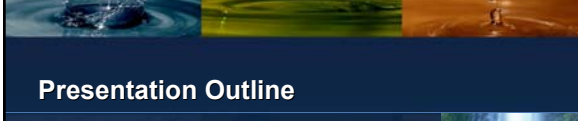


## Oregon's Stormwater Runoff Quality -- Managing Through Underground Injection Control Systems


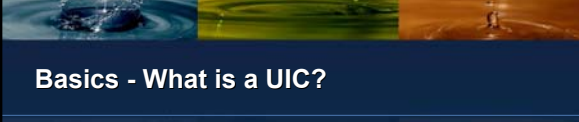
21 April 2009

Barbara Adkins - City of Portland  
Becky Brosnan - Kennedy/Jenks Consultants



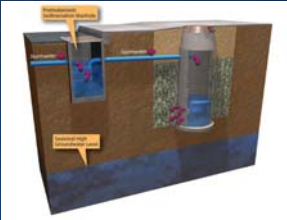
## Presentation Outline

- ♦ Basics of UIC's
- ♦ ACWA UIC Efforts
- ♦ ACWA - Oregon Stormwater Quality
- ♦ Portland UIC Program
  - ♦ Monitoring
  - ♦ Stormwater quality
  - ♦ Addressing exceedances
- ♦ Questions / Discussion





## Basics - What is a UIC?

UICs or Injection Systems are human-made devices used to discharge fluids underground




- ✓ Dry wells or drill holes
- ✓ Soakage trenches
- ✓ Perforated pipes
- ✓ Infiltration gallery
- ✓ Large drain fields
- ✓ Automotive floor drains
- ✓ Agricultural drains



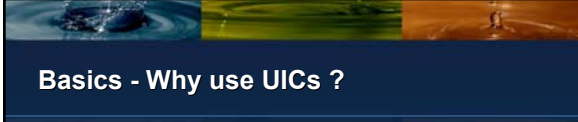
## Basics - UIC Classes

- Class I: inject waste fluids *below* Underground Source of Drinking Water (USDW)
- Class II: inject fluids for oil/gas activity *below* USDW
- Class III: mineral extraction fluids
- Class IV: inject hazardous waste *above* or *into* a USDW - prohibited, excluding remediation sites
- Class V: all other injection systems, *above* or *into* a USDW - wells directly in groundwater are prohibited




## Basics - Who has UICs?

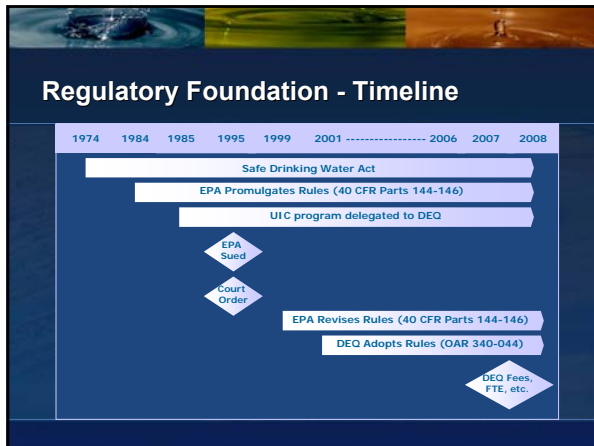
- Nearly every city & county in Oregon
- Many School Districts
- "Big Box" developments
- Ports
- Residential streets & private roads
- Grocery stores & malls
- Industrial sites
- ❖ 70,000 registered / 80% stormwater



## Basics - Why use UICs ?

- Recharge groundwater
- Attenuate storm surges to surface water
  - Reduce stream "flashiness"
  - Reduces erosion and turbidity
- Stormwater management necessity
  - Public safety
  - Space constraints





