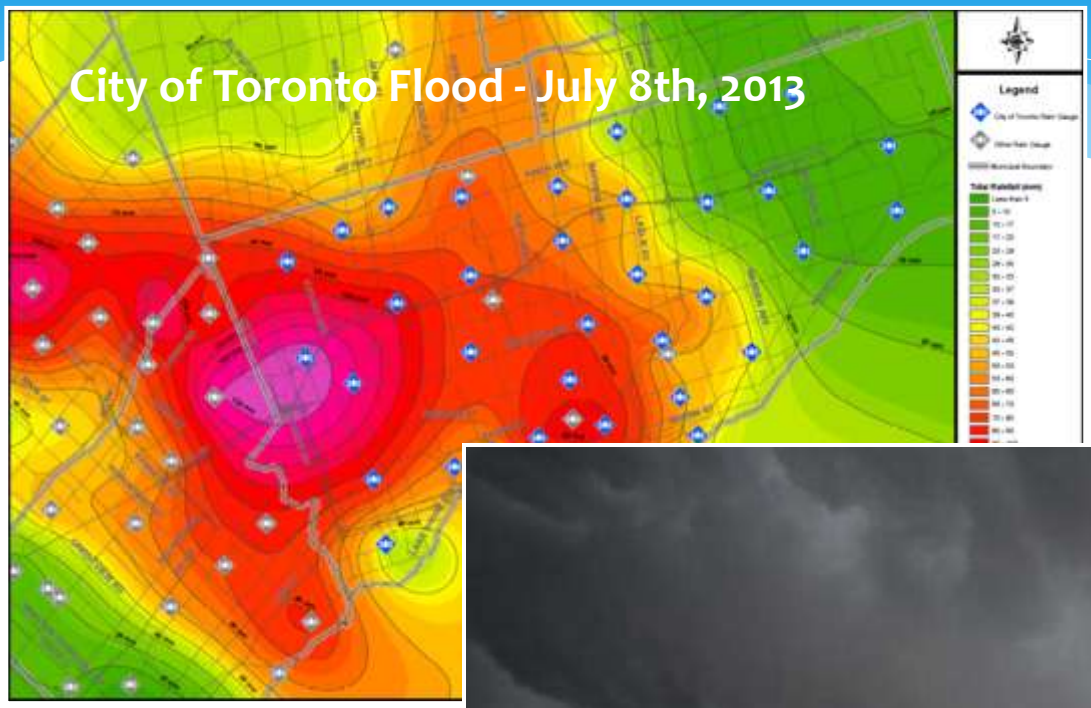
City of Toronto Wet Weather Flow Monitoring Network: Baseline Conditions 2008 – 2011

Sharing Loading Estimation Experiences Workshop

Tuesday, January 20, 2015

Presented By: Derek Smith

City of Toronto Flood - July 8th, 2013



Source: The Canadian Press

Water Quantity

Source: The Canadian Press

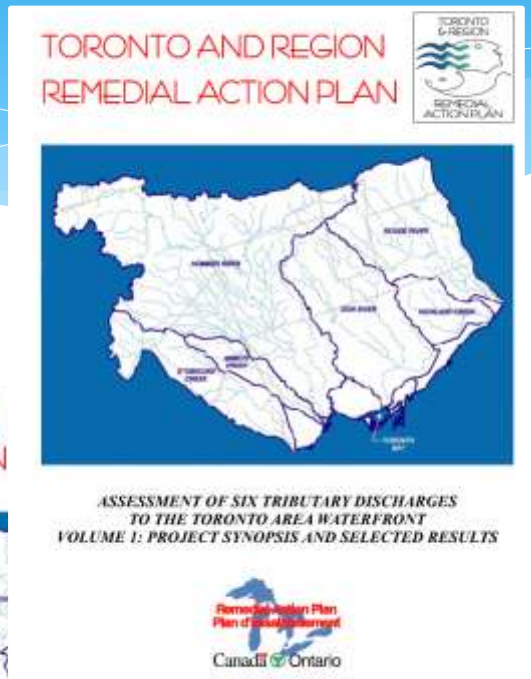
Water Quality

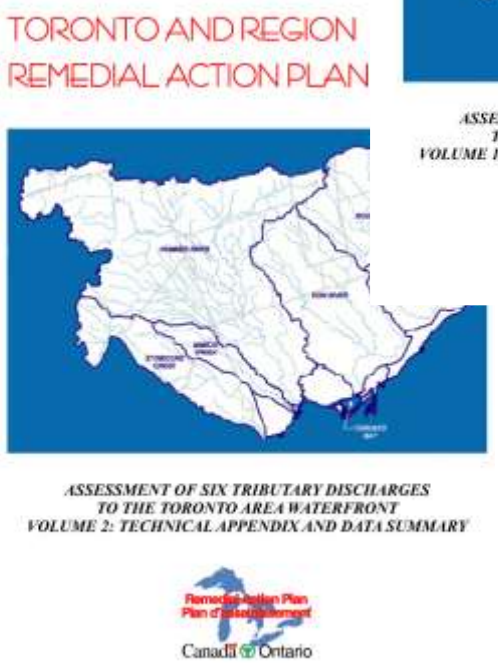
Background: 1999 RAP Study

* Data collected 1990 to 1992.

Objectives:

* ID the chemical characteristics of each tributary.
* Estimate mean contaminant concentrations under dry and wet flows.
* Compare contaminant concentrations between watercourses.
* Estimate the seasonal and annual contaminant mass discharge.





Background: 1999 RAP Study

* Results from this study were intended to assist in the development, prioritization and design of remedial options (e.g. the TWWFMP) and will form a database by which the effectiveness of remedial measures can be evaluated once implemented (Boyd, 1999).

Background: TWWF Master Plan

* The *City of Toronto's Wet Weather Flow Master Plan* is an initiative to address the impacts of runoff in order to protect watersheds and infrastructure.
* Designed with a "*treatment train*" approach.
* Approved September 2003 and is a 75 to 100 year initiative.

Background: TWWF Monitoring Network

* Est. in 2007 by Toronto Water.
* Used to assess the Master Plan.
* A benchmark against which the effects or benefits of implementing the TWWFMP over the next 25 to 50 years.
* Network operation is on a 10 year cycle (3-4yrs collection, 1-2yrs reporting, 5yr shut down).

City of Toronto Wet Weather Flow Monitoring Network

Baseline Conditions 2008 to 2011

Toronto and Region Conservation Authority
Restoration Services
Flood Management Service
Hydrometrics and Flood Infrastructure Program

Toronto and Region Conservation for The Living City

TORONTO

December 2013

(Second Draft)

Network Design

* Fully automated
* TRCA, EC, & WSC gauges used

Information Collected:

* Solid and liquid precipitation
* Discharge
* Water quality
* Air temperature
* Snow pack depth
* Conductivity

Siting Criteria:

