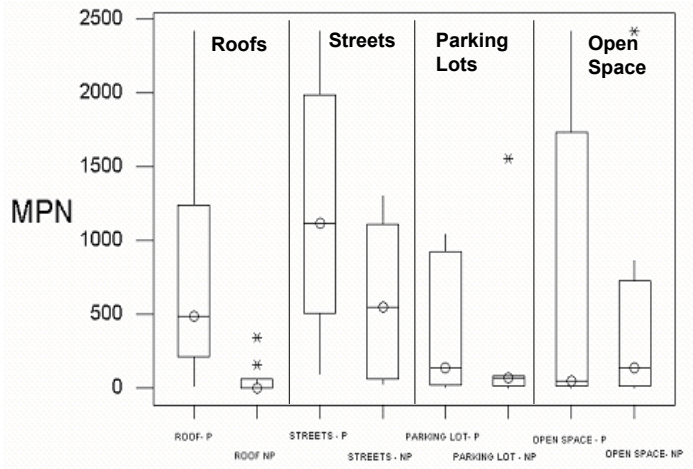
Comparison of Sites Prone and Not Prone to Urban Wildlife Use (*E. coli*)



Warm Months

Shergill 2004

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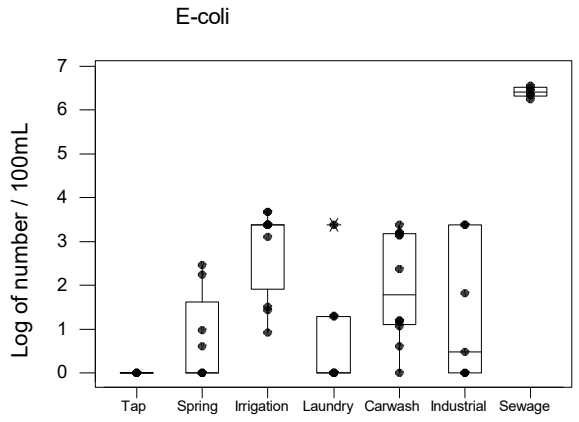
Dry Weather Reference Sample Results (other sources of urban water bacteria levels)



Shergill 2004

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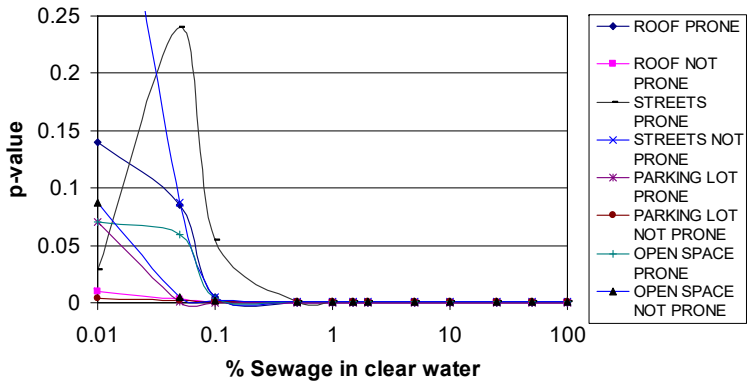
Stormwater v/s Sewage -*E. coli*



Can detect relatively low levels of sewage contamination in urban waters due to the very high bacteria levels found in raw sewage. However, urban wildlife can cause E. coli levels to 12,000 MPN/100mL without evidence of sewage.

