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Evaluating the effect of residential catchment maturity on phosphorus export coefficients in Ontario

March 26th, 2024

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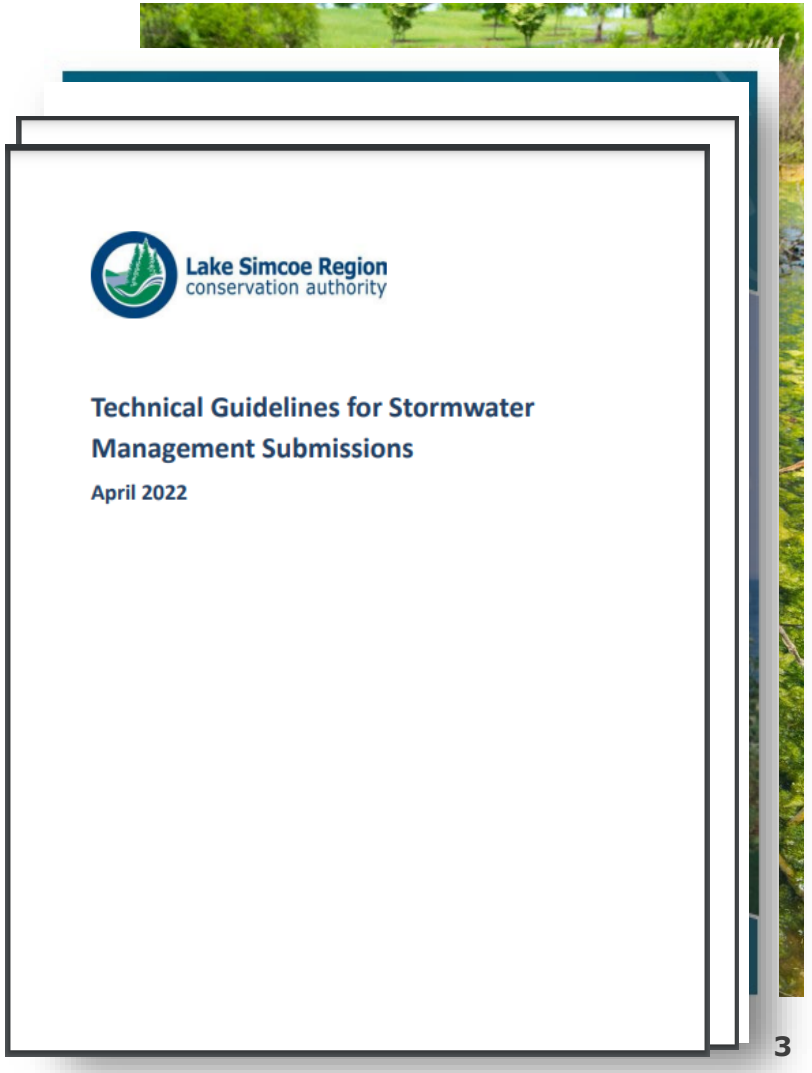
Lake Simcoe Region
conservation authority

Background

Phosphorus: Key nutrient leading to eutrophication

- Water quality protection
- Regulatory compliance
- Planning and design
- Environmental assessment



Factors affecting phosphorus coefficient

- Land use
- Soil type
- Precipitation pattern
- Atmospheric deposition
- Tile drainage