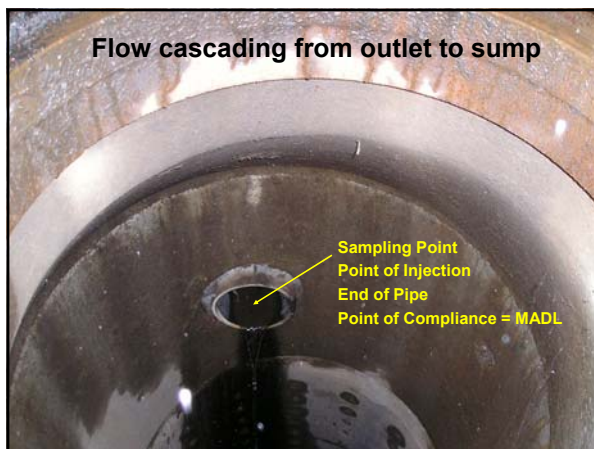
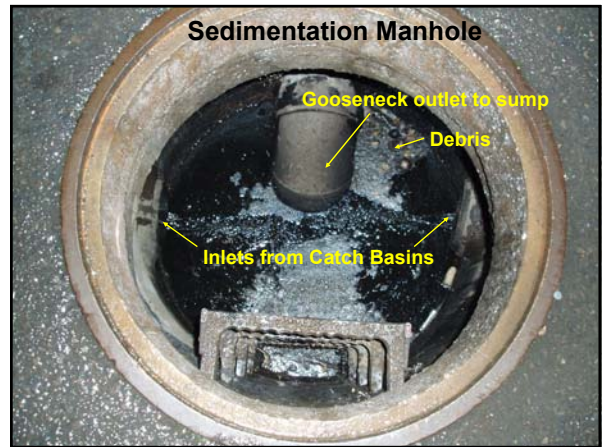
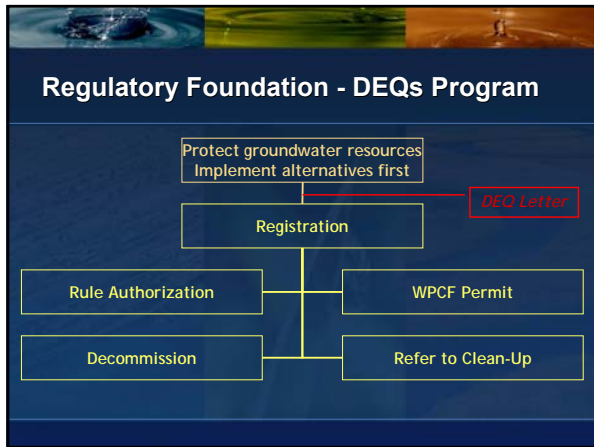
### Regulatory Foundation - Big Difference

**Federal Clean Water Act**

- Discharge to surface water body
- Benchmarks
- Maximum Extent Practicable

**Safe Drinking Water Act**

- Discharge to groundwater
- Concentration limits
- No Maximum Extent Practicable



### ACWA UIC WPCF Permit Project - Introduction

- Cities of Gresham, Troutdale, Bend, Redmond, Eugene, Keizer, Milwaukie, and Canby, Clackamas County Water Environment Services, Multnomah County, and TriMet
- Assist with permit development, stormwater and groundwater analysis, development of monitoring and sampling plans, and technical assistance

## ACWA UIC WPCF Permit Project - Data Compiling

- Cities of Bend, Canby, Keizer, Troutdale, Redmond, Eugene, Gresham, Portland, and Salem; Clackamas County - WES, Multnomah County, Clean Water Services, TriMet, ODOT
- *Final Report Analysis of Oregon Urban Runoff Water Quality Monitoring Data Collected from 1990 to 1996.* Prepared for ACWA by Woodward-Clyde Consultants. June 1997
- WPCF Permit No. 102830, Class V Stormwater UIC Systems, City of Portland
- Collaborative monitoring data for UIC BMP study conducted by ACWA members
- **Approximately 10,180 sample results were compiled (UIC and MS4), comprising a total of 41 analytes**

## ACWA UIC WPCF Permit Project - Methods

- Relationship between concentrations for each analyte and land uses (residential, commercial, industrial, open space, and transportation), using the Kruskal-Wallis one-way analysis of variance
  - A non-parametric method for testing equality of population medians among three or more independent groups
  - 95% significance value was used to determine relationships between land use and concentrations
  - *Note: Nonparametric tests are used in place of parametric counterparts when certain assumptions about the population are questionable. For example, when comparing two independent samples, these tests do not assume the difference between the samples is normally distributed*
- Nonparametric tests are often more powerful in detecting population differences when certain assumptions are not satisfied*