Shergill 2004

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Sediment and Bacteria Washoff Tests and Source Area Sheetflow Monitoring, Toronto (Pitt and McLean 1986)

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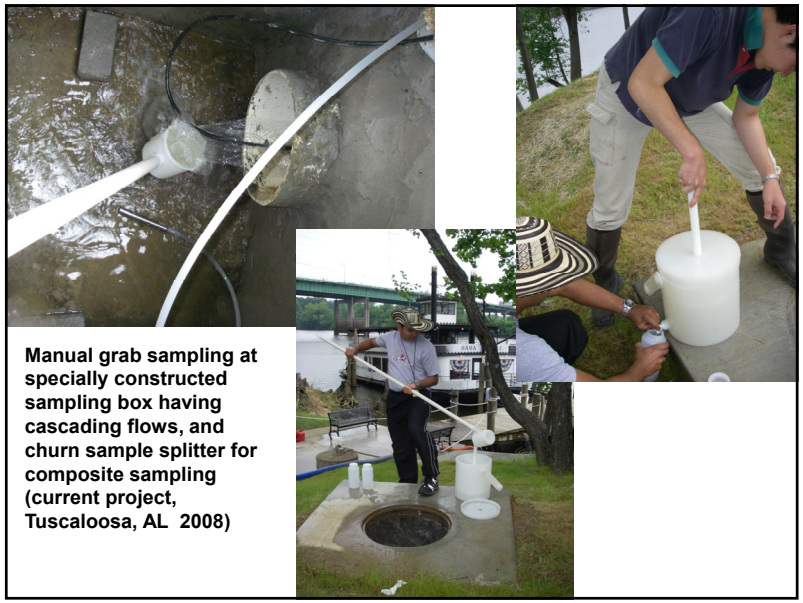

Manual grab sampling at specially constructed sampling box having cascading flows, and churn sample splitter for composite sampling (current project, Tuscaloosa, AL 2008)

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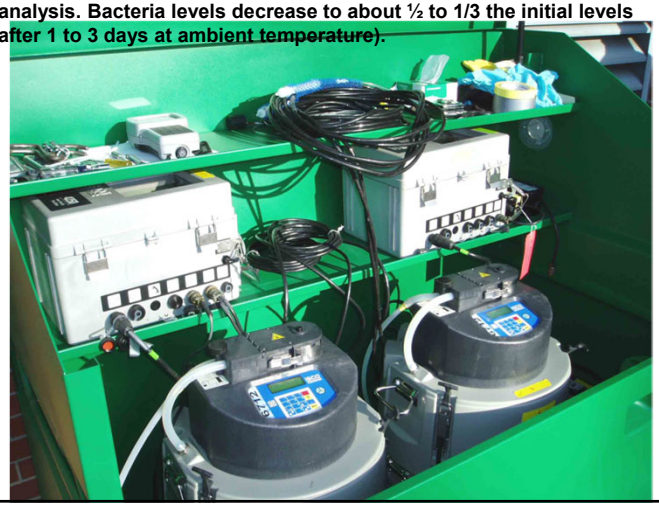
Paired Automatic Samplers to Collect Influent and Effluent Samples for Evaluating Stormwater Control

(OK if samples are brought to lab within about 6 hrs of collection for analysis. Bacteria levels decrease to about ½ to 1/3 the initial levels after 1 to 3 days at ambient temperature).



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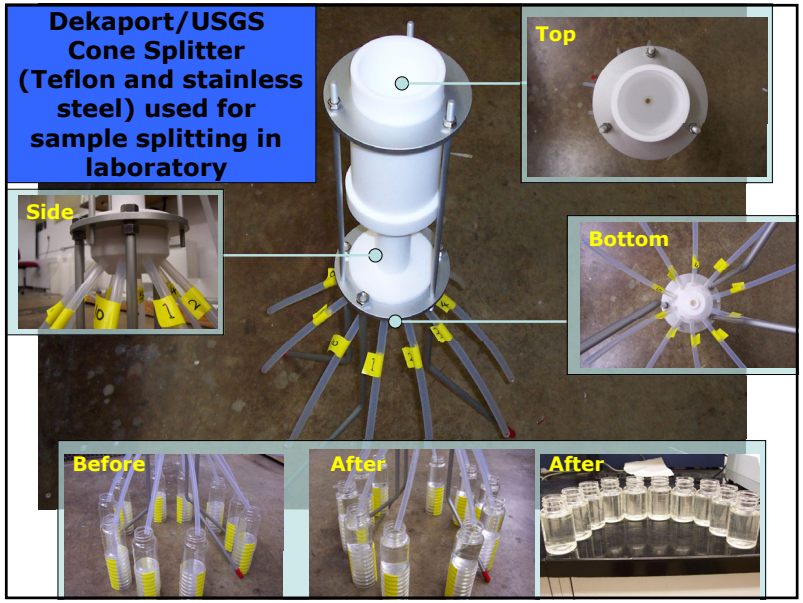
Dekaport/USGS Cone Splitter (Teflon and stainless steel) used for sample splitting in laboratory



