Sources of Pollutants in Urban Areas

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NSQD Median (COV)	SS (mg/L)	COD (mg/L)	Fecal colif. (#/100mL)	TKN (mg/L)	Cu (µg/L)
All data combined (3,770 events)	58 (1.8)	53 (1.2)	5090 (4.6)	1.4 (1.4)	16 (2.2)
Residential (1061 events)	48 (1.8)	55 (1.1)	7800 (5.1)	1.4 (1.3)	12 (1.8)
Open Space (62 events)	51 (1.9)	21 (1.8)	3100 (2.9)	0.6 (1.0)	5.3 (2.2)
Commercial (497 events)	43 (2.0)	63 (1.0)	4500 (2.8)	1.6 (0.9)	17 (1.5)
Industrial (518 events)	77 (1.5)	60 (1.2)	2500 (5.6)	1.4 (1.2)	22 (2.0)
Institutional (20 events)	17 (0.8)	50 (0.9)	n/a	1.4 (0.5)	n/a
Freeways (185 events)	99 (2.5)	100 (1.1)	1700 (1.9)	2.0 (1.4)	35 (1.0)

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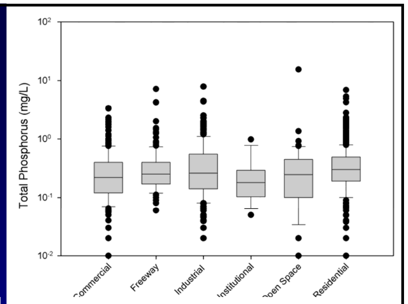
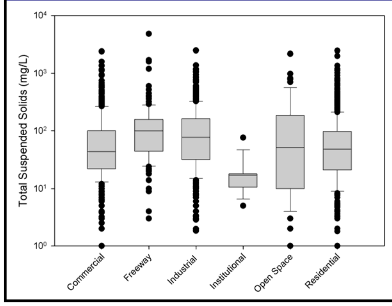
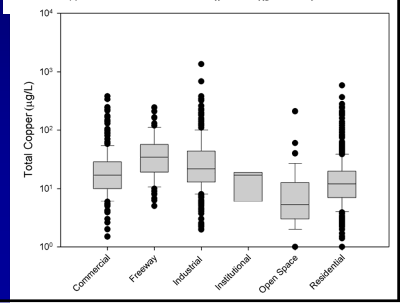
These grouped box-whisker plots sort all of the data by land use. Kruskal-Wallis analyses indicate that all constituents have at least one significantly different category from the others. Heavy metal differences are most obvious.







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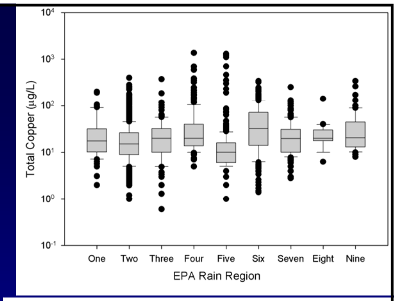
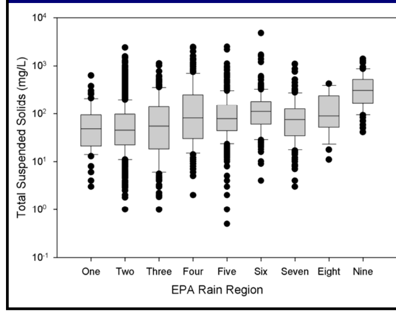
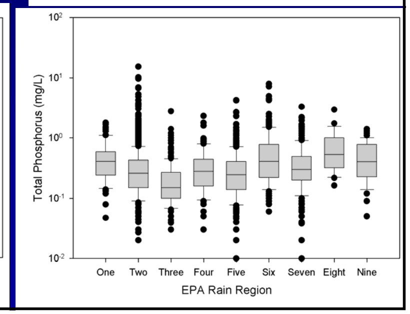
Residential area concentrations grouped by EPA rain zones. Zones 1-4 are east half of country, zones 5-9 are western half of country. Zones 3 and 7 are the wettest zones.







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Description of Eight WI DNR Study Areas

SITE	LAND USE	ACRES	# EVENTS
Harper	Residential	41	55
Monroe	Residential	232	75
Canterbury	Residential	964	55
Marquette	Resid/Com.	288	64
Superior	Commercial	22	91
West Town	Commercial	40	66
Syene Rd.	Industrial	114	108
Badger Rd.	Maint. Yard	4	40

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Source Area Monitoring to Predict Sources of Runoff Pollutants

- Controlled washoff tests
- Small area sheetflow sampling
- Large area sheetflow sampling
- Outfall monitoring

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SIGNIFICANT FACTORS AND ANOVA P VALUES

PAH:	
Fluoranthene	Rain depth * dry period (0.04)
Pyrene	Rain depth * dry period (0.03)
Benzo (b) fluoranthene	Rain depth * dry period (0.05)
Benzo (k) fluoranthene	Dry period (0.002)
Benzo (a) pyrene	Rain depth * dry period (0.03)
Naphthalene	Dry period (0.002)
Benzo (a) anthracene	Rain depth * dry period (0.04)
Phenanthrene	Dry period (0.003)