## ACWA UIC WPCF Permit Project - Methods

- Relationship between concentrations for each analyte and vehicle trips (> or < 1000 TPD), using the Mann-Whitney U test
- Test for assessing whether two independent samples of observations are from the same population
- A 95% significance value was used to determine relationships between vehicle trips and concentrations
- For a 95% significance value, the results of the Mann-Whitney test were compared to a probability (p) value of 0.05, which signifies there is at least a 95% probability the independent samples are not from the same population

## ACWA UIC WPCF Permit Project - Methods

- Statistical analyses were performed to explore the relationship between land use and analyte concentrations (lead, PCP, DEHP), and relationship between vehicle trips and analyte concentrations (lead, PCP, DEHP)
- Analyses on benzo(a)pyrene (B(a)P) and nitrate-nitrogen (NO3-N) to represent all major classes of chemicals in the dataset
- Summary statistics and distribution testing showed data generally followed a non-parametric distribution

Analytes Exceeding Screening Levels <sup>a</sup>						
Analyte <sup>a</sup>	# of Exceedances <sup>b</sup>	# of Samples	% Exceeding	OAR Ref. Level (mg/L)	EPA MCL (mg/L)	Portland Permit MADL (mg/L)
Antimony <sup>a</sup>	1 (1)	247	0.3	— <sup>d</sup>	0.006	0.006
Arsenic	2 (2)	646	0.2	0.05	0.01	0.01
Benzo(a)pyrene	2 (2)	740	0.3	—	0.0002	0.0002
Cadmium	8 (8)	1609	0.5	0.01	0.005	0.005
Chromium	10 (3)	1226	0.8	0.05	0.1	0.1
Di(2-ethylhexyl) phthalate <sup>a</sup>	30 (30)	641	4.7	—	0.006	0.006
Lead <sup>a</sup>	227 (78)	1762	12.7	0.05	0.015	0.05
NO3-N	2 (2)	633	0.3	10	10	10
Pentachlorophenol <sup>a</sup>	79 (79)	675	11.7	—	0.001	0.001
Zinc	1 (1)	1661	0.1	5	—	5

**Notes:**  
<sup>a</sup> Screening Levels are OAR 340-0020, EPA Maximum Contaminant Level, and Portland Maximum Allowable Discharge Limit.  
<sup>b</sup> # of detected concentrations > than screening level(s). Values in parentheses are exceedances of MADL.  
<sup>c</sup> Metals results were not differentiated between total and dissolved.  
<sup>d</sup> — No screening level is available.  
<sup>e</sup> Analytes were only sampled by City of Portland.  
 Analytes in bold had more than 10% of samples exceeding the screening level(s).  
 Detection limits for 50 non-detect concentrations of antimony exceeded respective screening level(s).  
 Detection limits for 4 non-detect of bis(2-chloroethyl)ether, 22 non-detect of selenium, and 80 non-detect of thallium exceeded respective screening level(s).

## ACWA UIC WPCF Permit Project - Results

- 10 analytes had at least one exceedance of screening level(s). Majority were for lead, PCP, and DEHP
- Concentrations of some analytes were significantly higher in some land uses than others
- In general, industrial and transportation land uses had higher concentrations than residential land uses
- However, sample size among different land use groups was not consistent, with the number of samples collected from residential land uses exceeding the number of samples from other land uses by an order of magnitude in many cases

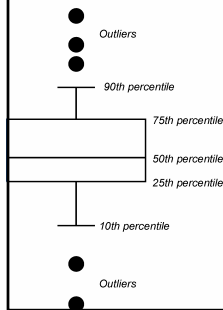
## ACWA UIC WPCF Permit Project - Results

- Vehicle trip class is a stronger predictor of concentrations than land use, as the relationship was consistent among all analytes for which the test was performed
- Differences based on vehicle trips were statistically more significant than differences based on land use.
- Because vehicle trip class is essentially embedded in land use information, these factors are not independent