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Fate of bacteria after discharge investigated in receiving waters during several studies

Five Mile Creek, Birmingham, AL, *In-Situ* Dieoff Study

Easton, *et al.* 1999

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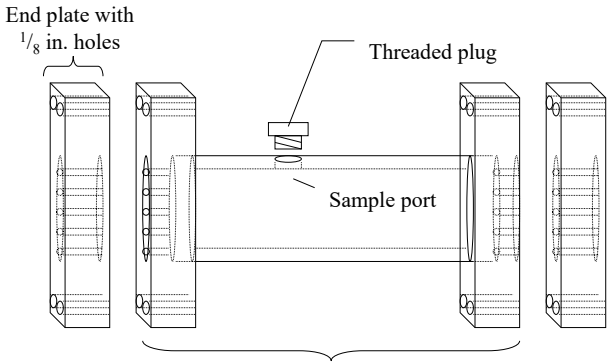
Acrylic Parts of *In-Situ* Chamber



Easton, *et al.* 1999

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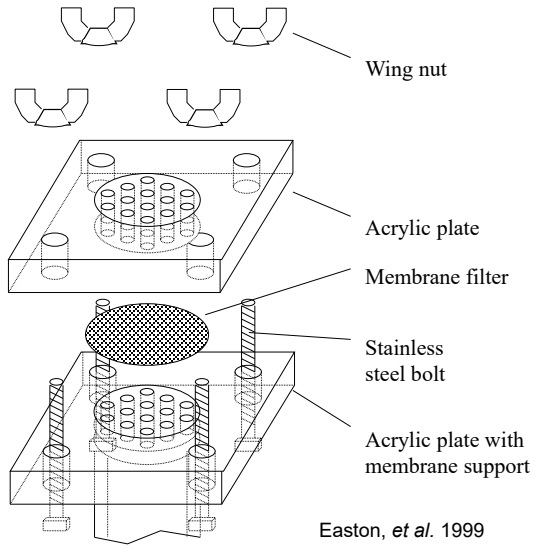
End Plate of *In-Situ* Chamber Showing Location of Membrane Filter.

Note the filter is supported on both surfaces.



Easton, *et al.* 1999

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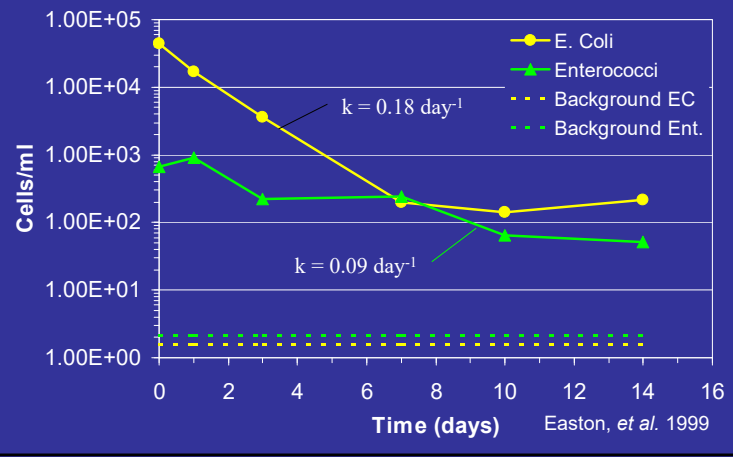
Die-off Curves for *E. coli* and Enterococci