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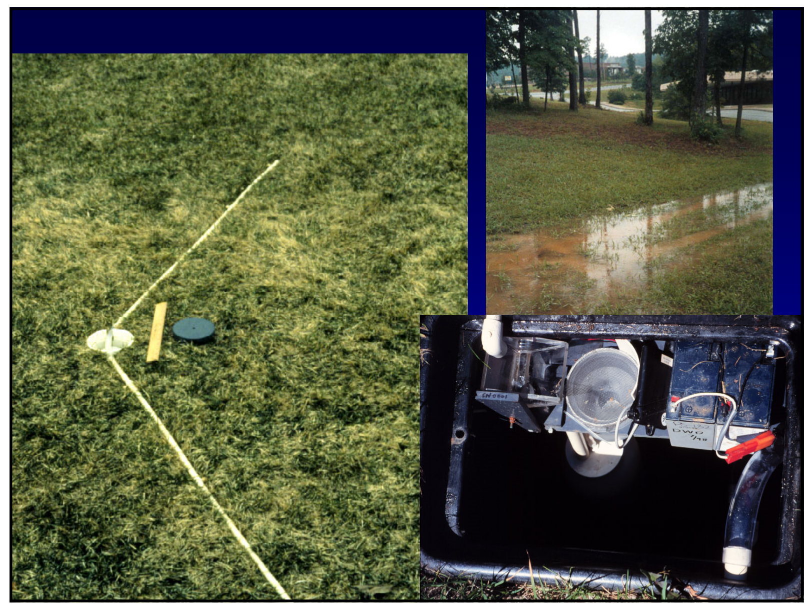

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Role of Modeling to Identify Stormwater Pollutant Sources and to Evaluate Controls

- Need to sort issues in complex systems.
- Use of Geographical Information Systems (GIS) allows efficient data management and presentation of information.
- GIS can integrate data from many sources and interface with watershed and receiving water models.
- Can focus on critical source areas and land uses.

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The Source Loading and Management Model (SLAMM)

- Developed during past 25 years during EPA, state, and Canadian funded research.
- Identifies pollutant sources during different rain and climatic conditions.
- Prioritizes subwatersheds and critical source areas.
- Evaluates alternative development scenarios, pollution prevention, and combinations of source area and outfall control options.

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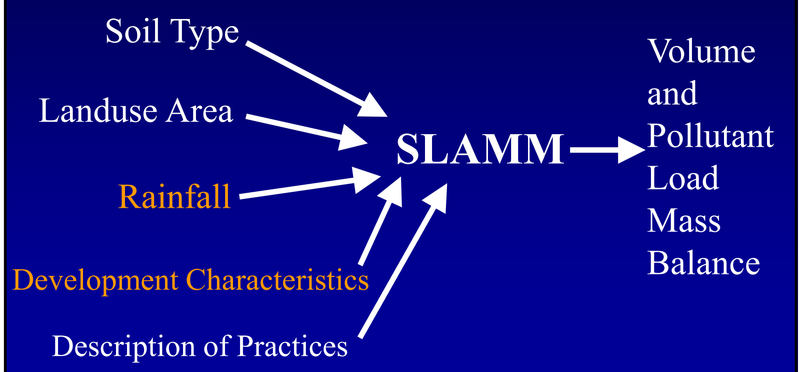
SLAMM Inputs and Outputs



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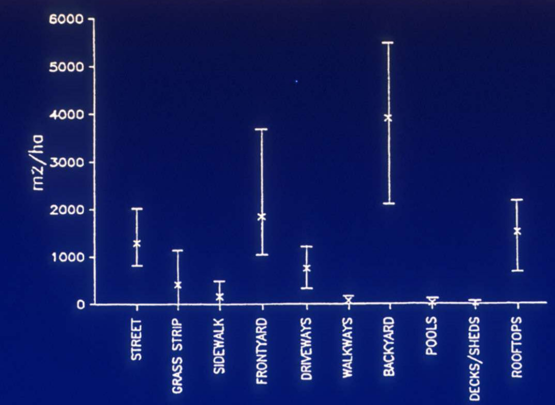
Source Areas - Milwaukee Medium Density Residential (without alleys)



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Medium Density Residential Development Characteristics

Source	% Area
• Roofs	15%
• Driveways	8%
• Sidewalks	2%
• Streets	13%
• Lawns	62%

Other Characteristics

Roofs: Pitched; % connected = 30%; Sandy Soils.

Driveways: % connected = 70%; Low/Med. Density

Streets: Texture = smooth; Length = 2 mi.; Dirt Accumulation = default value.

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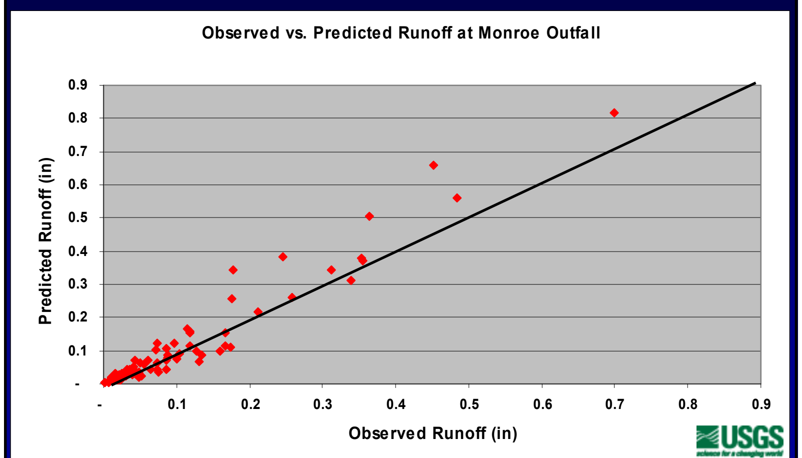