* Similar to WSC & WMO manuals
* Consider operational logistics

Red = Essential for calculating pollutant load and timing samples

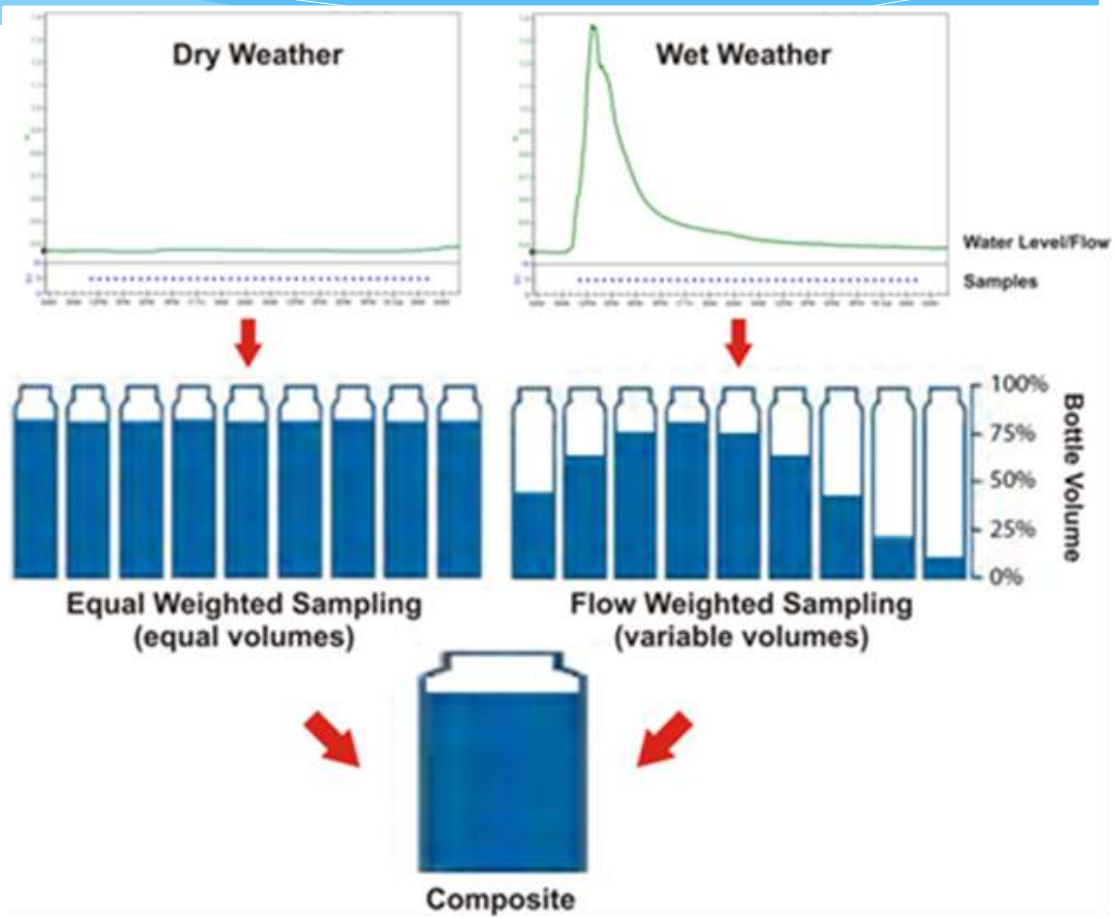
Methodology: Water Quality

* Sampled over 42hrs
* Triggered by water level
* Refrigerated

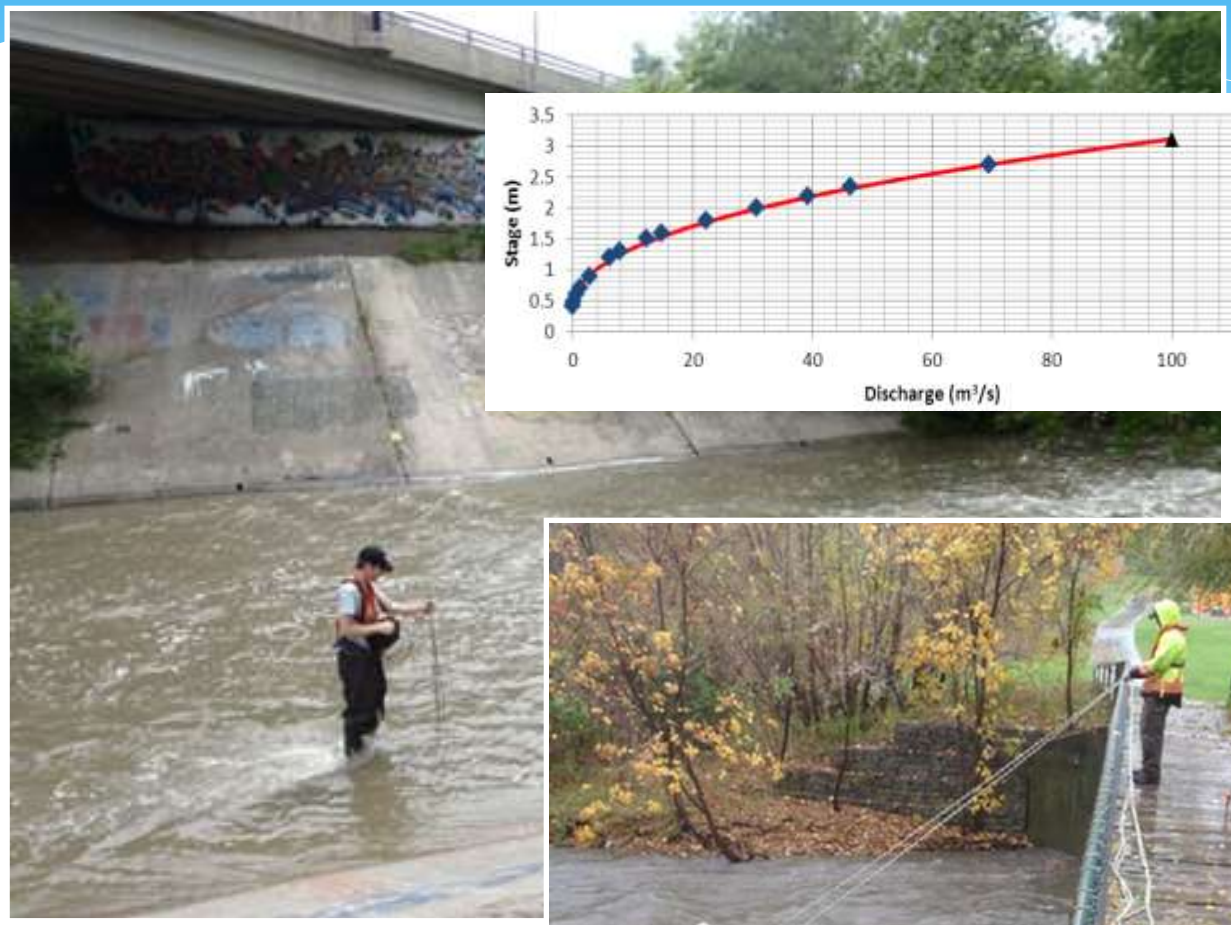
Event Type	Criteria	Sample Frequency	Notes
Dry Weather	No precipitation in region 3-5 days prior to collection date.	1 per season	Confirmation using TRCA real-time flood warning website, local weather forecasts, and the WSC real-time stream gauge website.
Wet Weather	Regional liquid precipitation >=5mm considered, typically >=10mm.	Anytime (pending conditions and resources)	Pending antecedent conditions to produce runoff. Confirmation using TRCA real-time flood warning website, current radar, and other real-time web based meteorological tools to track storm through GTA.
Snowmelt	Presence of snow on ground, air temperature above or near freezing, decrease in snow depth on ground, or rain on snow event.	1 per season (minimum)	Significant water level rise, confirmation of all criteria using Env. Canada Pearson International and Buttonville Airport meteorological stations, TRCA real-time flood warning and WSC real-time stream gauge websites.

Methodology: Water Quality

- Both equal weighted sampling and level/flow proportioned sampling
- Event Mean Concentration (EMCs)
- Beale Ratio Estimator and Area Weighted loads
- Submitted to City of Toronto Laboratory