## ACWA UIC WPCF Permit Project - Sources

- PCP** - treated wood, wood preservatives
- DEHP** - used automotive oil, automotive belts, brake pads, packing peanuts, tires, flexible PVC ( flooring and wall lining materials, sealants, wire sheathing, rain coats, rubber boots, medical utility devices)
- Lead** - wheel weights, roofs, road paints, pesticides, native soils, fireworks

### Explanation of Box Plots



**90th percentile:** 90% of the values fall below this mark

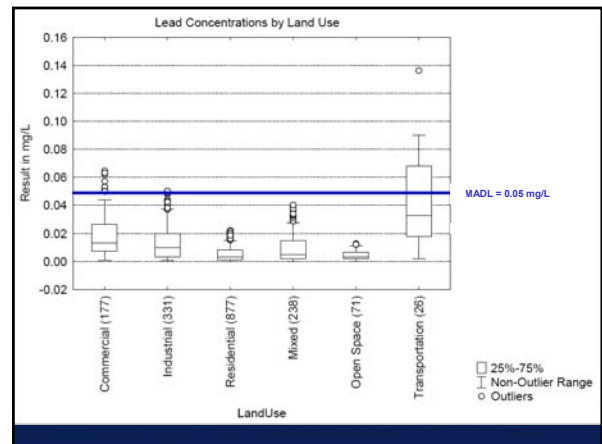
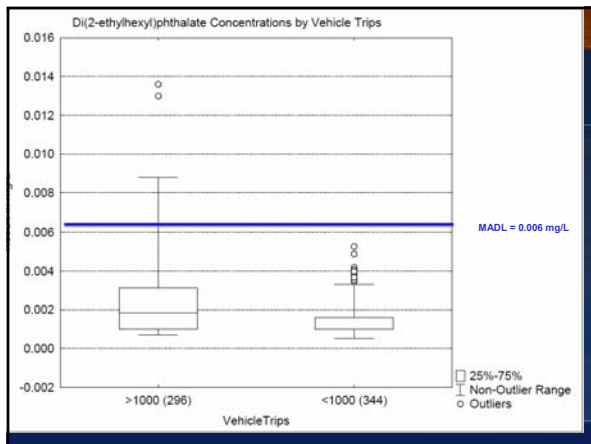
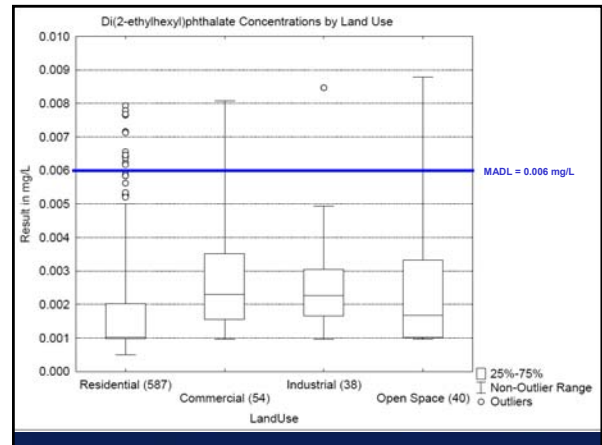
**75th percentile:** 75% of the values fall below this mark