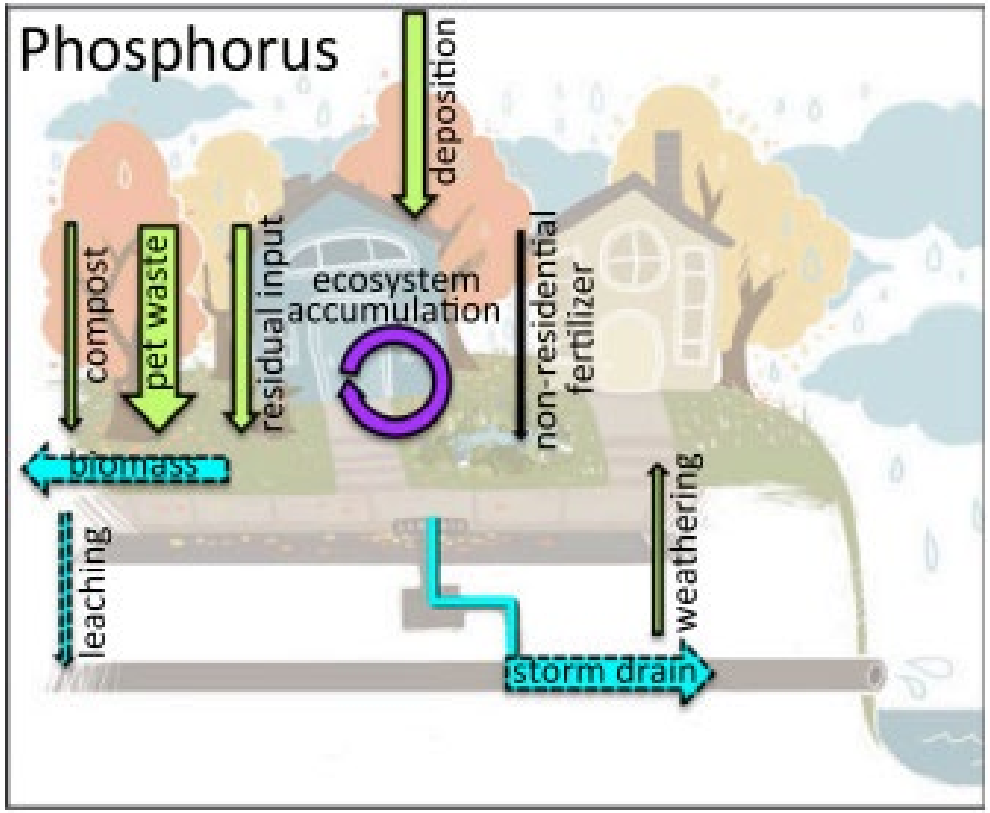
Control

- Vegetation
- Ground water
- Household waste (pet & yard waste)

Variable

Land use – High intensity residential

Growth of high intensity development (residential, commercial, industrial, institutional) will contribute >40% of total phosphorus load to the Lake Simcoe (Berger group, 2010).



Hobbie, et al. (2017).

Phosphorus coefficient for high intensity residential

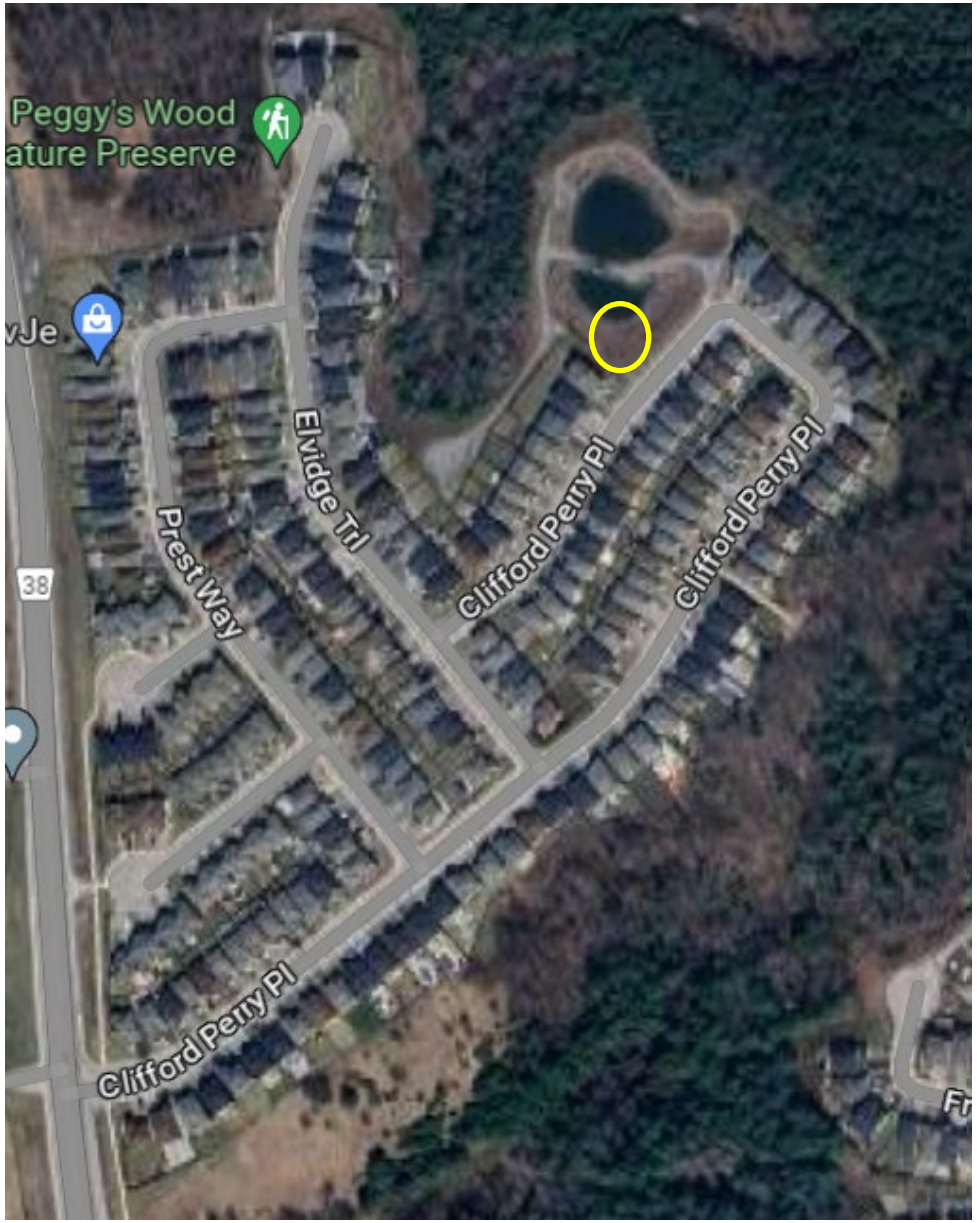
A large range of 0.19-6.23 kg/ha/yr (Reckhow et al. 1980).