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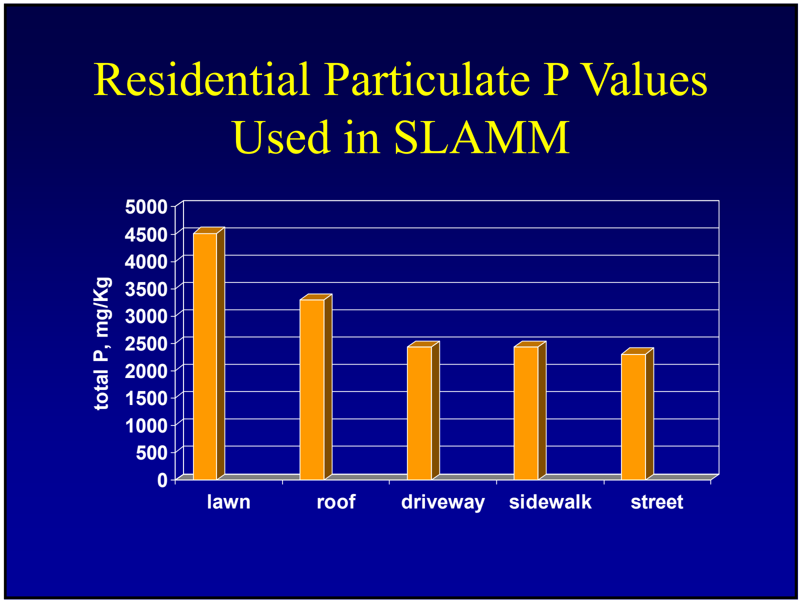
Residential Particulate P Values
Used in SLAMM
total P, mg/Kg
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
lawn
roof
driveway
sidewalk
street

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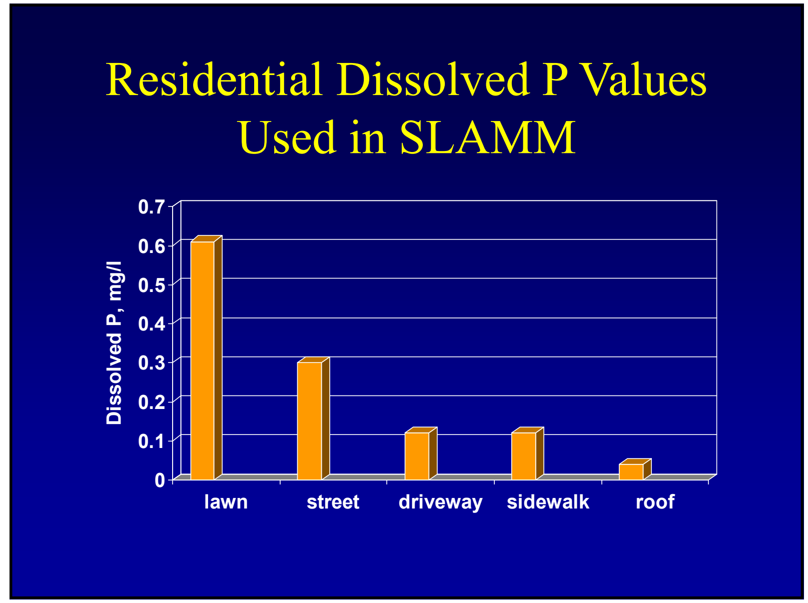
Residential Dissolved P Values
Used in SLAMM
Dissolved P, mg/l
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
lawn
street
driveway
sidewalk
roof

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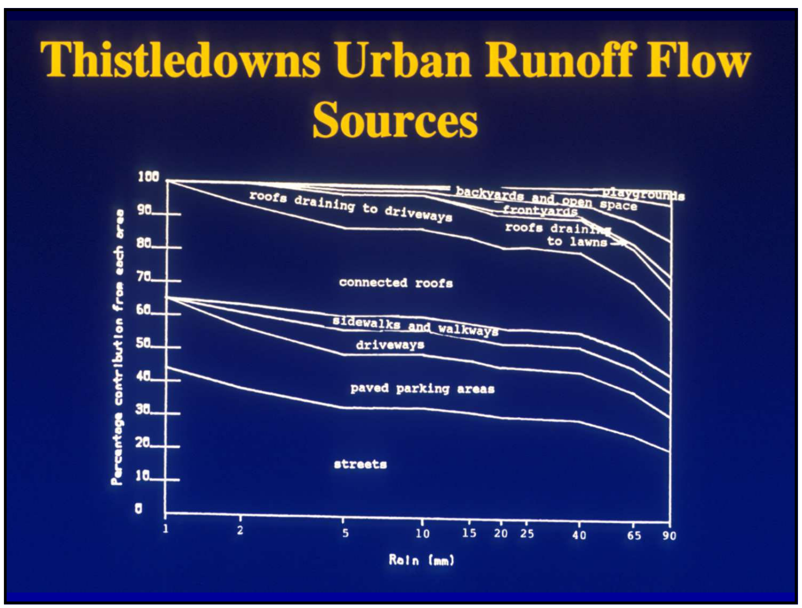
Thistledowns Urban Runoff Flow
Sources
Percentage contribution from each area
backyards and open space
playgrounds
frontyards
roofs draining to driveways
roofs draining
to lawns
connected roofs
sidewalks and walkways
driveways
paved parking areas
streets
Rain (mm)

