# Sources of Bacteria and their Variability in Urban Watersheds

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1

1

## Observed Bacteria Data in the National Stormwater Quality Database, version 3 (average and COV)

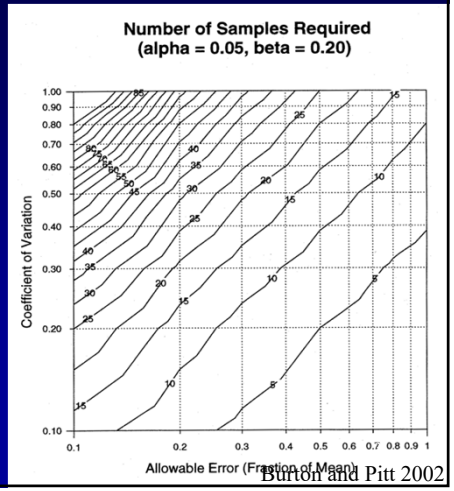
| Land Use (number of observations) | Fecal Coliform (CFU/100 mL) |
|---|---|
| Overall (2,154) | 47,700 (5.0) |
| Residential (505) | 55,900 (5.7) |
| Commercial (270) | 26,100 (3.0) |
| Industrial (317) | 47,300 (6.1) |
| Freeways (67) | 8,600 (2.7) |
| Open Space (7) | 7,300 (1.2) |

**Very large variabilities and widely ranging numbers of samples**

2

## 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 fecal coliforms, the COV values are very large (1.2 to 6.1 in the NSQD). A typical goal of 25% allowable errors would require hundreds of samples, unless a better understanding/explanation of the variability was possible.

