# The National Stormwater Quality Database (NSQD) Version 4

Alex Maestre[1], Robert Pitt[1], Jane Clary[2]

Department of Civil, Construction, and Environmental Engineering[1]
The University of Alabama – Tuscaloosa, AL

Wright Waters Engineers[2]
Denver, Colorado

2015 American Water Resources Conference

Denver, Colorado| November 16-19 2015

1

# Introduction

- Reference for urban stormwater quality throughout the United States

- The database is organized by State, EPA Rain Region, and Land Use

- Started in 2001 compiling the results of Phase I NPDES Municipal Separate Sewer Storm Systems in collaboration with the Center of Watershed Protection

- Current version contains the results of about 9,100 storm sampling events

2

# Background

- The purpose of the NSQD is to collect outfall Event Mean Concentration (EMC) data and supporting information from previously conducted monitoring programs.

- This data can be used to assist stormwater managers in identifying typical stormwater conditions for their area.

- This data can also be used by stormwater researchers to identify trends and differences between different sampling methods, land use, geographical location, and other factors.

- Initially developed and managed by the University of Alabama. The database was recently transferred to the International Stormwater BMP Database web site.

3

# Sources of Information

- Almost 600 sampling locations, with a median of 10 samples per site (maximum 115). More than 700 new storms were added to this most recent version of the database in addition to reviewing and adding supporting information for the complete dataset.

- We recently compiled new information from Colorado (34 sites), California (2 sites), and Kansas (10 sites).

- We also developed and conducted an expanded QA/QC process for the complete dataset. We reviewed and standardized notes, supporting information, and qualifiers for each record. Most of the NSQD effort is expanded in QA/QC analyses.

- Most of the data in version 4 was obtained from Phase I NPDES municipal monitoring programs along with several other sources.
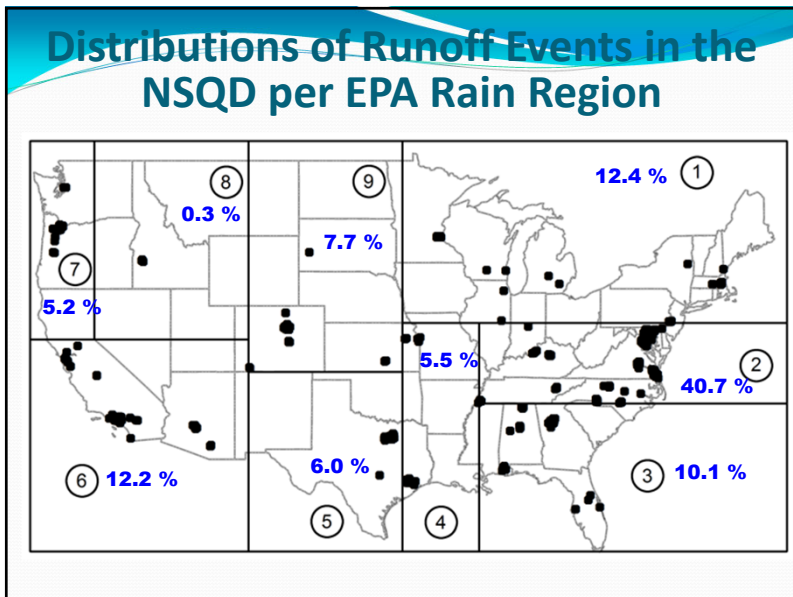
4

## Data Origin for NSQD Information

| Source | Total Storms | Percentage |
|---|---|---|
| Phase I NPDES (MS4) | 5,707 | 62.5 |
| EPA's Nationwide Urban Runoff Program (NURP) | 1,757 | 19.2 |
| International BMP Database (influent data at outfalls) | 883 | 9.7 |
| Special Projects (USGS, state programs, and others) | 783 | 8.6 |
| **TOTAL** | 9,130 | 100 |

5



6

## Distributions of Runoff Events in the NSQD per EPA Rain Region



7

## New Features in Version 4.0
### (in addition to expanded data coverage and expanded QA/QC)

- Descriptive Statistics including censored values
  - Average
  - Median
  - Standard Deviation

- Probability Distribution including censored values
  - First Quartile (Q1)
  - Median
  - Third Quartile (Q3)
  - Total of 15 percentile values to represent the complete distribution