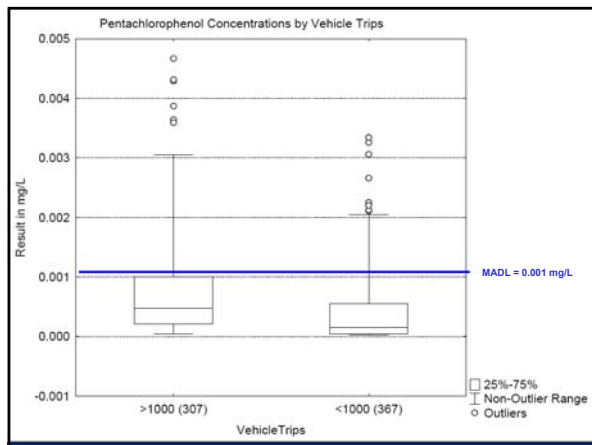
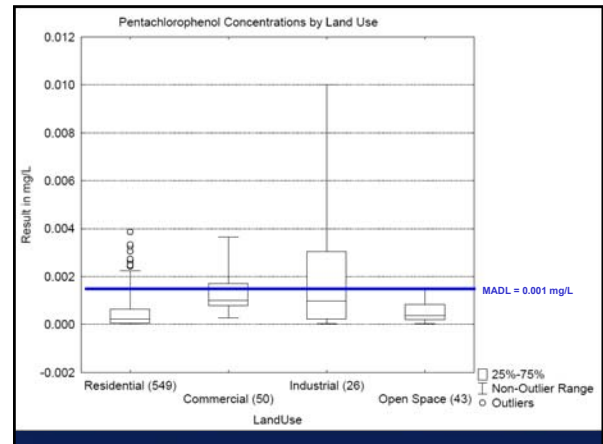
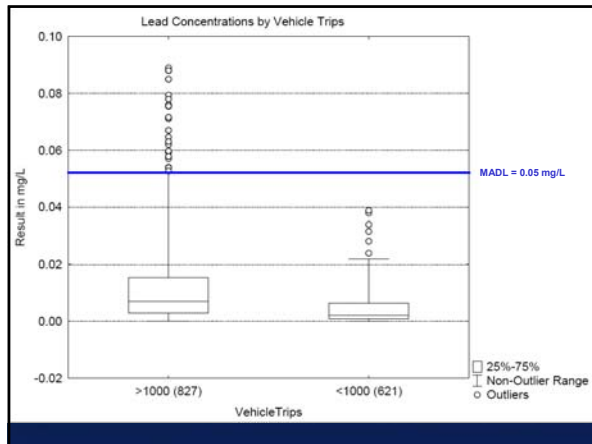
**50th percentile:** 50% of the values fall below this mark

**25th percentile:** 25% of the values fall below this mark

**Outliers:** values that exceed the 90th percentile or are below the 10th percentile

**Median:** value that corresponds to the middle case when all individual scores are arranged in order by score; the value that divides the cases into two halves of equal frequency.





### ACWA Data Next Steps

- Quality Control review
- Interaction between land use and vehicle trips, in order to ascertain whether land use, number of vehicle trips, or a combination of both factors is best at predicting concentrations of lead, PCP, and DEHP
  - Factorial analysis of variation may be unrealistic, as the two groups are not completely independent
  - For example, all commercial, mixed, and transportation land use locations corresponded with >1,000 trips. Of the land use classes with both > and < 1,000 vehicle included, concentrations were higher from locations with > 1,000 trips

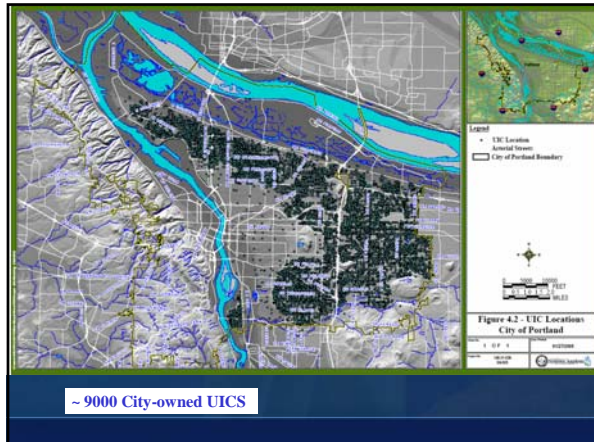
### City of Portland's WPCF Permit

- 10-year permit issued by DEQ in 2005
- Regulates construction, operation, and maintenance of all City-owned UICs
- Incorporates watershed approach and Portland's stormwater hierarchy for stormwater management

### City of Portland's WPCF Permit

Protects groundwater as a drinking water resource

- Numeric stormwater standards
  - Federal Drinking Water Standards (e.g., MCLs)
  - Oregon Groundwater Protection Standards
  - Health based limits
- Requires minimum separation distance between bottom of UIC and seasonal high groundwater
- Permit specified setbacks from private or public drinking water wells