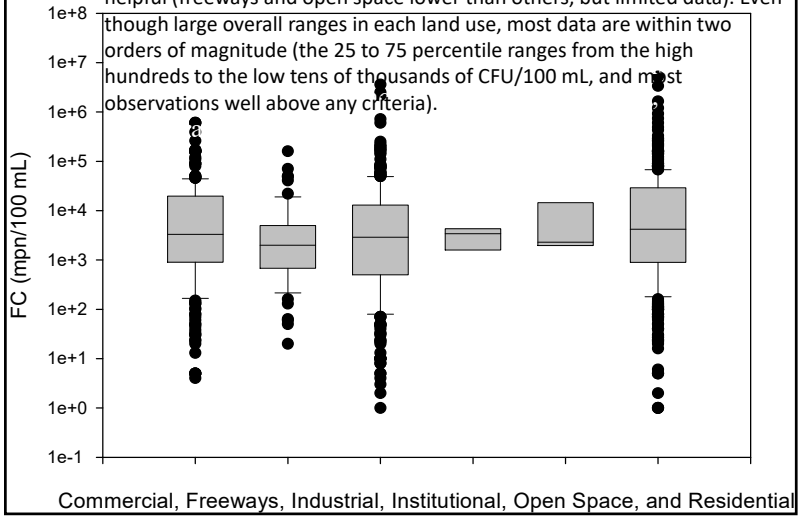



Burton and Pitt 2002

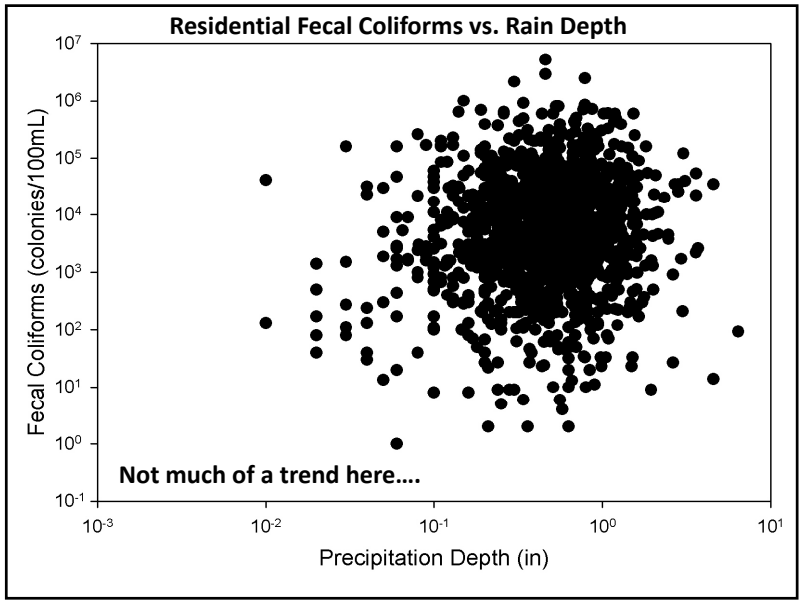
3

## Fecal Coliform Bacteria by Land Use Categories

As noted before, the differences between land uses may be somewhat helpful (freeways and open space lower than others, but limited data). Even though large overall ranges in each land use, most data are within two orders of magnitude (the 25 to 75 percentile ranges from the high hundreds to the low tens of thousands of CFU/100 mL, and most observations well above any criteria).

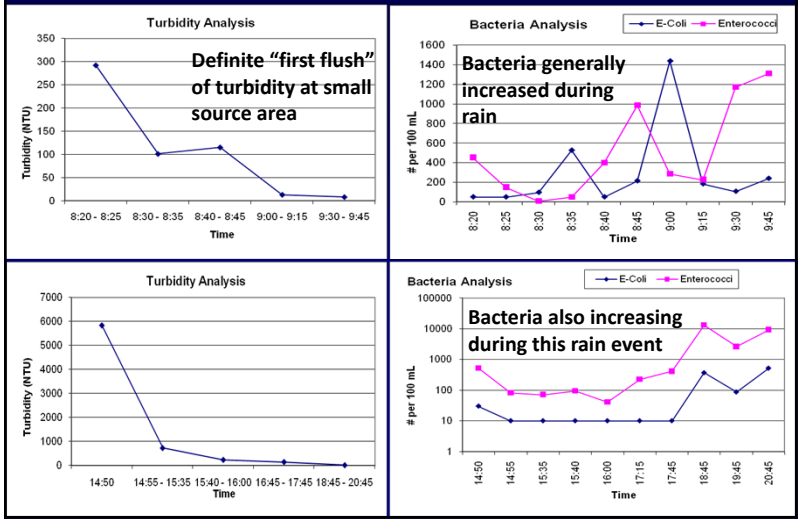



4



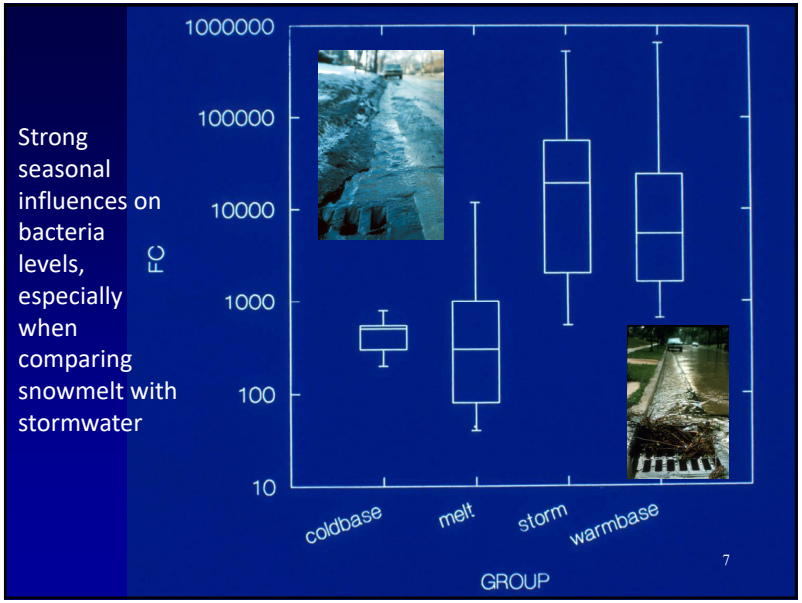

5

## Monitoring of 0.4 ha Parking Lot and Surrounding Landscaped Area, Tuscaloosa, AL




6

Strong seasonal influences on bacteria levels, especially when comparing snowmelt with stormwater