- Also integrated with BMP International Database statistical summaries

8

## Slide 9

# Land Use Distribution

| | | |
|---|---|---|
| **Residential** | **Freeways** | **Industrial** |
| 47.7% | 5.6% | 13.2% |
| bbp.ocean.edu | Purdue.edu | berkeley.edu |
| **Commercial** | **Institutional** | **Open Space** |
| 19.8% | 4.8% | 5.6% |
| tlsohio.edu | indstate.edu | Snre.umich.edu |

NSQD also includes some data representing the first 30 minutes of the storm (first flush) compared to simultaneous data for the complete event.

9

## Slide 10

# Site and Sampling Method Descriptions

- Narrative about each municipality/site monitoring program
- Aerial photos
- Watershed delineation (if available)
- Methods used for sampling and for the water quality analyses
- Constituents collected and period of collection
- Each report for each municipality is approximately 7 pages long
- These reports are in progress and will be available on the NSQD/International BMP website

10

## Slide 11

# Example Site Description (first page)



11

## Slide 12

# Pitt's Teaching and Research Web Site with Supporting Information and Many other Documents



12

## Section of Pitt's Web Site with Selected NSQD Publications and Downloads

**Recent Papers and Presentations of National Stormwater Quality Database**

Pitt, R., A. Maestre, and R. Morquecho. "Stormwater characteristics as contained in the nationwide MS4 stormwater phase 1 database." Water World and Environmental Resources Conference 2004, Environmental and Water Resources Institute of the American Society of Civil Engineers, Salt Lake City, Utah. July 27 - August 1, 2004. (conference CD-ROM) (1606 Kb)

Maestre, A., Pitt, R. E., and R. Morquecho. "Nonparametric statistical tests comparing first flush with composite samples from the NPDES Phase 1 municipal stormwater monitoring data." Presented at the Stormwater and Urban Water Systems Modeling Conference. Computational Hydraulics, Inc. Toronto, Canada. Feb 2003 (1389 Kb)

Maestre, A., R. Pitt, S.R. Durrans, and S. Chakraborti. "Stormwater quality descriptions using the three parameter lognormal distribution." Presented at the Stormwater and Urban Water Systems Modeling Conference. Computational Hydraulics, Inc. Toronto. February 19 - 29, 2004. (801Kb)

Maestre, A. and R. Pitt. "Identification of significant factors affecting stormwater quality using the National Stormwater Quality Database." In: Stormwater and Urban Water Systems Modeling, Monograph 14. (edited by W. James, K.N. Irvine, E.A. McBean, and R.E. Pitt). CHI. Guelph, Ontario, pp. 287 - 326. 2006 (967Kb)

**National Stormwater Quality Database (NSQD). Version 1.1 -- Spreadsheets**

| NSQD Version 3 Spreadsheet | Excel File |
|---|---|

This most recent update on NSQD. It contains contains 8,602 rain events from 104 cities throughout the continental United States, and represents all 9 EPA Rain Zones and 12 land use categories.

Total size: 7.51 Mb, Updated: February 3, 2008, Version 3

| NSQD Version 1.1 Spreadsheet | Excel File |
|---|---|

13

## International BMP Database Website

International Stormwater BMP Database

Home    Get Data ▾    Submit Data ▾    Documents ▾    Guidance ▾    About ▾

**National Stormwater Quality Database**

**Overview**

The National Stormwater Quality Database (NSQD) is an urban stormwater runoff characterization database developed under the direction of Dr. Robert Pitt, P.E., of the University of Alabama and the Center for Watershed Protection under support from the U.S. Environmental Protection Agency. Originally released in 2001, followed by several updates, it has recently moved to a new long-term home as a companion project to the International Stormwater BMP Database. The NSQD is being maintained as a separate stand-alone database, serving as an important resource for municipal stormwater managers and researchers who are seeking urban runoff characterization data. The NSQD can be searched for water quality data based on land use, state, and EPA Rain Zone, along with several other criteria. The NSQD can be downloaded from this website, and a new on-line user interface will be developed in the future.