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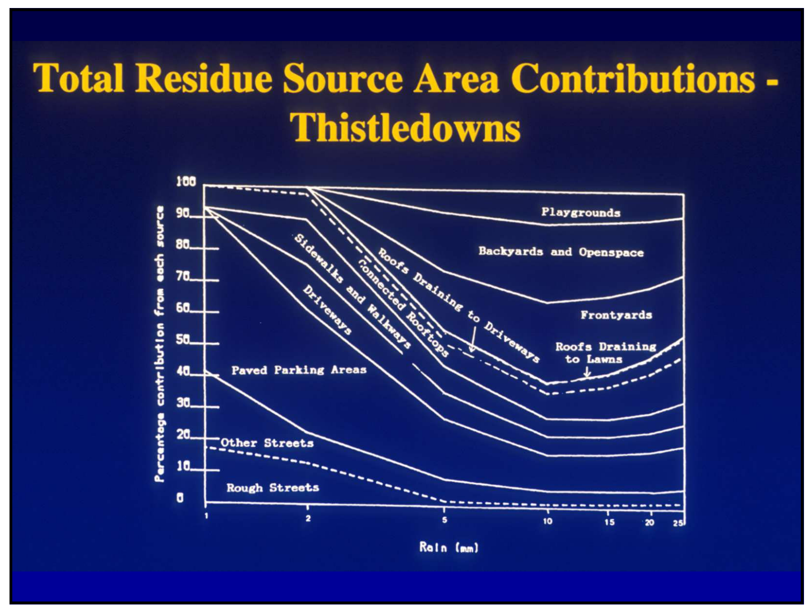
Total Residue Source Area Contributions -
Thistledowns
Percentage contribution from each source
Playgrounds
Backyards and Openspace
Frontyards
Roofs Draining to Driveways
Roofs Draining
to Lawns
Connected Rooftops
Sidewalks and Walkways
Driveways
Paved Parking Areas
Other Streets
Rough Streets
Rain (mm)

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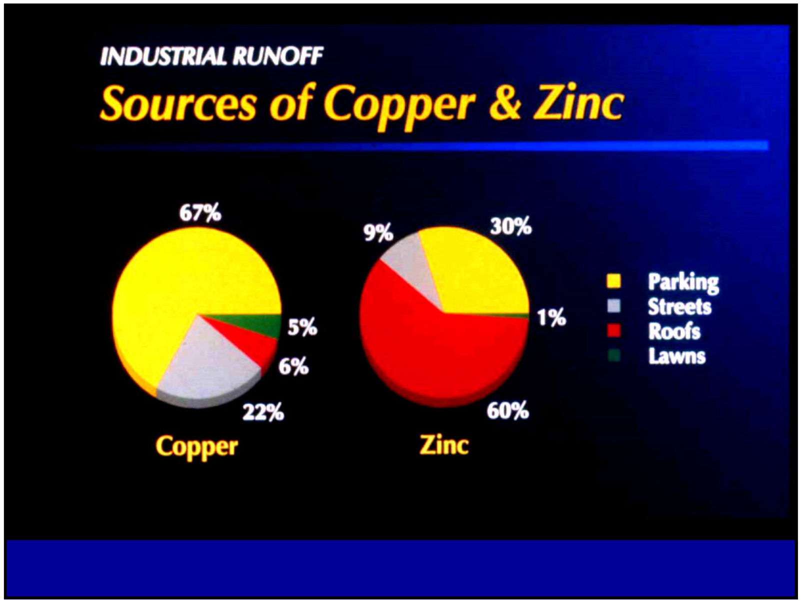
INDUSTRIAL RUNOFF
Sources of Copper & Zinc
67%
5%
6%
22%
Copper
9%
30%
1%
60%
Zinc
Parking
Streets
Roofs
Lawns

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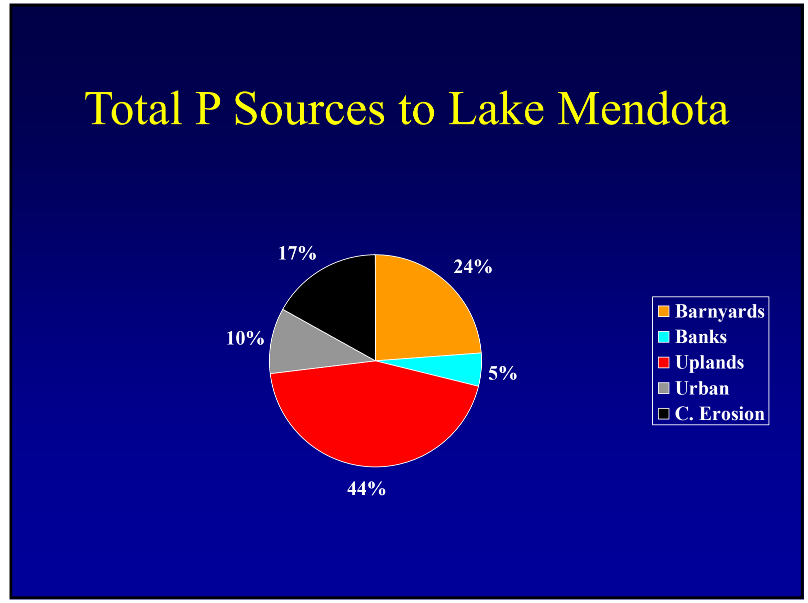
Total P Sources to Lake Mendota
17%
24%
10%
5%
44%
Barnyards
Banks
Uplands
Urban
C. Erosion