7

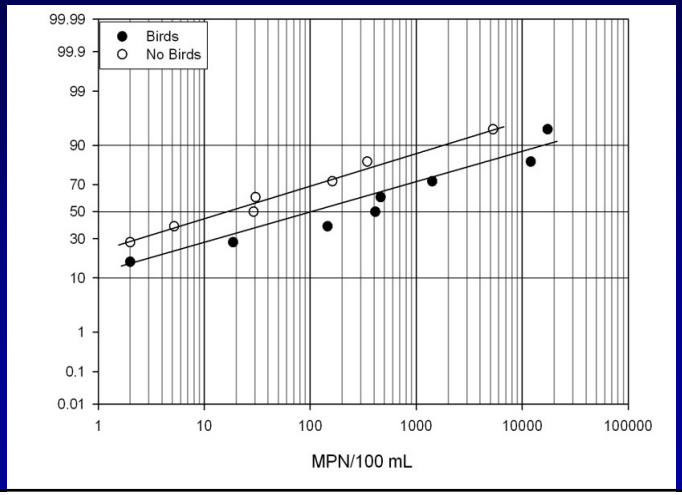
## Tuscaloosa, AL, "Library" File Data (flow components affect combined water quality)

| Mean/COV | *E. Coli* (CFU/100 mL) | Enterococci (CFU/100 mL) |
|---|---|---|
| Tap water | 0 (0) | 0 (0) |
| Spring water | 2.4 (0.8) | 1.0 (1.6) |
| Car wash water | 1480 (0.07) | 1213 (1.4) |
| Industrial wastewater | 409 (2.7) | 477 (2.3) |

Potential baseflow components during warm weather

8

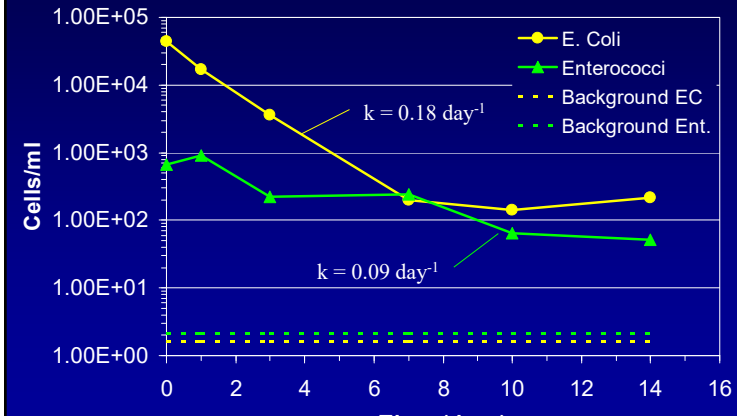
Roof runoff *E. coli* levels greatly affected by overstory trees that provide habitat for urban wildlife (squirrels and birds)




9

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

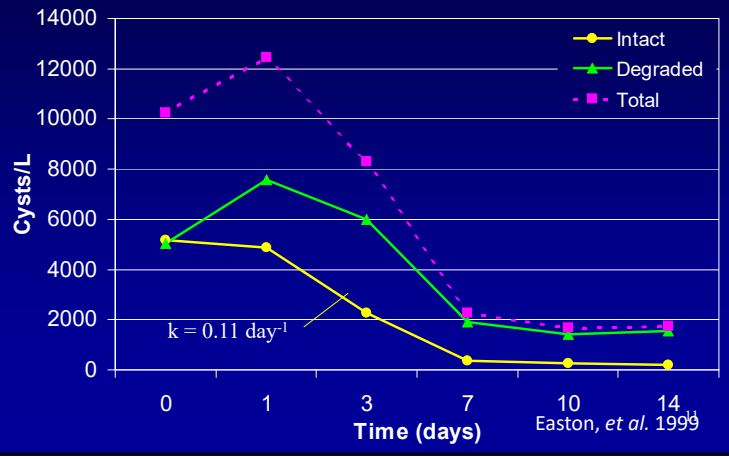
**Die-off curves for *E. coli* and Enterococci during *in-situ* microcosm tests**




Easton, *et al.* 1999

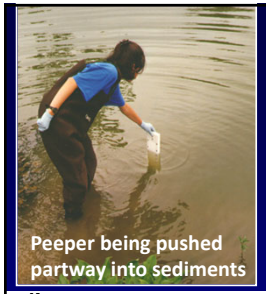
10

## *In-situ* microcosm tests of die-off curves for *Giardia lamblia* in urban receiving waters



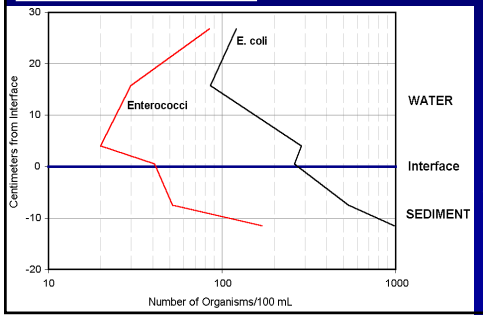

Easton, *et al.* 1999

11




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

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




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

Ellis, *et al.* 1998

12

## Full Factorial Experiment to Investigate Bacteria Survival on Pavement and Urban Soils: Moisture, temperature, and light vs. time