- MECP 1.32 kg/ha/yr (SWAMP studies (2005)).
- USEPA 1.3 kg/ha/yr (1983).
- Modeling 0.21-0.67 kg/ha/yr (Berger Group (2010)).

Monitoring sites

- High intensity residential
- Newmarket, ON

Age (Years)	Drainage Area
< 5	11.1
10-15	10
>20	23.63



Monitoring station

Automated sampler & AVM

5-minute flow monitoring

Time-paced, flow-composited sampling (EMC)

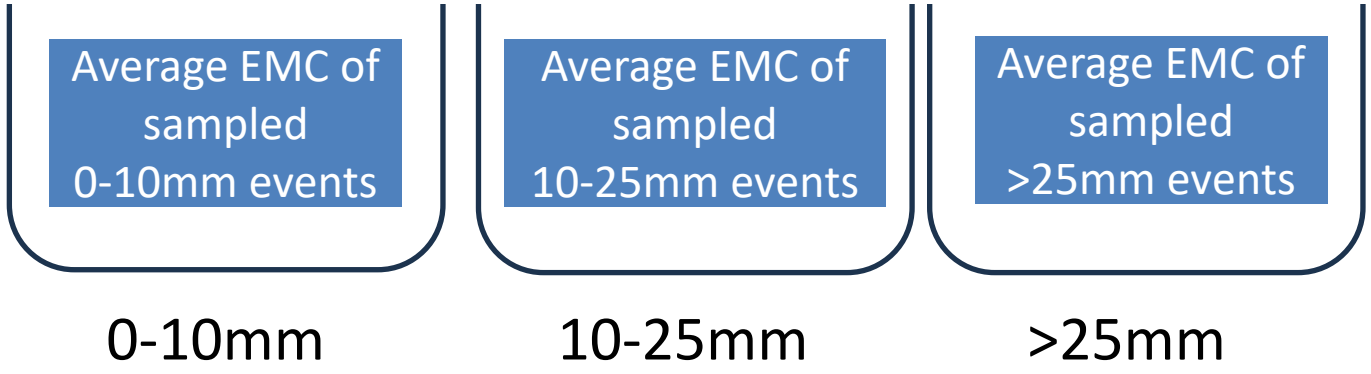
Closest rain gauge station (York Region/LSRCA)

Chloride, TSS, orthophosphate, total phosphorus

Visual tree count and ID

Load estimation method

- Limited number of events sampled
- Binned all the events based on size
- Average concentration of sampled events in each bin used to estimate total load of the bin