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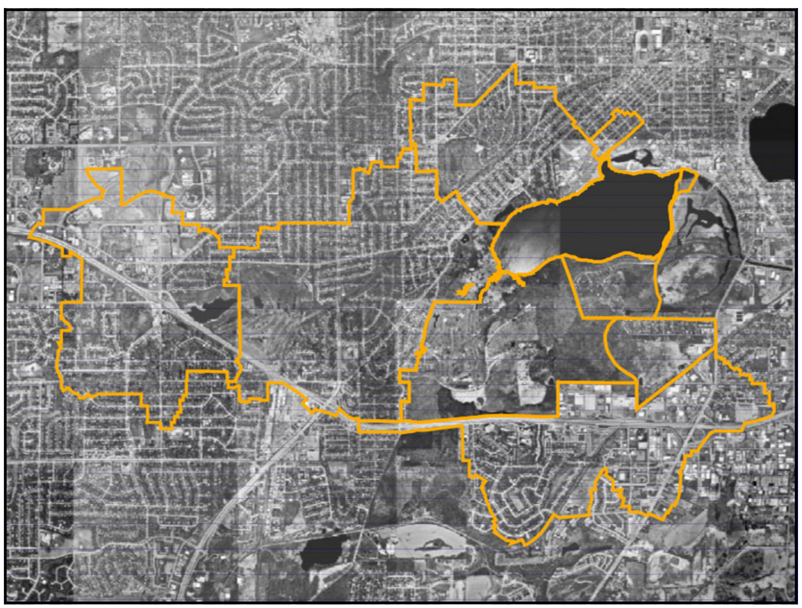

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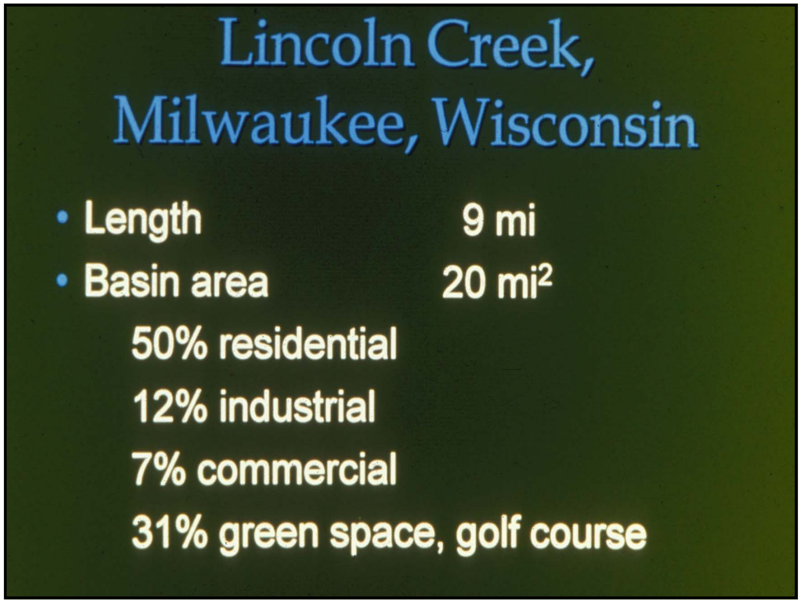
Lincoln Creek,
Milwaukee, Wisconsin
• Length 9 mi
• Basin area 20 mi2
50% residential
12% industrial
7% commercial
31% green space, golf course

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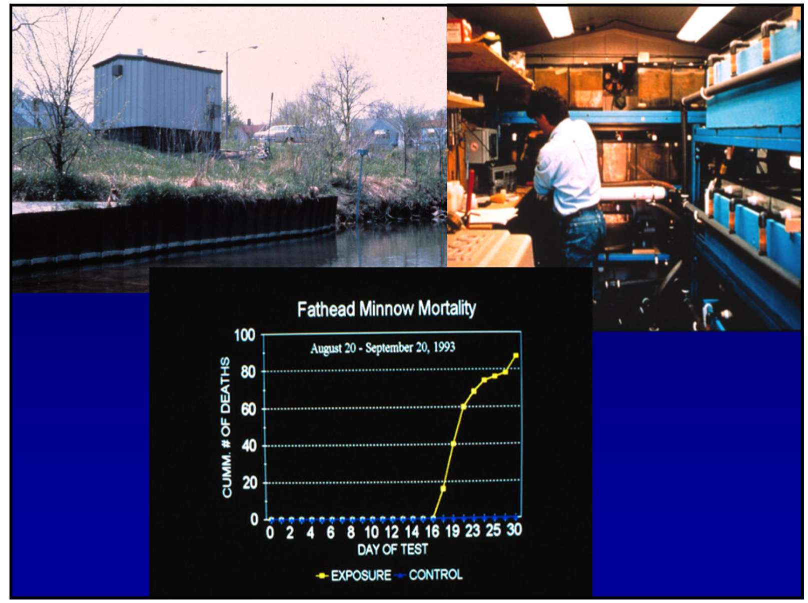
Fathead Minnow Mortality
August 20 - September 20, 1993
CUMM. # OF DEATHS
0 20 40 60 80 100
0 2 4 6 8 10 12 14 16 19 23 25 30
DAY OF TEST
EXPOSURE CONTROL