**Download the NSQD**

The NSQD Version 3.1 (last updated March 2011) can be downloaded in two formats containing the same information:

1. NSQD Version 3.1 Excel Spreadsheet (original format) **Coming Soon**
2. NSQD Version 3.1 Access Database (new format) **Coming Soon**

**Papers and Previous NSQD Analyses**

During the transition of the NSQD to its new home, additional explanatory information can be accessed here .

**NSQD History**

In 2001, the University of Alabama and the Center for Watershed Protection were awarded a U.S. Environmental Protection Agency, Office of Water 104(b)3 grant to collect and evaluate stormwater data from a portion of the NPDES (National Pollutant Discharge Elimination System) MS4 (municipal separate storm sewer system) stormwater permit holders. In 2008, the NSQD was updated with additional data under continued 104(b)3 support from the EPA. These stormwater quality data and site descriptions were collected and reviewed to describe the characteristics of national stormwater quality, to provide guidance for future sampling needs, and to enhance local stormwater management activities in areas having limited data. The monitoring data collected over nearly a ten-year period from more than 200

14

## Constituents and Number of Observations Included in NSQD ver. 4 (having at least 50 observations)

- Total events: 9,130
- Precipitation depth: 5,172
- Runoff depth: 2,591
- Hardness: 1,670
- Alkalinity: 525
- pH: 3,253
- Temperature: 1,251
- TDS, 4,158
- Conductivity: 1,517
- Chloride: 869
- Total solids: 100
- Total suspended solids: 7,713
- Turbidity: 936
- $BOD_5$: 5,227
- COD: 5,290
- DO: 192
- Fecal coliforms: 2,223
- Fecal streptococcus: 1,317
- Total coliforms: 282

- Total nitrogen: 1,213
- Total Kjeldahl N: 7,044
- Total organic N: 66
- Ammonia: 3,020
- Nitrate N: 1,028
- Nitrite N: 714
- Nitrite + nitrate: 5,748
- Total phosphorus: 8,019
- Filtered P: 4,051
- Ortho phosphate: 746
- Filtered ortho P: 244
- Total antimony: 1,584
- Filtered antimony: 641
- Total arsenic: 2,441
- Filtered arsenic: 770
- Total barium: 582
- Total beryllium: 1,509
- Filtered beryllium: 578
- Total cadmium: 4,105
- Filtered cadmium: 961

- Total chromium: 2,328
- Filtered chromium: 821
- Total copper: 5,915
- Filtered copper: 1,002
- Cyanide: 1,338
- Total iron: 608
- Filtered iron: 556
- Total lead: 363 (before 1984)
- Total lead: 5,032 (since 1984)
- Filtered lead: 1,016 (since 84)
- Total mercury: 1,702
- Filtered mercury: 706
- Total nickel: 2,164
- Filtered nickel: 807
- Total selenium: 1,737
- Filtered selenium: 682
- Total silver: 1,880
- Filtered silver: 766
- Total thallium: 1,423
- Filtered thallium: 653
- Total zinc: 6,638
- Filtered zinc: 984

15

## Constituents and Number of Observations Included in NSQD ver. 4 (having at least 50 observations) (continued)

- Oil and grease: 2,330
- Total petroleum hydrocarbons: 295
- Acrolein: 464*
- Acrylonitrile: 205*
- Benzene: 213
- Bromoform: 189*
- Carbon tetrachloride: 189*
- Chlorobenzene: 213*
- Chlorodibrimo methane: 189*
- Chloroethane: 213*
- Chloroethylvinylether: 624
- Chloroform: 499
- Dichlorobro methane: 116
- 1,1-Dichloroethane: 258*
- 1,2-Dechloroethane: 247*
- 1,1-Dichloroethylene: 71*

- 1,2-Dichloropropane: 212*
- Trans-1,3-Dichloropropene: 150*
- 1,3-Dichloropropylene: 42*
- Ethyl benzene: 575
- Methyl bromide: 207*
- Methyl chloride: 321
- Methylene chloride: 457
- 1,1,2,2-Tetachloroethane: 222*
- Tetrachloroethylene: 99
- Trichloroflourormethane: 156*
- Toluene: 573
- 1,2-Transdichloroethylene: 82*
- 1,1,1-Trichloroethane: 226
- 1,1,2-Trichloroethane: 222*
- Trichloroethylene: 83*
- Vinyl chloride: 222*