Load estimation method

- Validation and error estimation

Bin (precipitatoin mm)	Bin size	Total event volume	Load Chloride.kg	Load TSS.kg	Load OP.kg	Load TP.kg	
>25	7	12595	764.28	411.69	0.44	1.37	Observed
			720.23	458.80	0.49	1.44	Estimated
			-5.76	11.44	10.42	5.26	Error%
10-25	14	24185	1105.32	2292.18	1.05	4.74	Observed
			944.44	2606.80	0.89	5.05	Estimated
			-14.56	13.73	-14.75	6.68	Error%
0-10	17	9417	350.83	903.90	0.32	1.88	Observed
			329.93	1064.69	0.31	2.12	Estimated
			-6.34	15.10	-0.96	11.18	Error%
Sum	38		2220.43	3607.77	1.80	7.99	Observed
			2038.64	4083.17	1.65	8.54	Estimated
			-8.19	13.18	-8.72	6.92	Error%

Results

Catchment Age	Catchment Area (ha)	Monitoring Duration (days)	Monitored precipitation (mm)	Monitored precipitation range (mm)	Monitored events	Sampled events	Percent of total volume sampled
< 5	11.1	643	1054	0.2-59	144	38	76%
10-15	10	858	1880	0.2-103	251	44	40%
> 20	23.63	837	1658	0.2-56	253	32	26%

Export coefficients

Catchment Age	Chloride Load (kg/ha/yr) ± Error%	TSS Load (kg/ha/yr) ± Error%	OP Load (kg/ha/yr) ± Error%	TP Load (kg/ha/yr) ± Error%
< 5	102.09 ± 8%	234.26 ± 13%	0.09 ± 8%	0.48 ± 7%
10-15	262.37 ± 5%	221.22 ± 3%	0.17 ± 2%	0.72 ± 2%
> 20	132.55 ± 1%	151.34 ± 23%	0.12 ± 6%	0.51 ± 14%

- MOE: 1.32 kg/ha/yr
- Modeling: 0.21-0.67 kg/ha/yr
- Catchment age does not describe phosphorus coefficients

Effect of runoff ratio

Catchment Age	Chloride Load (kg/ha/yr) ± Error%	TSS Load (kg/ha/yr) ± Error%	OP Load (kg/ha/yr) ± Error%	TP Load (kg/ha/yr) ± Error%	Runoff Ratio
< 5	102.09 ± 8%	234.26 ± 13%	0.09 ± 8%	0.48 ± 7%	0.33
10-15	262.37 ± 5%	221.22 ± 3%	0.17 ± 2%	0.72 ± 2%	0.39
> 20	132.55 ± 1%	151.34 ± 23%	0.12 ± 6%	0.51 ± 14%	0.33