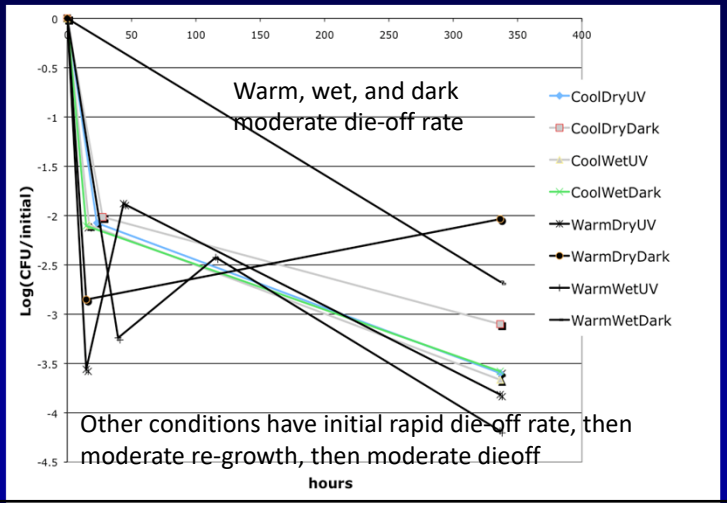
| | |
|---|---|
| Warm (90$^0$ F) Dry (~30% RH) | Warm (90$^0$ F) Moist(~85% RH) |
| UV Shielded | UV Shielded |
| Cool (40$^0$ F) Dry (38% RH) | Cool (40$^0$ F) Moist(~85% RH) |
| UV Shielded | UV Shielded |


Wilson 2011

13

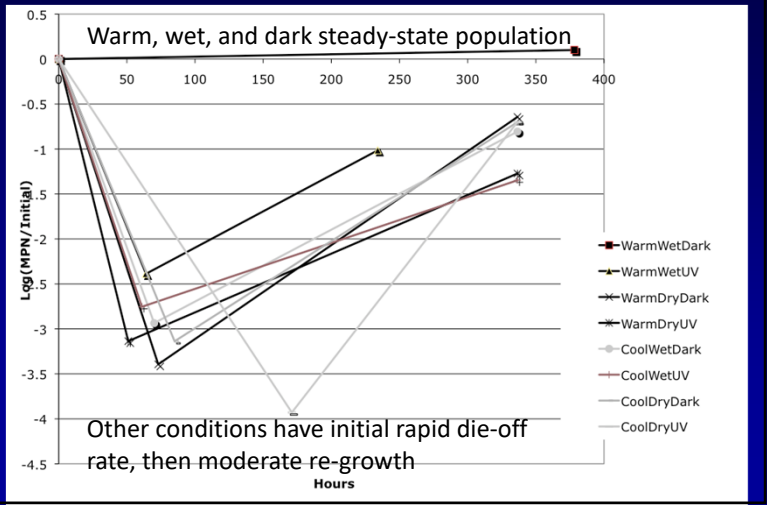
13

## *E. coli* survival on concrete for different environmental conditions




14

## Enterococci survival on concrete for different environmental conditions




15

## Conclusions

- Stormwater bacterial levels are high and variable, requiring many storm samples to confidently quantify.
- Some differences by land use (as expected, most open space areas have lower bacteria levels than developed areas).
- Seasonal variations very important (especially comparing stormwater with snowmelt)
- Many factors affect stormwater bacteria levels: contamination by industrial or sewage and urban wildlife (and their habitats).
- Upon discharge, rapid die-off then reach equilibrium conditions.
- Sedimentation with increased populations near sediment/water interface and elevated interstitial water bacteria levels.
- Survival on concrete is similar, with potential several growth and die-off stages. Warm, dark, and moist conditions result in their greatest survival.

16

16


17