### UIC System Monitoring

- Permit requires a “rigorous and statistically valid” monitoring program to demonstrate UICs are operated in manner that protects groundwater as a drinking water resource
- City worked with EPA experts to design a “statistically robust” monitoring program
- Sampling locations selected using *Generalized Random Tessellation Stratified (GRTS) survey design*
  - randomly selects sampling locations from a population of potential locations whose members are distributed over a large space in a manner that produces a spatially balanced sample

### UIC Compliance Monitoring

- 30 randomly, spatially distributed UICs including:
  - 1 fixed panel (15 locations sampled Years 1-10)
  - 5 rotating panels (15 locations in each panel. Panels sampled once in permit Years 1-5 and once in Years 6-10)
- Sample locations are equally divided between two traffic flow categories: <1,000 trips per day (TPD) and >1,000 TPD
- Plus any locations exceeding the annual mean

### UIC System Monitoring

- Sampling design is based on the proportion of exceedance calculated for PCP
- PCP was the analyte with the most number of detected exceedances of the MADL in a pre-permit pilot study
- Using a 90% confidence interval and +/-12% half width, a sample size of 30 was selected

### Target Storm Criteria

- Predicted rainfall  $\geq 0.2$  inches per storm
- Predicted rainfall duration of  $\geq 6$  hours
- Antecedent dry period of  $\geq 6$  hours (<0.1 inches of precipitation over previous 6 hours)

### Stormwater Analyses

- Over 120 pollutants analyzed and reported for each sampling event
  - Volatile Organic Compounds
  - Polynuclear Aromatic Hydrocarbons
  - Semivolatile Organic Compounds
  - Herbicides/Pesticides
  - Metals (total and dissolved)
  - Nitrate/Nitrogen
  - Total Suspended Solids (TSS)

## UIC Compliance Monitoring

Common Pollutants

Benzene	Toluene
Ethylbenzene	Xylenes
Pentachlorophenol	Di(2-ethylhexyl)phthalate
Benzo(a)pyrene	Total Arsenic
Total Chromium	Total Cadmium
Total Lead	Total Copper
Total Nitrogen	Total Zinc

## UIC Compliance Monitoring

Priority Pollutants - Collected in Years 1, 4 and 9

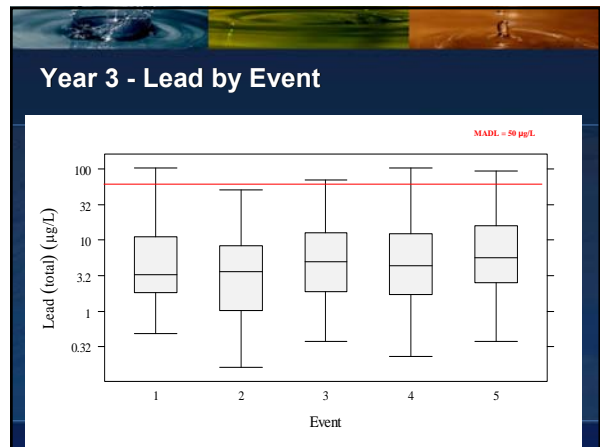
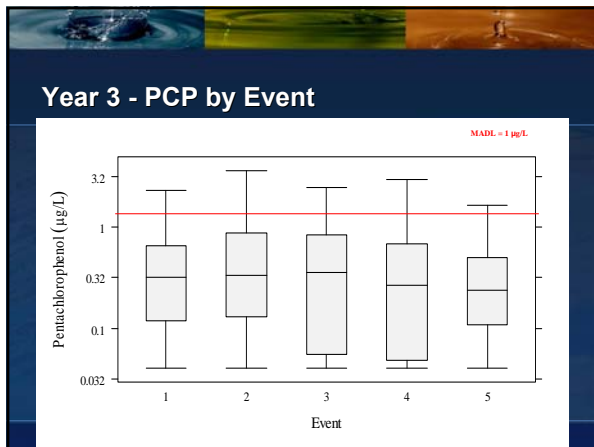
Total Antimony	Total Barium
Total Beryllium	Total Cyanide
Inorganic Mercury	Total Selenium
Total Thallium	Alachlor
Atrazine	Carbofuran
Carbon Tetrachloride	Chlordane
Chlorobenzene	2,4-D
Dalapon	o-Dichlorobenzene
p-Dichlorobenzene	1,3-Dichlorobenzene
Bis(2-chloroisopropyl)ether	Bis(2-chloroethyl)ether
Dinoseb	Diquat
Glyphosate	Lindane
Pichloram	1,2,4-trichlorobenzene