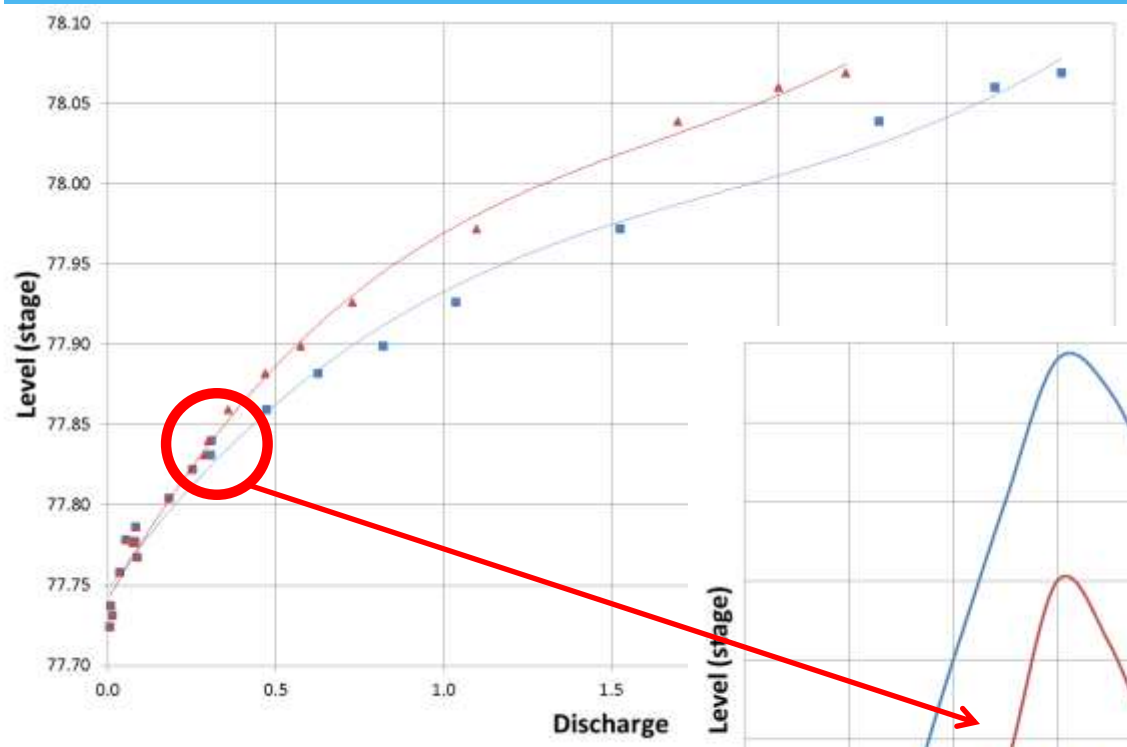
Methodology: Water Quantity

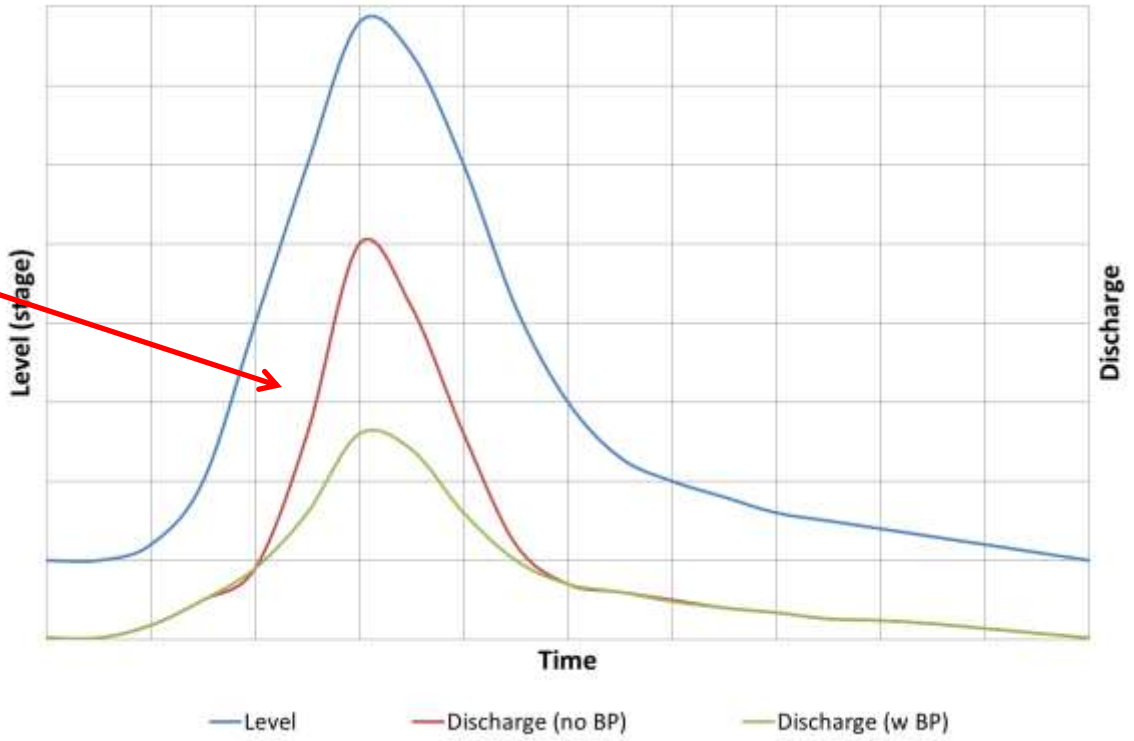


Stage (m)	Discharge (m^3/s)
0.42	0.02
0.5	0.128
0.6	0.425
0.8	1.64
0.9	2.59
1	3.79
1.2	6.96
1.3	8.96
1.4	11.2
1.6	16.7
1.7	19.8
1.9	27.1
2	31.2
2.2	40.3
2.3	45.4
2.5	56.6
2.7	69.1
	83.1
	90.6
	98.5
	100

NOTE: Slide demonstrating the need for good stage/discharge data in order to calculate pollutant load.

Methodology: Water Quantity





NOTE: Slide demonstrating how breakpoints or channel changes can affect flow data while level is the same. Again, a good stage/discharge relationship will help determine this. You should use caution if level proportioning. Flow proportioning preferred.

Methodology: RAP vs. TWWFMN

Attribute	1990-1992	2008-2011
Number of stations	6	14
Station location	mouth of all watersheds	mouth of all watersheds, central, and north border of Toronto
Autosampler used	yes	yes
Autosampler trigger	manually	automated (water level)
Telemetry	no	yes
Sample rate	20 minutes up to 24 hours	Hourly for 42 hours (wet weather and snowmelt), hourly for 24 hours (dry weather)
Sample vessel	6 x 20 L stainless steel canisters	14 x 1 L Teflon bottles (aliquots)
Sample manifold used	yes	no
Sample volume	1.5 liters per sample; up to 120 litre composite	325mL per sample (975 mL per 1 L aliquot) up to 42 L.
Sample line	Teflon	Teflon
Sample processing	equal proportion, time weighted composite	Flow proportioned (wet weather and snowmelt), equal weighted composite (dry weather)
Pre-sample line rinsing	No	yes
Refrigeration	No	yes
Laboratories	MOE and Mann Testing Laboratories	Toronto Water Laboratories / Region of Durham Laboratories*
Dry weather sampling	Yes	yes
Wet weather sampling	Yes	yes
Snowmelt sampling	No	Yes

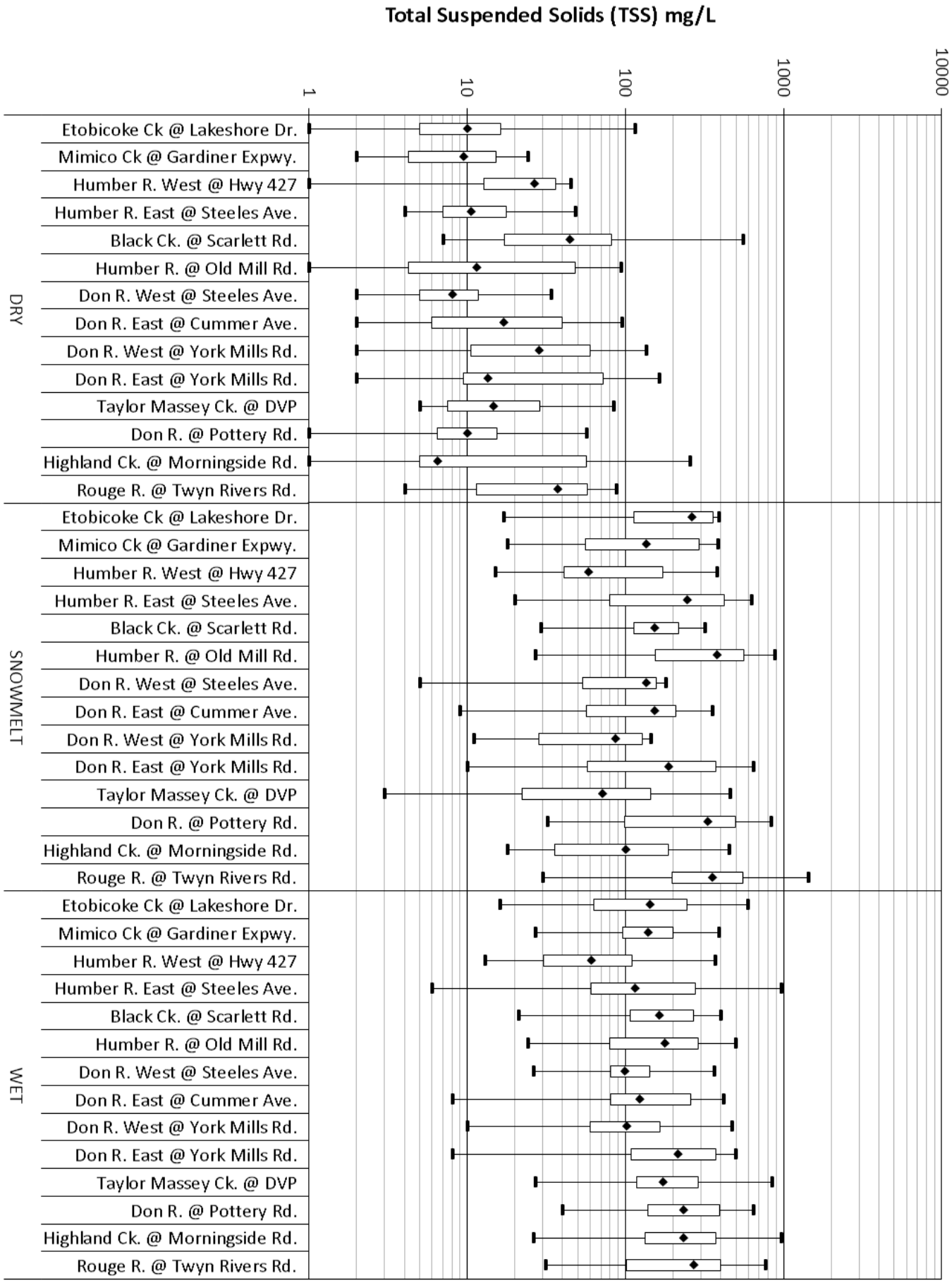
NOTE: Arrows point to the key differences between the two studies and how samples were collected/processed.