Runoff ratio describes phosphorus coefficients

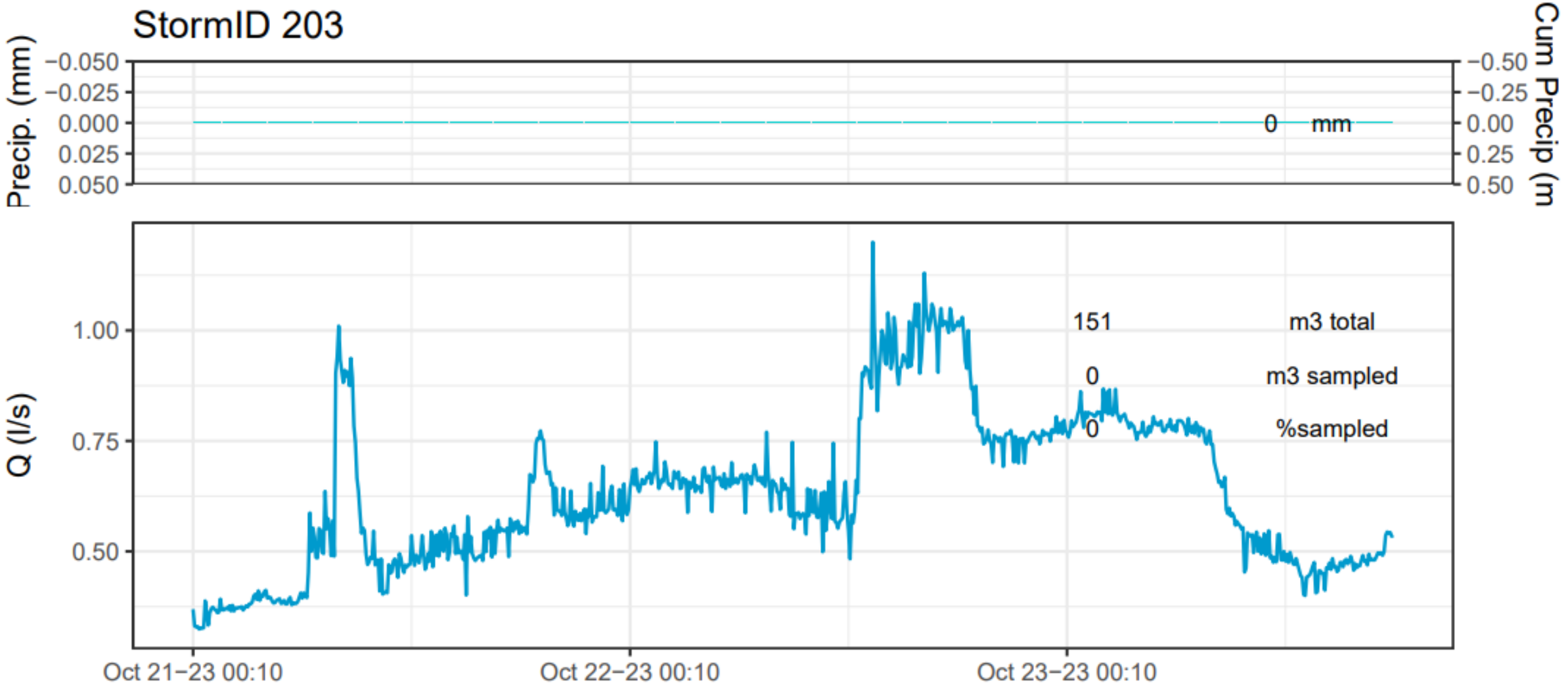
- Further evaluation of IP ratio

Effect of tree count and canopy coverage

Catchment Age	Chloride Load (kg/ha/yr) ± Error%	TSS Load (kg/ha/yr) ± Error%	OP Load (kg/ha/yr) ± Error%	TP Load (kg/ha/yr) ± Error%	Tree count (/ha)	Canopy coverage (m2/ha)
< 5	102.09 ± 8%	234.26 ± 13%	0.09 ± 8%	0.48 ± 7%	32	123
10-15	262.37 ± 5%	221.22 ± 3%	0.17 ± 2%	0.72 ± 2%	55	789
> 20	132.55 ± 1%	151.34 ± 23%	0.12 ± 6%	0.51 ± 14%	32	450

Tree count and canopy coverage describes phosphorus coefficients (also observed by Janke et al. 2017)

Baseflow


StormID 203
Precip. (mm)
−0.050
−0.025
0.000
0.025
0.050
0 mm
Cum Precip (m
−0.50
−0.25
0.00
0.25
0.50
Q (l/s)
1.00
0.75
0.50
151 m3 total
0 m3 sampled
0 %sampled
Oct 21−23 00:10
Oct 22−23 00:10
Oct 23−23 00:10

Baseflow

- High chloride concentrations (200-500 mg/l) [EMC 30-140 mg/l]
- Low TSS concentrations (2-6 mg/l) [EMC 20-114 mg/l]
- Low phosphorus concentrations
  - TP 0.01-0.08 mg/l [EMC 0.13-0.23 mg/l]
  - OP 0.005-0.03 mg/l [EMC 0.03-0.07 mg/l]

Groundwater interference

Effect of groundwater

- Cumulative baseflow volume ~ cumulative storm event volume
- Sampling the baseflow/groundwater is critical
- Low phosphorus concentrations in groundwater do not affect phosphorus coefficients

Conclusions

- Observed phosphorus coefficients for high intensity residential land use within Lake Simcoe watershed ranged in 0.48-0.72 kg/ha/yr
- Canopy coverage and runoff ratio within a catchment can describe phosphorus export coefficients
- Groundwater interference may influence the phosphorus export coefficients; therefore, it is important to monitor and sample
- Catchment age affects integrity of infrastructure

Next steps

- Understanding the influence of pet waste
- Understanding seasonal changes through modified load estimation methodology
- Understanding impervious to pervious ratios at each site
- Further studies: Time the sampling to capture the seasonal leaf effect
- Further studies: Variety of geographic areas, precipitation patterns and land use

Acknowledgement

Ontario

Ministry of the Environment, Conservation and Parks

Newmarket

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