Easton, *et al.* 1999

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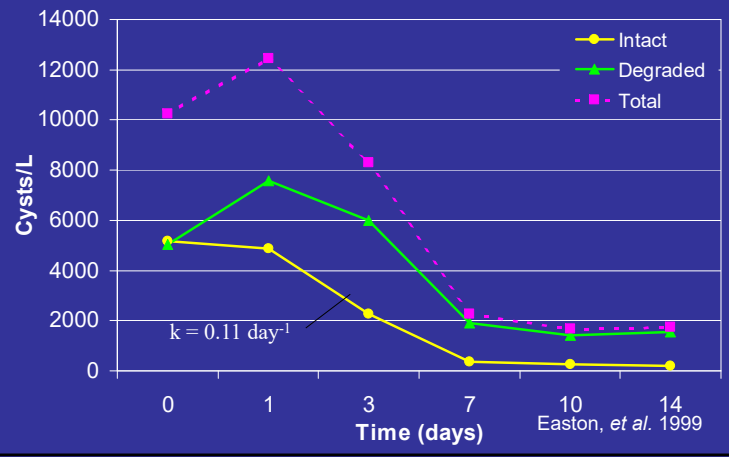
Die-off Curve for *Giardia lamblia*



Easton, *et al.* 1999

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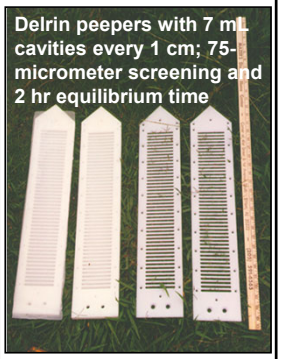
Fate of Bacteria after Discharge: Interstitial Water Bacteria Levels using Peepers

Peeper being pushed partway to sediments

Urban pond site (also did creeks)



Delrin peepers with 7 mL cavities every 1 cm; 75-micrometer screening and 2 hr equilibrium time

Ellis, *et al.* 1998

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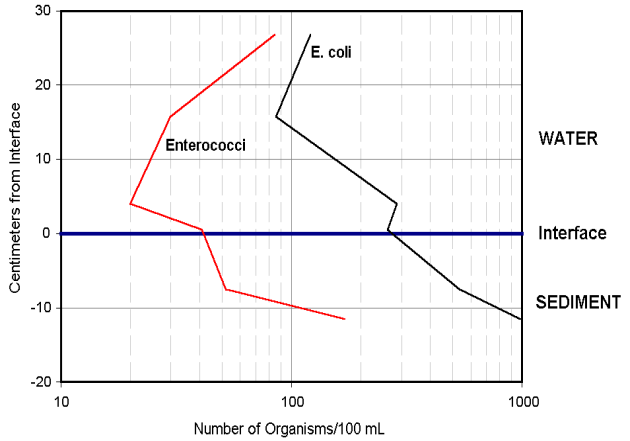
Bacteria Profile in East Lake



Bacteria levels increase near sediment interface and are elevated in interstitial water.

Ellis, *et al.* 1998

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Ending Comments

- **Need to study bacteria sources, transport, treatment, and fate (complete mass balance) to understand relationships between receiving water uses and controls.**
- **Stormwater bacteria is not source limited: it frequently increases during large events, even while other constituents decrease.**
- **Many samples are needed to characterize bacteria levels due to very large variations.**
- **Urban wildlife and pets can be significant sources of indicator bacteria in urban areas: just because standards are exceeded does not mean that sewage contamination exists.**
- **Fate of bacteria includes traditional dieoff, but sedimentation also important. Equilibrium conditions are reached where further reductions are much slower.**
- **High levels of bacteria are found in urban stream sediment interstitial water.**
- **Bacteria analyses need to be conducted soon after the event. Samples need vigorous agitation to break up possible large colonies of bacteria before analyses. Samples should be divided using a cone splitter, as needed, before analysis.**

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