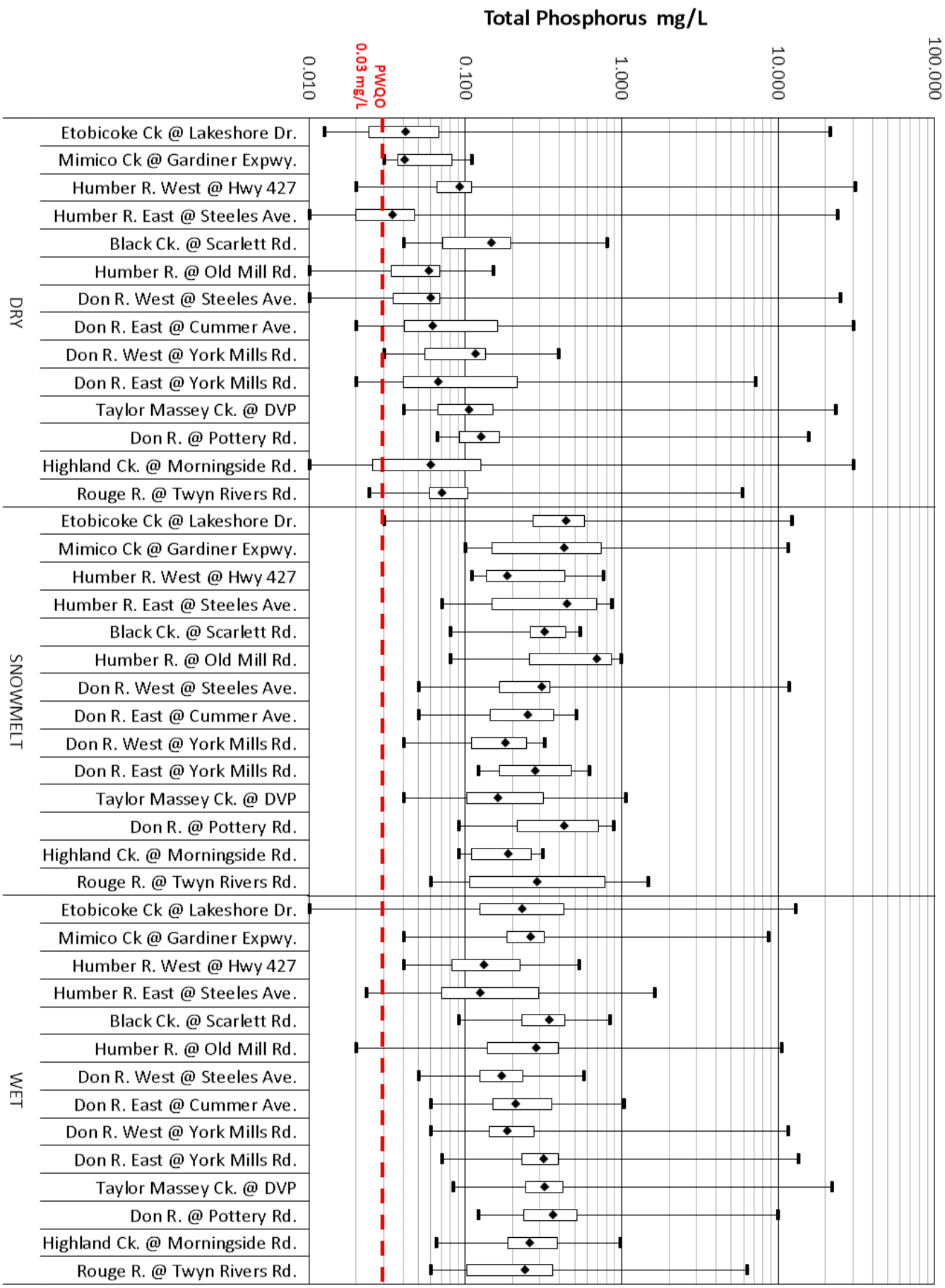
Selected Results

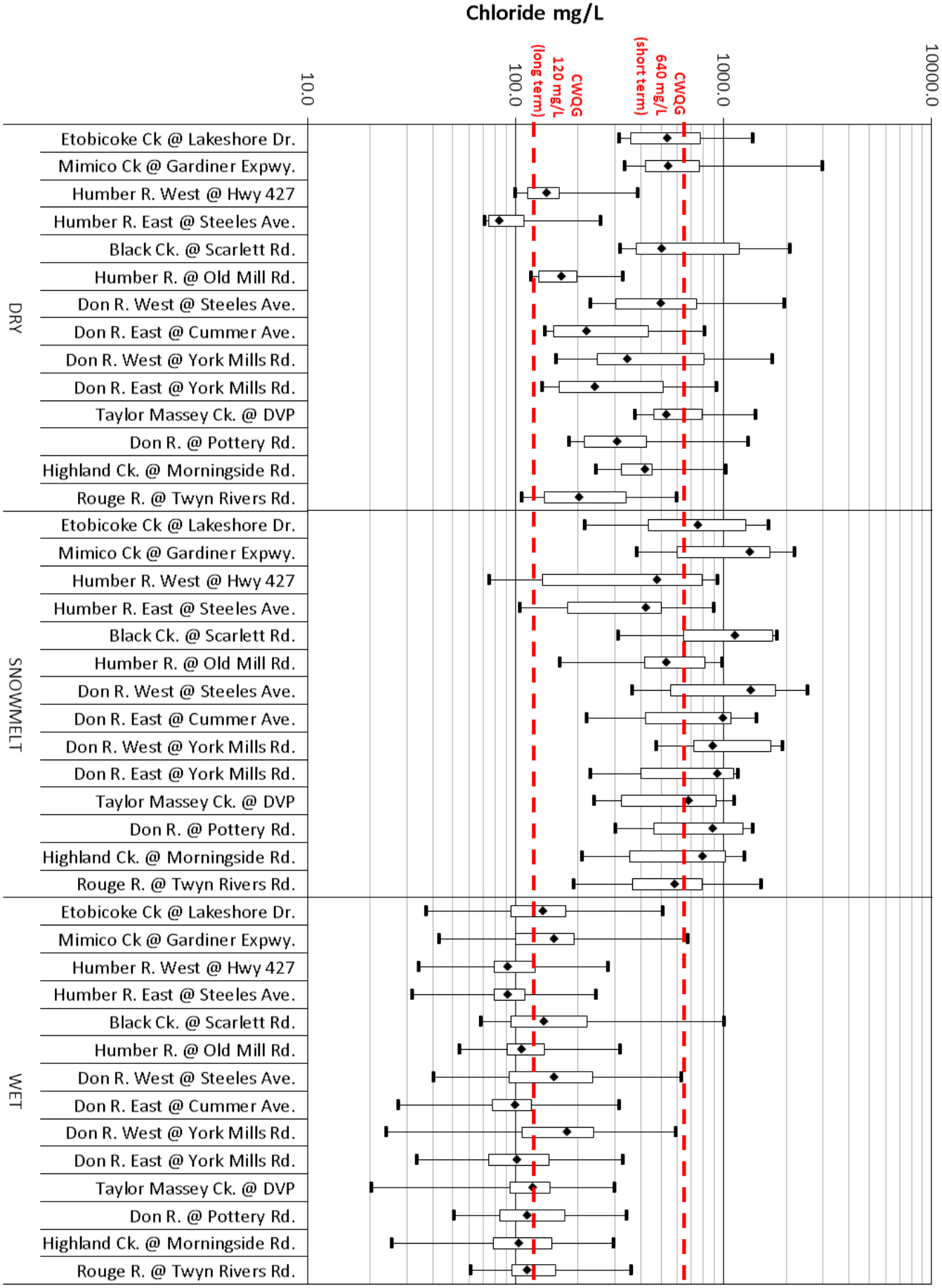
* Over 50 sampling events at all 14 stations:
  * Dry Weather n 8-10
  * Wet Weather n 33-35
  * Snowmelt n 6-7

NOTE: Precipitation information from 10 stations in and bordering the City of Toronto

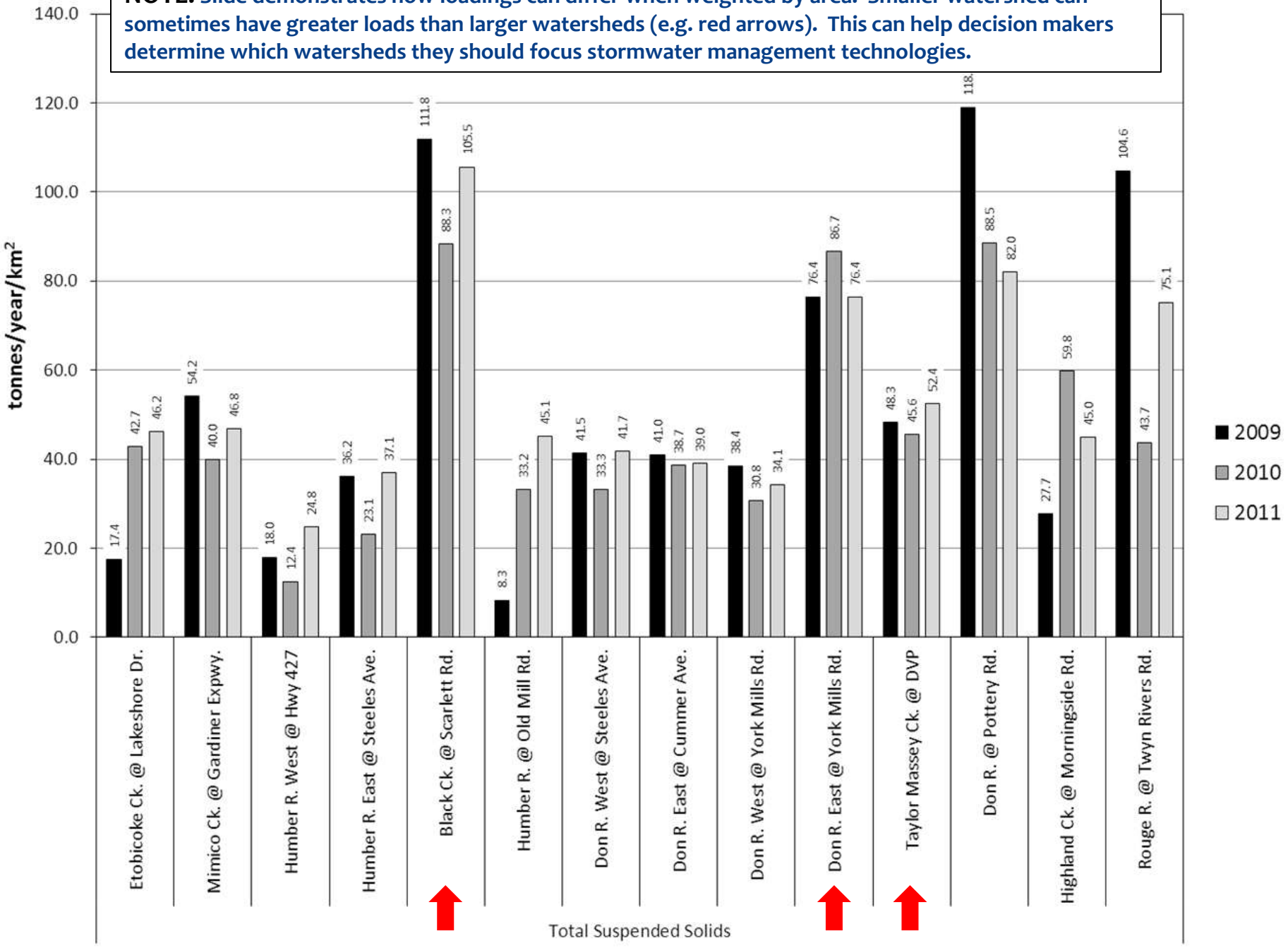
	Total Precipitation (mm)		Event Duration (hrs.)		Maximum Rainfall Intensity (mm/5min)		Maximum Rainfall Intensity (mm/hr.)		Event Rainfall Intensity (mm/hr.)	
	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Mean	24.0	5.2	18.3	1.4	1.9	1.0	6.3	2.8	2.3	0.7
Median	24.7	4.0	13.5	1.1	1.2	0.7	5.0	1.5	1.5	0.3
Minimum	2.6	0.1	1.2	0.2	0.4	0	0.9	0.2	0.3	0.1
Maximum	48.9	17.1	55.2	4	7.9	3.7	24.6	18.2	23.7	9.9