## Results

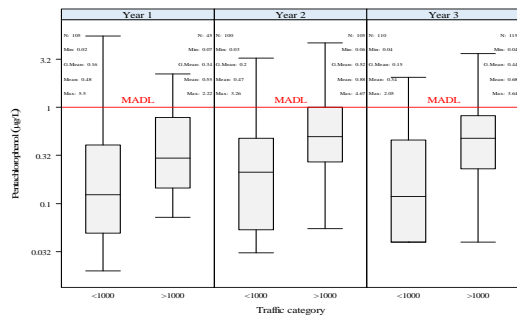
- Stormwater quality in public rights-of-way generally meets levels protective of drinking water. Concentrations generally
  - Detected at low concentrations below permit limits
  - Within a narrow concentration ranges
  - Consistent over 3 years
- Limited pollutants of concern: PCP, lead, B(a)P and DEHP
- Concentrations for high traffic (>1000 TPD) rights-of-way higher than low traffic (<1000 TPD)

## Years 1 - 3 Stormwater Results

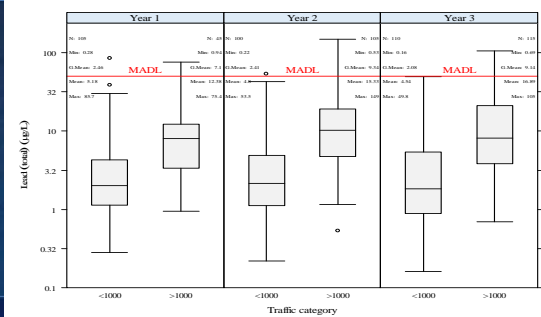
- Pollutants with frequencies of detection  $\geq 50\%$ :
  - Common Pollutants: arsenic, chromium, copper, lead, zinc, PCP, and DEHP
  - PPS Analytes: antimony, barium, and mercury.
  - Ancillary Pollutants: phenanthrene, pyrene, chrysene, and fluoranthene
- Pollutants that has exceeded Annual Mean Concentrations  $\geq$  Permit Limits:
  - PCP



## PCP by Year and Traffic Category



## Lead by Year and Traffic Category



## Ongoing Analyses

- Pollutant Trends
- Extrapolating Results System-wide
- Pollutant Sources
- System Conditions
- Correlations
- Risk Assessment

## Response Actions

- Clean UIC systems
- Street Sweeping
- Source Investigations & Control
- Risk Assessment
- Corrective Action

## Acknowledgements

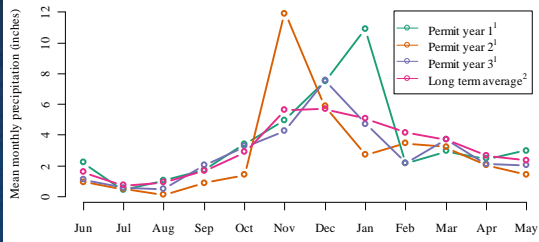
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- Rod Struck, Portland BES
- Janet Gillaspie
- Mark Cullington, Kennedy/Jenks Consultants

## UIC Compliance Monitoring Costs

- Field Operations: \$105,000 / year
- Laboratory Analyses: \$170,000 / year
- Priority Pollutant Scan (Years 1, 4, & 9)
  - Compliance Monitoring: \$60,000 / year
- Response Sampling ~ \$25,000 / year



## Regional Precipitation Data



1) Data source: Local Climatological Data - Portland Oregon.  
From <http://www.weather.gov/climate/index.php?wfo=pqr>

2) Data source: Portland International Airport. Period 1971 - 2000.  
From NOWData - NOAA Online Weather Data at [http://nowdata.noaa.gov/POR/mhACTS\\_results](http://nowdata.noaa.gov/POR/mhACTS_results)