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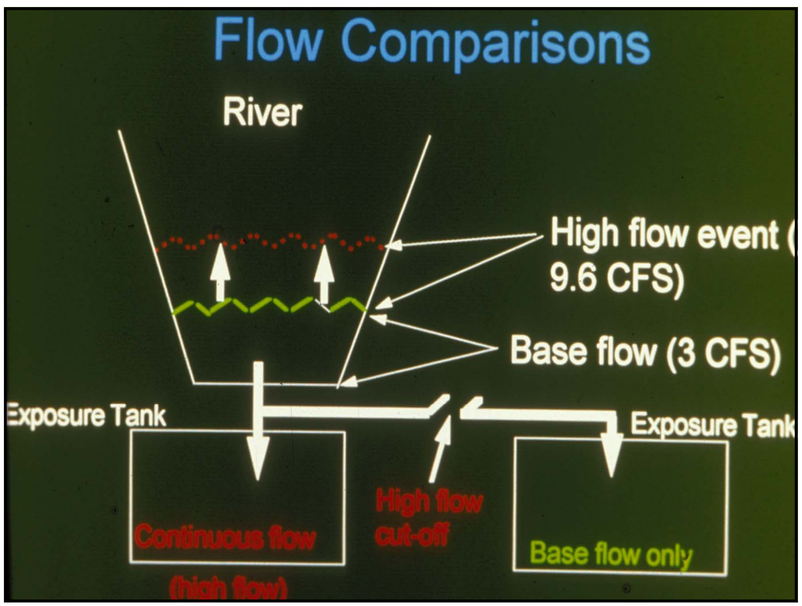
Flow Comparisons
River
High flow event (
9.6 CFS)
Base flow (3 CFS)
Exposure Tank
Exposure Tank
Continuous flow
(high flow)
High flow
cut-off
Base flow only

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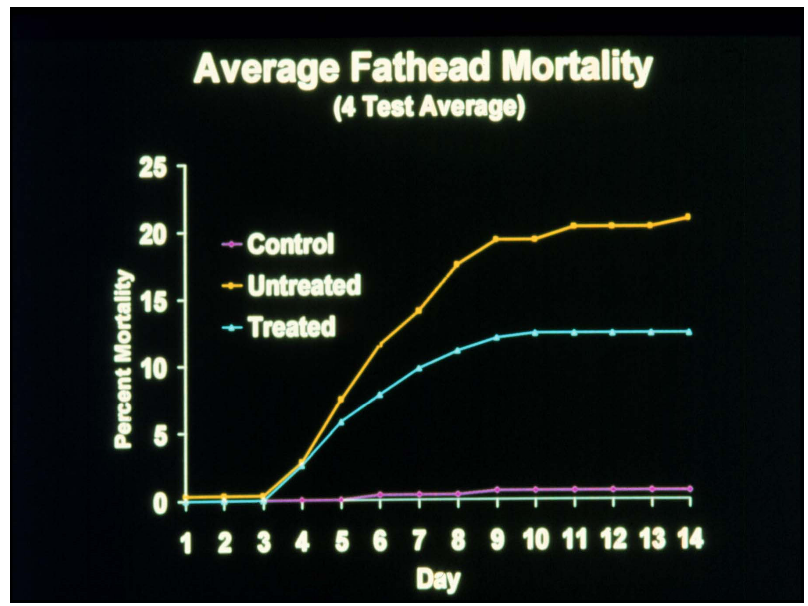
Average Fathead Mortality
(4 Test Average)
Percent Mortality
0 5 10 15 20 25
Control
Untreated
Treated
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Day

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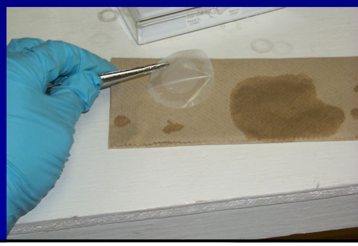
Sample Processing: Sieve Analyses





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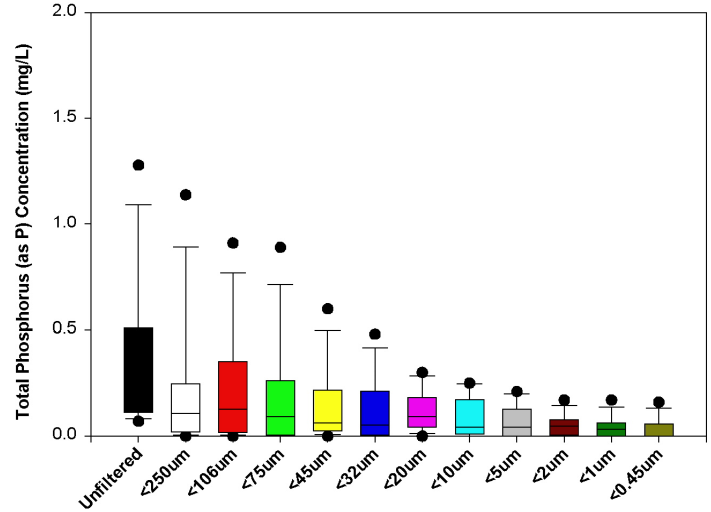

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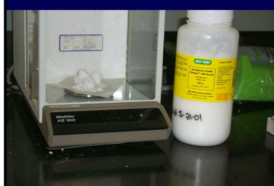
Sample Processing: Organo-Metallic Complexes



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Sample Processing: Metal Binding Strength