Total Suspended Solids (TSS) mg/L
1
10
100
1000
10000
DRY
SNOWMELT
WET
Etobicoke Ck @ Lakeshore Dr.
Mimico Ck @ Gardiner Expwy.
Humber R. West @ Hwy 427
Humber R. East @ Steeles Ave.
Black Ck. @ Scarlett Rd.
Humber R. @ Old Mill Rd.
Don R. West @ Steeles Ave.
Don R. East @ Cummer Ave.
Don R. West @ York Mills Rd.
Don R. East @ York Mills Rd.
Taylor Massey Ck. @ DVP
Don R. @ Pottery Rd.
Highland Ck. @ Morningside Rd.
Rouge R. @ Twyn Rivers Rd.

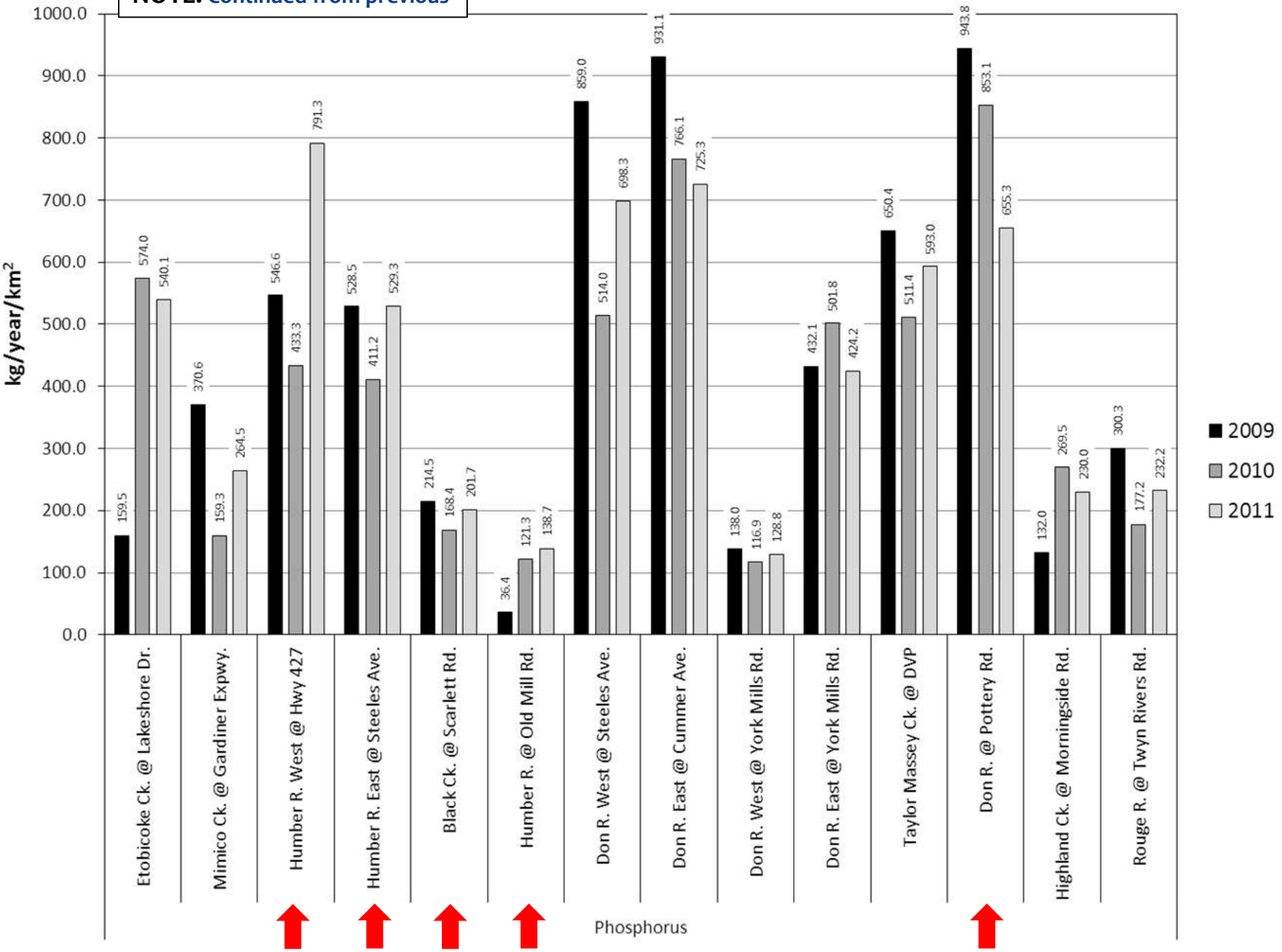

Total Phosphorus mg/L
0.010
PWQO
0.03 mg/L
0.100
1.000
10.000
100.000
DRY
SNOWMELT
WET
Etobicoke Ck @ Lakeshore Dr.
Mimico Ck @ Gardiner Expwy.
Humber R. West @ Hwy 427
Humber R. East @ Steeles Ave.
Black Ck. @ Scarlett Rd.
Humber R. @ Old Mill Rd.
Don R. West @ Steeles Ave.
Don R. East @ Cummer Ave.
Don R. West @ York Mills Rd.
Don R. East @ York Mills Rd.
Taylor Massey Ck. @ DVP
Don R. @ Pottery Rd.
Highland Ck. @ Morningside Rd.
Rouge R. @ Twyn Rivers Rd.


Chloride mg/L
10.0
100.0
1000.0
10000.0
CWQG 120 mg/L (long term)
CWQG 640 mg/L (short term)
DRY
Etobicoke Ck @ Lakeshore Dr.
Mimico Ck @ Gardiner Expwy.
Humber R. West @ Hwy 427
Humber R. East @ Steeles Ave.
Black Ck. @ Scarlett Rd.
Humber R. @ Old Mill Rd.
Don R. West @ Steeles Ave.
Don R. East @ Cummer Ave.
Don R. West @ York Mills Rd.
Don R. East @ York Mills Rd.
Taylor Massey Ck. @ DVP
Don R. @ Pottery Rd.
Highland Ck. @ Morningside Rd.
Rouge R. @ Twyn Rivers Rd.
SNOWMELT
Etobicoke Ck @ Lakeshore Dr.
Mimico Ck @ Gardiner Expwy.
Humber R. West @ Hwy 427
Humber R. East @ Steeles Ave.
Black Ck. @ Scarlett Rd.
Humber R. @ Old Mill Rd.
Don R. West @ Steeles Ave.
Don R. East @ Cummer Ave.
Don R. West @ York Mills Rd.
Don R. East @ York Mills Rd.
Taylor Massey Ck. @ DVP
Don R. @ Pottery Rd.
Highland Ck. @ Morningside Rd.
Rouge R. @ Twyn Rivers Rd.
WET
Etobicoke Ck @ Lakeshore Dr.
Mimico Ck @ Gardiner Expwy.
Humber R. West @ Hwy 427
Humber R. East @ Steeles Ave.
Black Ck. @ Scarlett Rd.
Humber R. @ Old Mill Rd.
Don R. West @ Steeles Ave.
Don R. East @ Cummer Ave.
Don R. West @ York Mills Rd.
Don R. East @ York Mills Rd.
Taylor Massey Ck. @ DVP
Don R. @ Pottery Rd.
Highland Ck. @ Morningside Rd.
Rouge R. @ Twyn Rivers Rd.