* All, or almost all, non-detected (20 or 30 organic compounds)

16

## Examples of Past Evaluations Conducted using the NSQD to Explore Fundamental Stormwater Characteristics and Experimental Design Suggestions

- Explain variations in stormwater quality by identifying significant land use, geographical area, and seasonal effects. Also examined effects of amount of impervious cover and size of drainage area on stormwater quality.
- Examine trends in stormwater quality with time (reflecting pollution prevention effects of lead removal from gasoline for example).
- Compare sampling effects on stormwater quality (automatic samplers vs. grab samples; time-weighted vs. flow-weighted composites; first flush vs. whole event samples).
- Determine the best approach in handling non-detectable results in the data base (compare different data substitution methods for effects on statistical measures).
- Determine suggested analytical methods to minimize detection limit problems when conducting stormwater monitoring activities.
- Verify the number of samples needed during stormwater monitoring to meet specific data quality objectives by determining actual expected variability in stormwater quality.

17

## Example Analyses using NSQD Information
### Concentrations and Variations by Land Use



Copper (ug/L) by Landuse

FW — Freeway
ID — Industrial
RE_CO_OP_IS — Residential – Commercial Open Space Institutional

Highly variable concentrations, but many significant data groupings

18

Even with lots of variability, the large number of samples and well distributed conditions enable significant data groupings to be identified based in the significant factors affecting the concentrations.

| Constituent | Land Use (LU) | Season (SN) | EPA Rain Zone (EPA) | LU*SN | LU*EPA | SN*EPA | LU*EPA*SN |
|---|---|---|---|---|---|---|---|
| TSS mg/L | <0.0001 | 0.74 | <0.0001 | 0.017 | <0.0001 | 0.18 | <0.0001 |
| BOD$_5$ mg/L | <0.0001 | 0.16 | <0.0001 | 0.0008 | <0.0001 | 0.0011 | 0.22 |
| COD mg/L | <0.0001 | 0.13 | <0.0001 | 0.034 | <0.0001 | 0.014 | 0.0085 |
| TP mg/L | <0.0001 | 0.69 | <0.0001 | 0.055 | <0.0001 | 0.0004 | <0.0001 |
| NO$_2$ + NO$_3$ mg/L | <0.0001 | 0.11 | <0.0001 | 0.052 | <0.0001 | 0.034 | 0.057 |
| TKN mg/L | 0.0026 | 0.024 | <0.0001 | 0.99 | <0.0001 | <0.0001 | 0.17 |
| Cu mg/L | <0.0001 | 0.11 | <0.0001 | 0.62 | <0.0001 | 0.038 | 0.14 |
| Pb mg/L | <0.0001 | 0.76 | <0.0001 | 0.42 | <0.0001 | 0.29 | 0.011 |
| Zn mg/L | <0.0001 | 0.91 | <0.0001 | 0.94 | <0.0001 | 0.014 | <0.0001 |

Yellow and green cells note statistically significant relationships ($p<0.05$); yellow should be used for predictive purposes as they contain the highest order interaction terms.

19

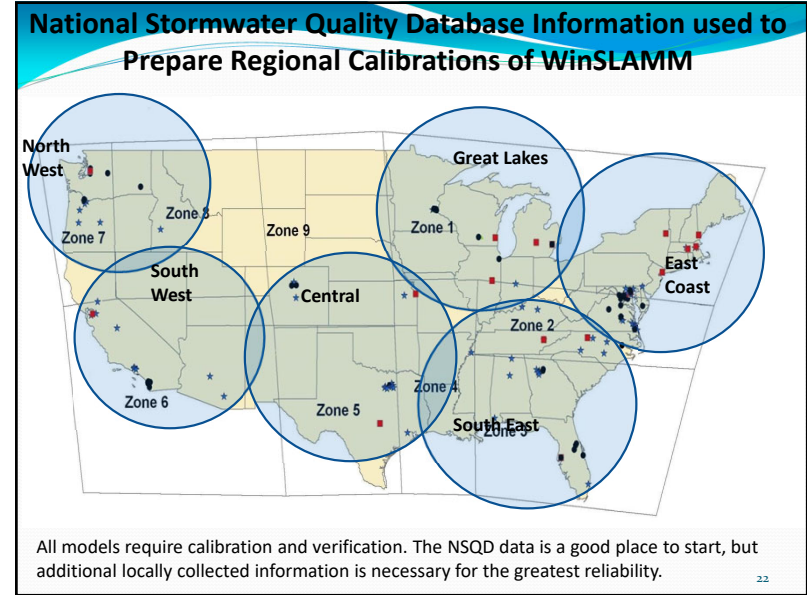## QA/QC Analyses to Identify Unusual Sites