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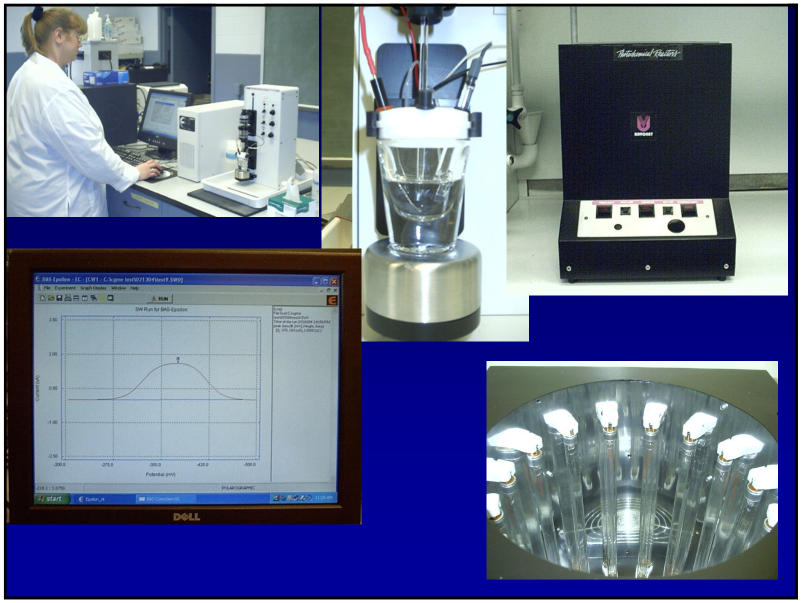

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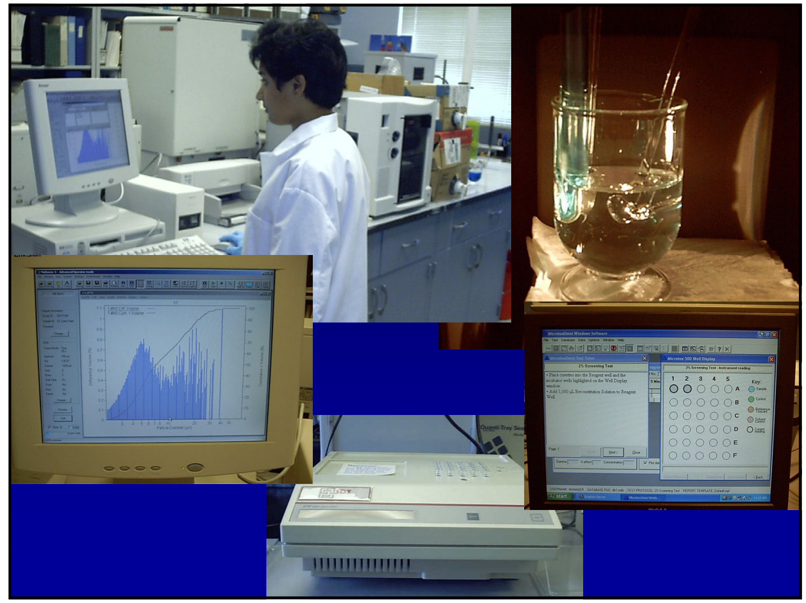

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Metal Associations

- Co-precipitation of iron and sulfate-reducing bacteria with stormwater heavy metals.
- Retention of stormwater pollutants to media under extended anaerobic and aerobic conditions.
- Stormwater pollutant associations with different particle sizes.
- Metal "binding strength" for different pH conditions.
- "Dissolved" metal associations with colloids.
- "Dissolved" Metal associations with organic compounds.

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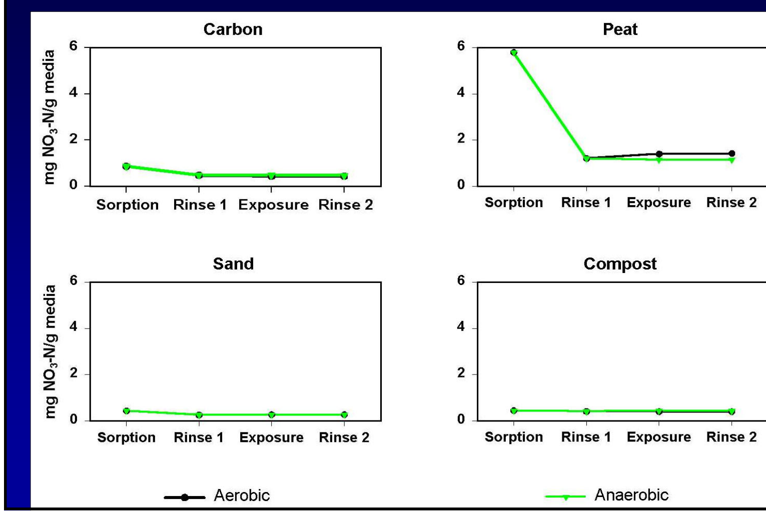
Behavior of Nitrate-N under Aerobic and Anaerobic Conditions



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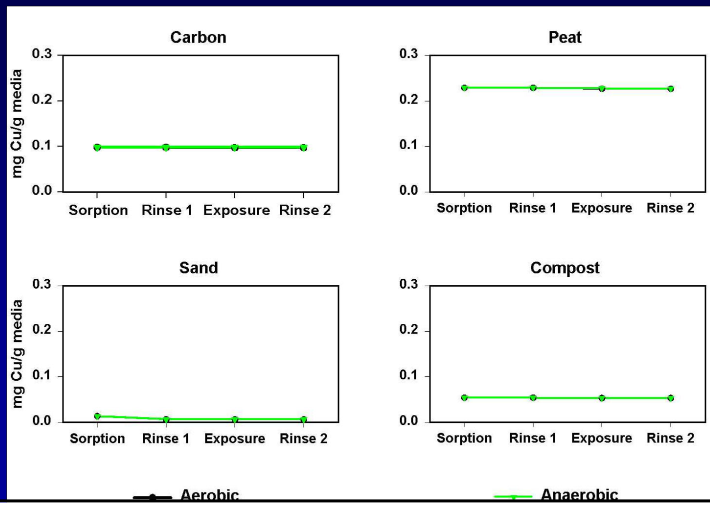
Behavior of Copper under Aerobic and Anaerobic Conditions