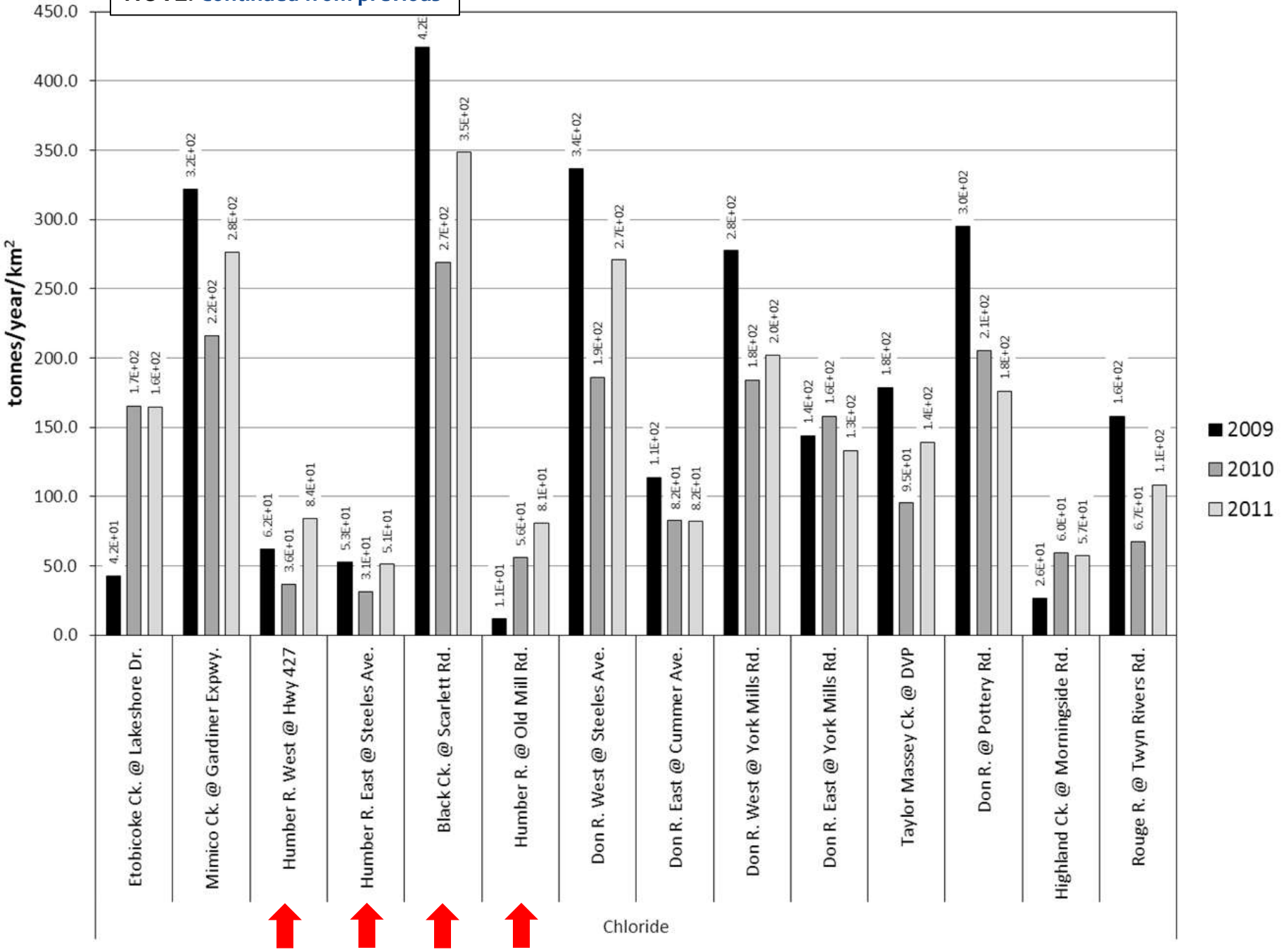
NOTE: Slide demonstrates how loadings can differ when weighted by area. Smaller watershed can sometimes have greater loads than larger watersheds (e.g. red arrows). This can help decision makers determine which watersheds they should focus stormwater management technologies.