Xbar-S Chart of Total Suspended Solids in Commercial Land Use

UCL=100
X̄=52.5
LCL=27.5

UCL=0.594
S̄=0.391
LCL=0.189

Unusual sites were further examined to identify possible reasons and to verify data

20

## Slide 21

**Evidence of debris tracking into monitored site from adjacent area.**

## Slide 22

**National Stormwater Quality Database Information used to Prepare Regional Calibrations of WinSLAMM**



All models require calibration and verification. The NSQD data is a good place to start, but additional locally collected information is necessary for the greatest reliability.
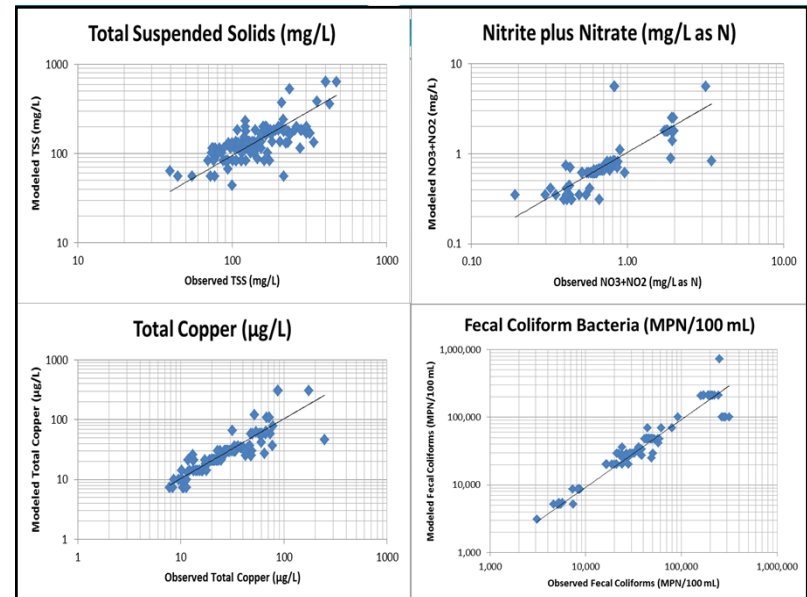
22

## Slide 23

**Number of Standard Land Use Files Used for Each Category for Regional WinSLAMM Calibrations**

| | Commer. | Indus. | Instit. | Open Space | Resid. | Freeways/ Highways | Total by Region |
|---|---|---|---|---|---|---|---|
| Central | 4 | 2 | 4 | 1 | 5 | 3 | 19 |
| East Coast | 3 | 1 | 1 | 1 | 2 | 3 | 11 |
| Great Lakes (the USGS/DNR files) | 6 | 4 | 4 | 2 | 11 | 4 | 31 |
| Northwest | 2 | 1 | 1 | 1 | 3 | 3 | 11 |
| Southeast | 7 | 2 | 3 | 5 | 8 | 4 | 29 |
| Southwest | 5 | 1 | 1 | 1 | 2 | 3 | 13 |
| Total by Land Use | 27 | 11 | 14 | 11 | 31 | 20 | 114 |

23

## Slide 24

## Summary

- The NSQD can be used to estimate expected stormwater conditions in areas lacking data. These data can be used for preliminary evaluations and to develop monitoring programs such as to identify critical areas needing additional data.

- NSQD can be used for stormwater quality model calibration.

- The database can be used to test common assumptions concerning stormwater characteristics, such as the role of first flush, monitoring methods, geographical location, watershed area, etc.

25

## Contact

Alex Maestre

amaestre@eng.ua.edu

Robert Pitt

rpitt@eng.ua.edu

Jane Clary

clary@wrightwater.com

26