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Colloidal and Ionic Form Analyses

- The Chelex-100 resin (5 g of resin mixed with 100 mL of filtered stormwater sample and shaken for 1 hr) separates ionic forms of metals from metals strongly bound to the metal-ligand complexes or those strongly adsorbed to colloidal particles.
- After the Chelex exposure, the sample is filtered again to remove the newly bound material (the ionic forms) and the Chelex. The filtered sample is then irradiated with UV to separate the colloidal and organo-metallic associations.

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Minocqua, WI, MCTT Installation

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Pilot-Scale Test Results

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Wisconsin Full-Scale MCTT Test Results

(median % reductions and median effluent quality)	Milwaukee (15 events)	Minocqua (7 events)
Suspended Solids	98 (<5 mg/L)	85 (10 mg/L)
Phosphorus	88 (0.02 mg/L)	>80 (<0.1 mg/L)
Copper	90 (3 µg/L)	65 (15 µg/L)
Lead	96 (1.8 µg/L)	nd (<3 µg/L)
Zinc	91 (<20 µg/L)	90 (15 µg/L)
Benzo (b) fluoranthene	>95 (<0.1 µg/L)	>75 <0.1 µg/L)
Phenanthrene	99 (<0.05 µg/L)	>65 (<0.2 µg/L)
Pyrene	98 (<0.05 µg/L)	>75 (<0.2 µg/L)

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Development of other Control Devices

- Multiple treatment processes can be incorporated into other stormwater treatment units sized for various applications.
  - Gross solids and floatables control (screening)
  - Capture of fine solids (settling or filtration)
  - Control of targeted dissolved pollutants (sorption/ion exchange)

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Upflow filter insert for catchbasins

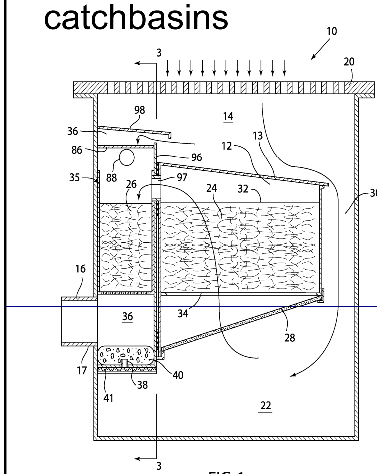

FIG. 1

Upflow Filter^{TM} patent pending

Uses sedimentation (22), gross solids and floatables screening (28), moderate to fine solids capture (34 and 24), and sorption/ion exchange of targeted pollutants (24 and 26). Upflow significantly reduces clogging of media common to most stormwater filters.

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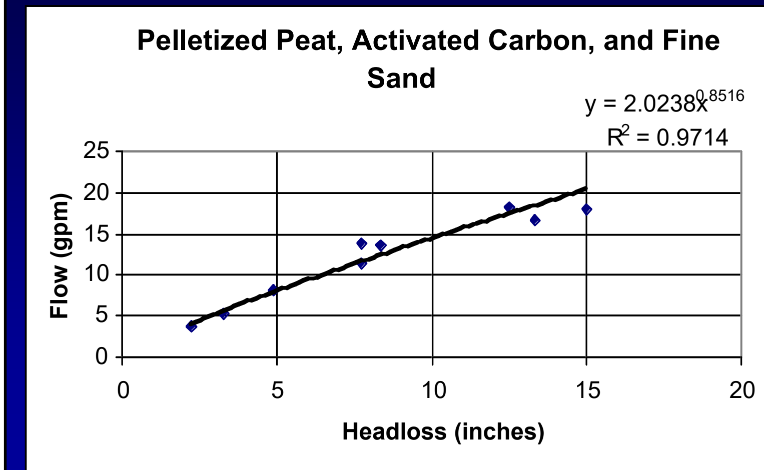
Successful flow tests using prototype unit and mixed media as part of EPA SBIR phase 1 project. Phase 2 awarded and further tests will start shortly, including ETV.



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Zinc Control with Upflow Filter™ Unit

- The MS4 NSQD indicates an overall averaged filtered zinc stormwater concentration of about 52 µg/L.
- WERF metal removal project (Johnson, *et al.* 2003) uptake experiments found that one of the mixtures of media that can be used in the Upflow Filter™ (activated carbon, pelletized peat, and fine sand) has an uptake capacity equal to the amount of filtered zinc in about 600 cubic meters of runoff.
- This would correspond to about 0.4 acres of pavement and 0.5 m of rainfall before the uptake capacity would be exceeded.
- This corresponds to about a 2 acre residential or 0.5 acre commercial area, with maintenance of once or twice a year.

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Conclusions

- The bench-scale treatability tests conducted during the development of the MCTT showed that a treatment train was needed to provide redundancy because of frequent variability in sample treatability storm to storm, even for a single sampling site.
- Possible to develop other stormwater controls that provide treatment train approach. Available research reports describe stormwater characteristics for critical source areas and treatability requirements.

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