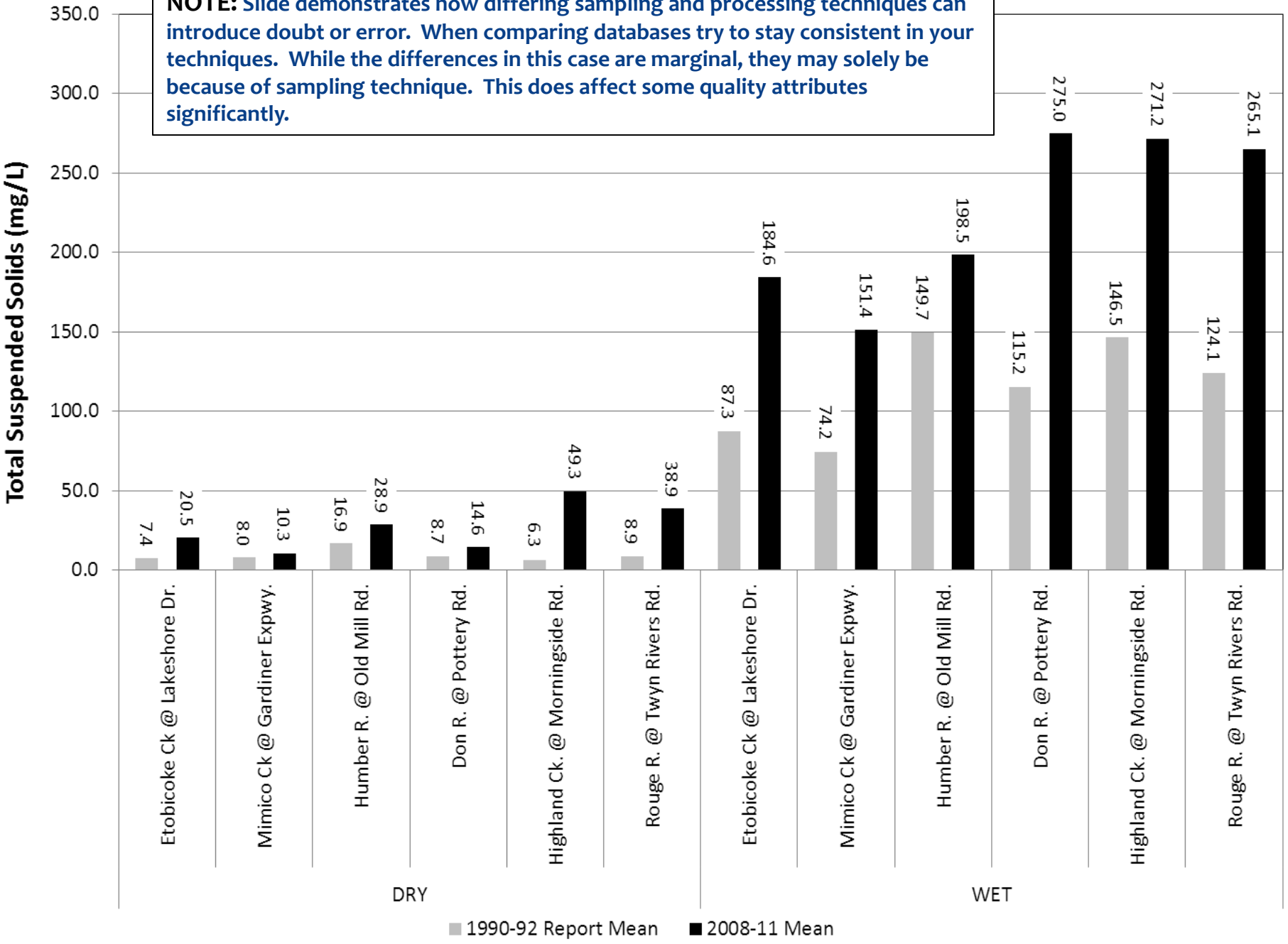
NOTE: Continued from previous

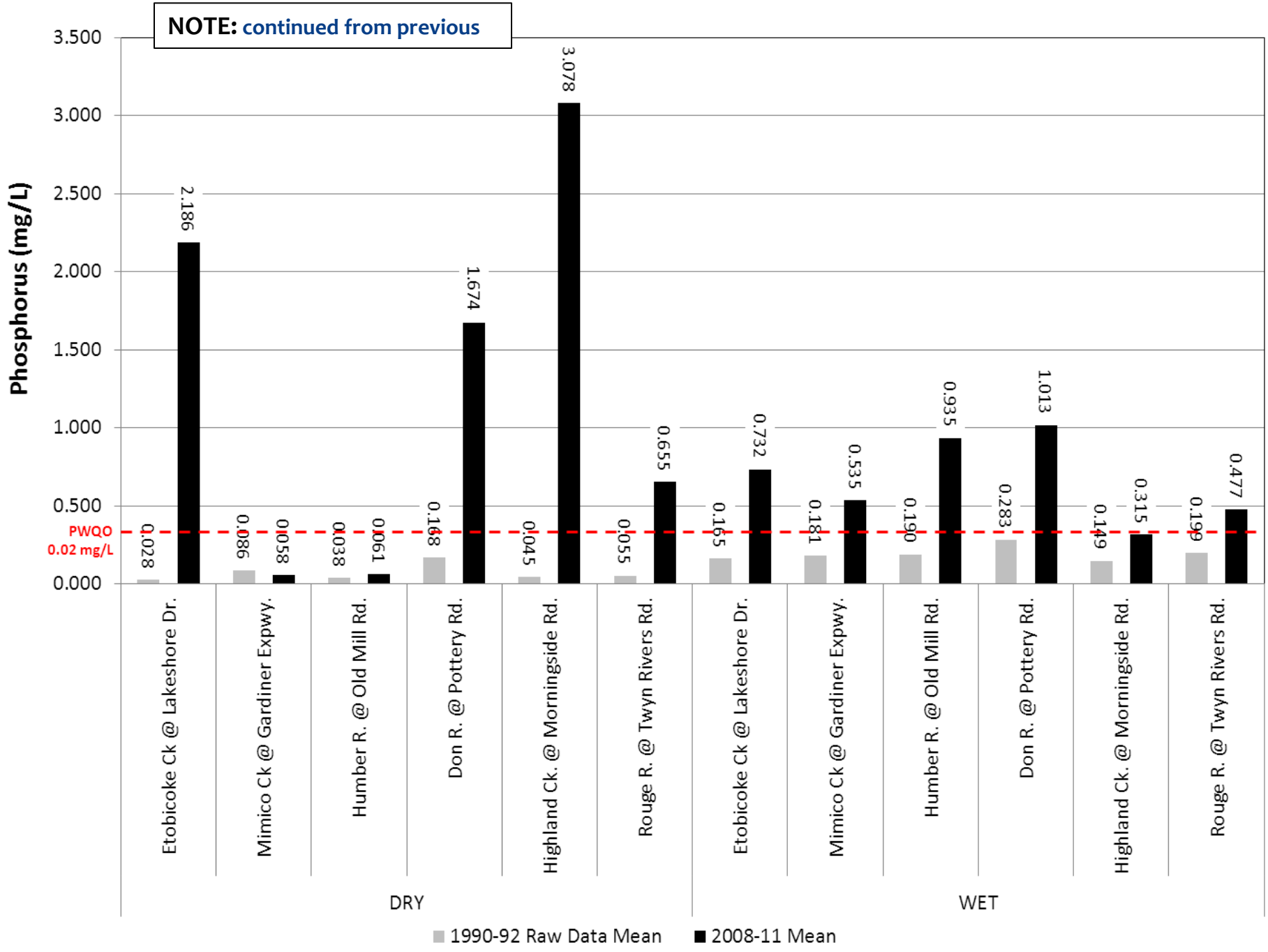


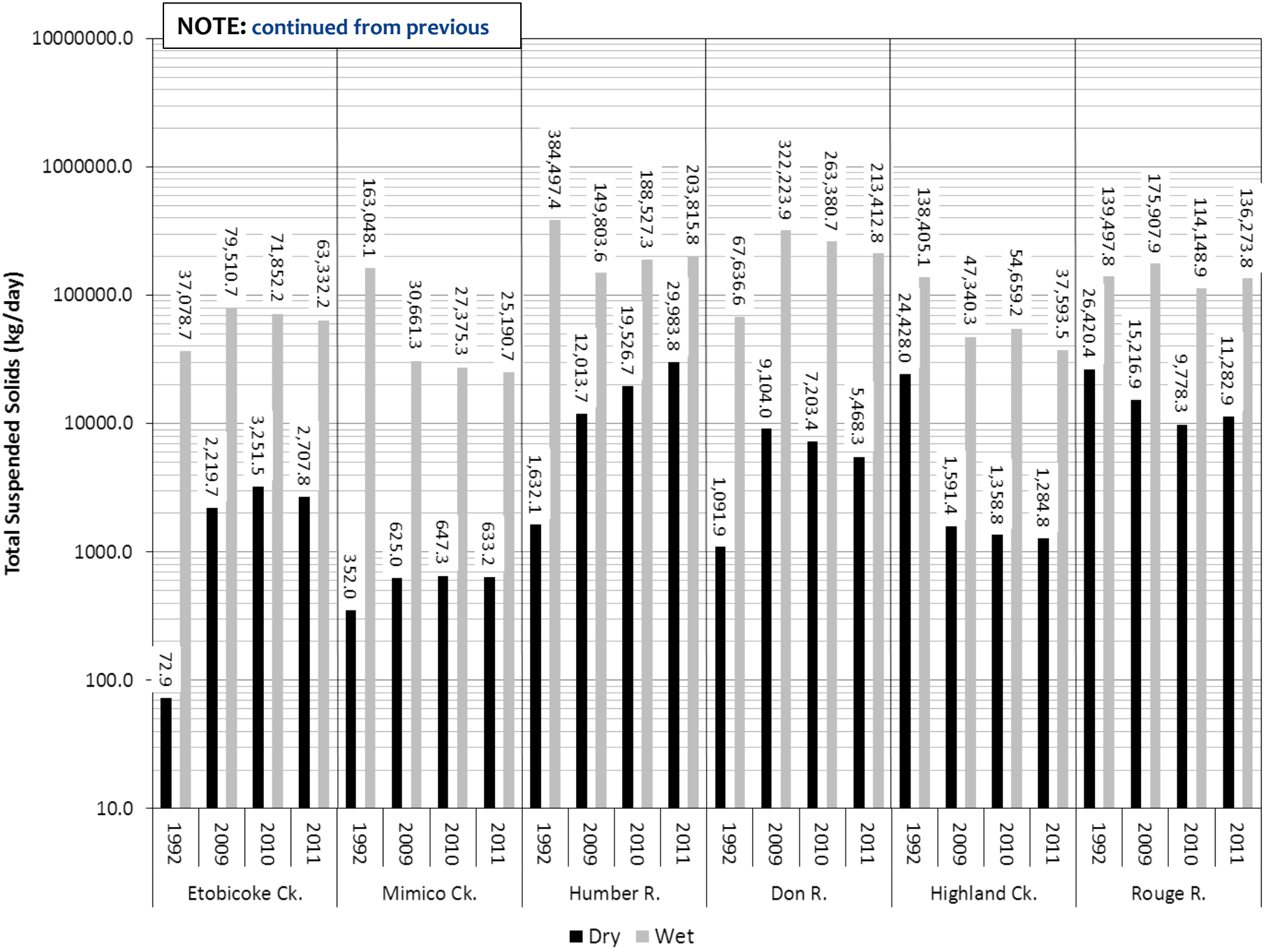
NOTE: Continued from previous

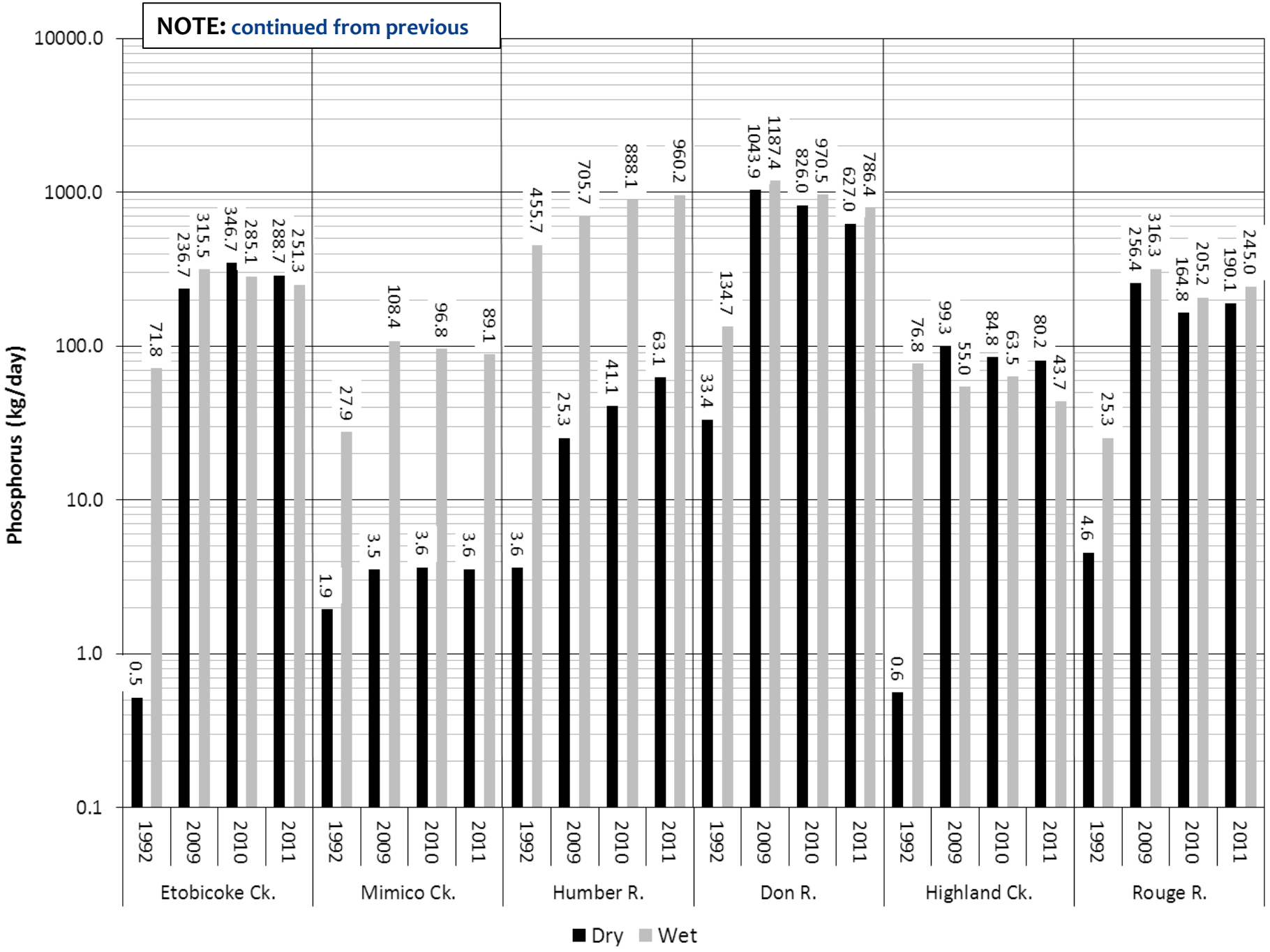


NOTE: Slide demonstrates how differing sampling and processing techniques can introduce doubt or error. When comparing databases try to stay consistent in your techniques. While the differences in this case are marginal, they may solely be because of sampling technique. This does affect some quality attributes significantly.




NOTE: continued from previous
Phosphorus (mg/L)
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
PWQO
0.02 mg/L
0.028
2.186
0.086
0.058
0.038
0.061
0.168
1.674
0.045
3.078
0.055
0.655
0.165
0.732
0.181
0.535
0.190
0.935
0.283
1.013
0.149
0.315
0.199
0.477
Etobicoke Ck @ Lakeshore Dr.
Mimico Ck @ Gardiner Expwy.
Humber R. @ Old Mill Rd.
Don R. @ Pottery Rd.
Highland Ck. @ Morningside Rd.
Rouge R. @ Twyn Rivers Rd.
Etobicoke Ck @ Lakeshore Dr.
Mimico Ck @ Gardiner Expwy.
Humber R. @ Old Mill Rd.
Don R. @ Pottery Rd.
Highland Ck. @ Morningside Rd.
Rouge R. @ Twyn Rivers Rd.
DRY
WET
1990-92 Raw Data Mean
2008-11 Mean


NOTE: continued from previous
Total Suspended Solids (kg/day)
10000000.0
1000000.0
100000.0
10000.0
1000.0
100.0
10.0
72.9
37,078.7
2,219.7
79,510.7
3,251.5
71,852.2
2,707.8
63,332.2
352.0
163,048.1
625.0
30,661.3
647.3
27,375.3
633.2
25,190.7
1,632.1
384,497.4
12,013.7
149,803.6
19,526.7
188,527.3
29,983.8
203,815.8
1,091.9
67,636.6
9,104.0
322,223.9
7,203.4
263,380.7
5,468.3
213,412.8
24,428.0
138,405.1
1,591.4
47,340.3
1,358.8
54,659.2
1,284.8
37,593.5
26,420.4
139,497.8
15,216.9
175,907.9
9,778.3
114,148.9
11,282.9
136,273.8
1992
2009
2010
2011
Etobicoke Ck.
Mimico Ck.
Humber R.
Don R.
Highland Ck.
Rouge R.
Dry
Wet

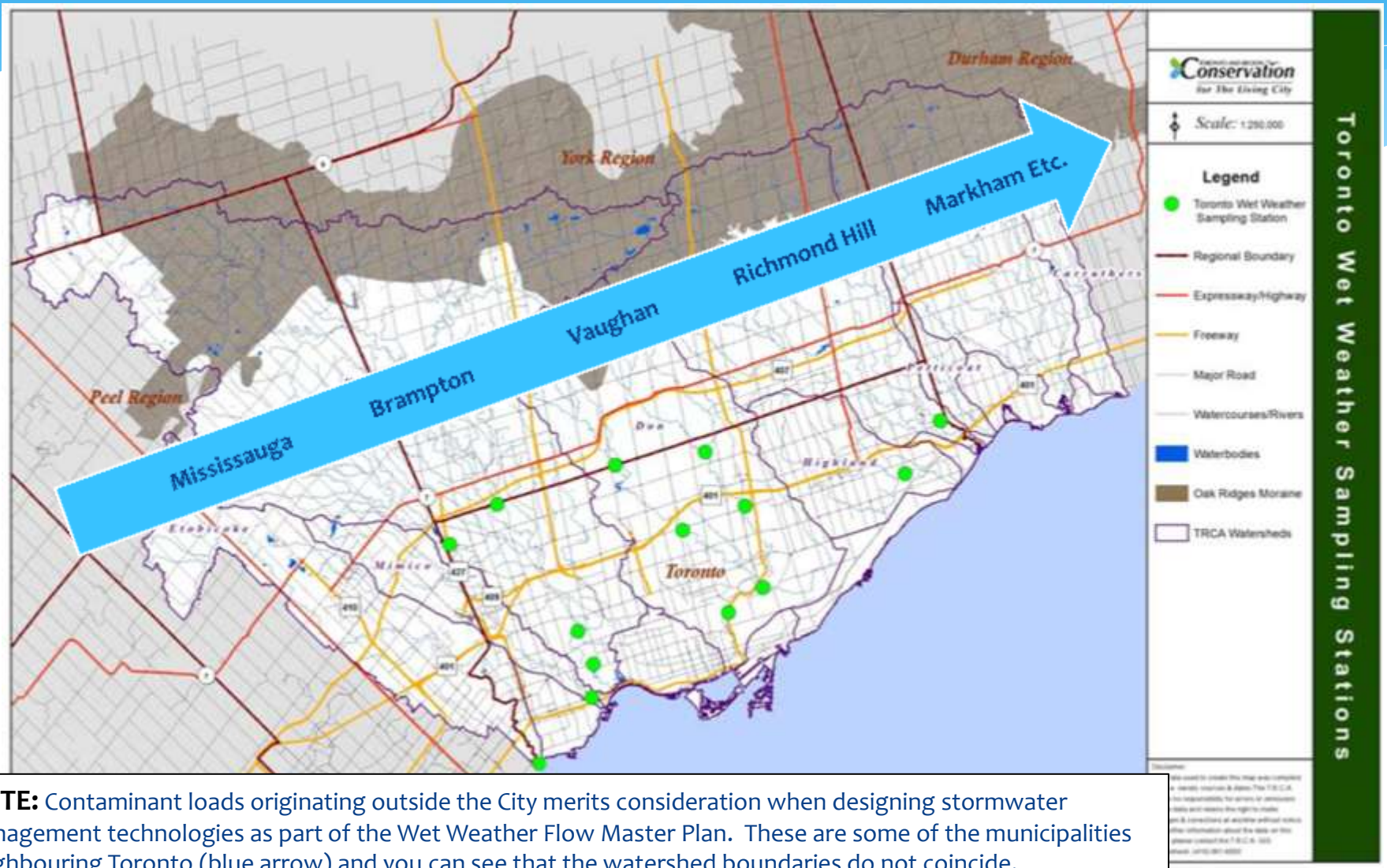

NOTE: continued from previous
Phosphorus (kg/day)
10000.0
1000.0
100.0
10.0
1.0
0.1
0.5
71.8
236.7
315.5
346.7
285.1
288.7
251.3
1.9
27.9
3.5
108.4
3.6
96.8
3.6
89.1
3.6
455.7
25.3
705.7
41.1
888.1
63.1
960.2
33.4
134.7
1043.9
1187.4
826.0
970.5
627.0
786.4
0.6
76.8
99.3
55.0
84.8
63.5
80.2
43.7
4.6
25.3
256.4
316.3
164.8
205.2
190.1
245.0
1992
2009
2010
2011
Etobicoke Ck.
Mimico Ck.
Humber R.
Don R.
Highland Ck.
Rouge R.
Dry
Wet

Selected Conclusions

* Snowmelt or “rain on snow” events appears to have a similar impact as wet weather flow and merit further investigation.
* All watercourses demonstrated some level of contaminant impairment for a variety of quality attributes.
* Taylor Massey Creek and Black Creek, while smaller, had some of the largest contaminant loads and warrant the focus of stormwater management technology implementation.
* Contaminant loads originating outside the City merits consideration when designing stormwater management technologies as part of the Wet Weather Flow Master Plan.

And here’s why…

Selected Conclusions



NOTE: Contaminant loads originating outside the City merits consideration when designing stormwater management technologies as part of the Wet Weather Flow Master Plan. These are some of the municipalities neighbouring Toronto (blue arrow) and you can see that the watershed boundaries do not coincide.

Selected Recommendations

* All future sampling should be flow proportioned for comparison.
* Stage-discharge curves should be maintained throughout the duration of study.
* Further investigation into the relationship between rainfall intensity/volume and watercourse loadings.
* The City should ascertain a better understanding of neighbouring municipal de-icing/SWM practices and impairments in order to customize stormwater management designs and initiatives in the City of Toronto (if not already done so).
* Site specific source controls for problematic contaminants should be considered as important as volume controls during the execution of the City of Toronto Wet Weather Flow Master Plan.

Derek Smith, Field Coordinator, Surface Water
The Ontario Ministry of Environment and Climate Change
Environmental Monitoring and Reporting Branch
125 Resources Road, Etobicoke, ON, M9P 3V6
Desk: 416 235 6232
Cell: 416 786 0866
Email: Derek.Smith2@ontario.ca

Thank You