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Inspiring Minds

Phosphorus Loading and Trophic State Assessment in the Paper Mill Lake Watershed

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waterstudies
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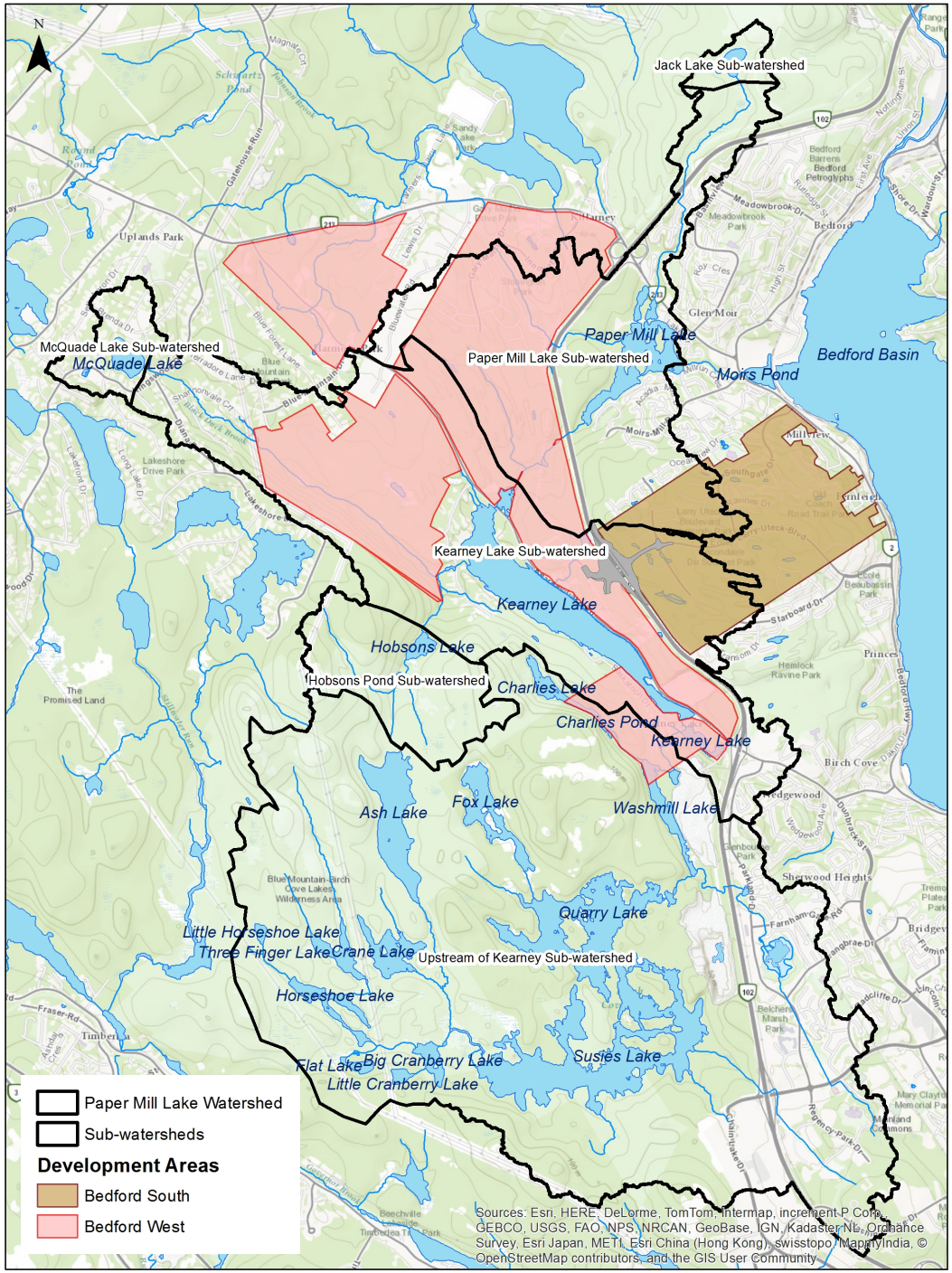
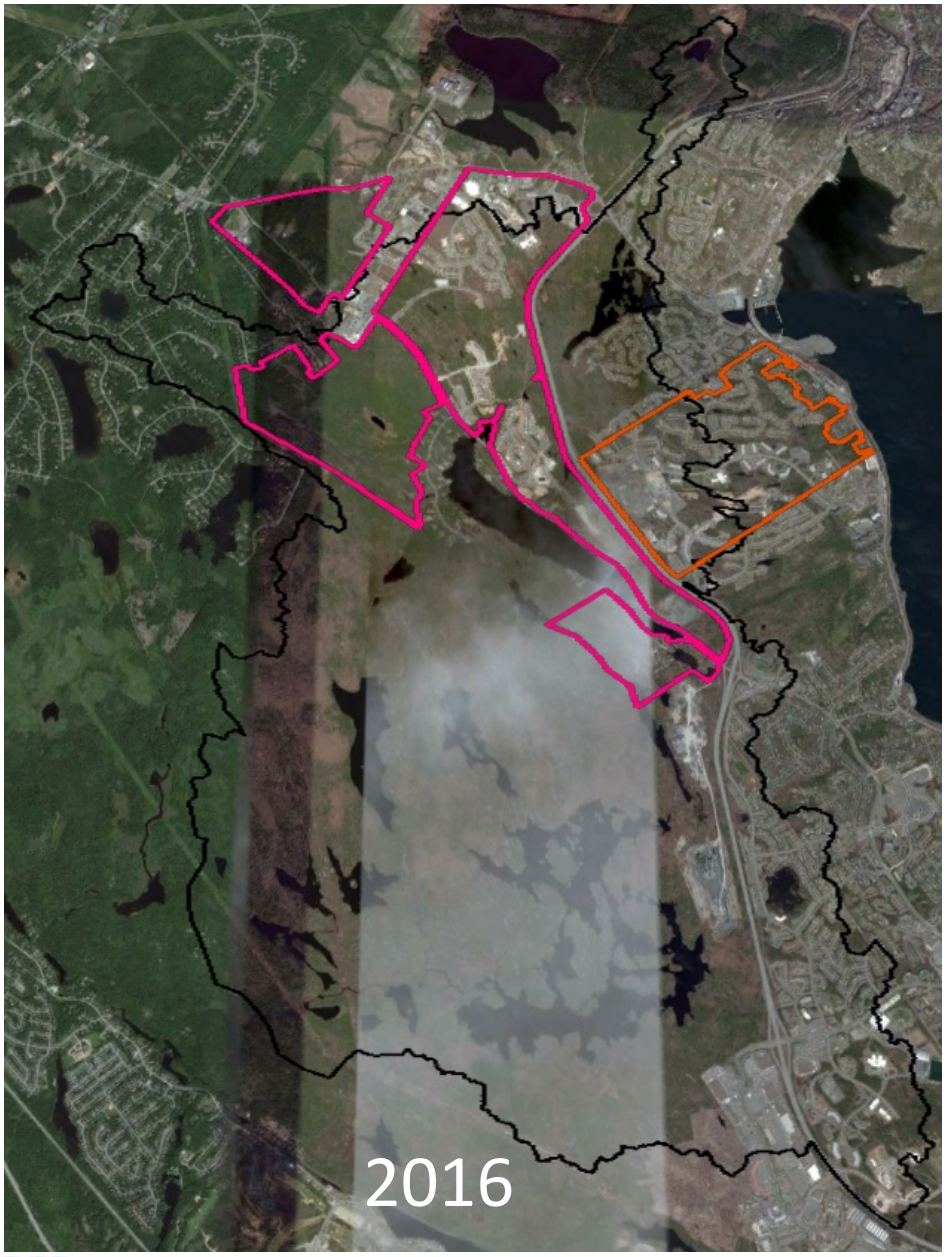


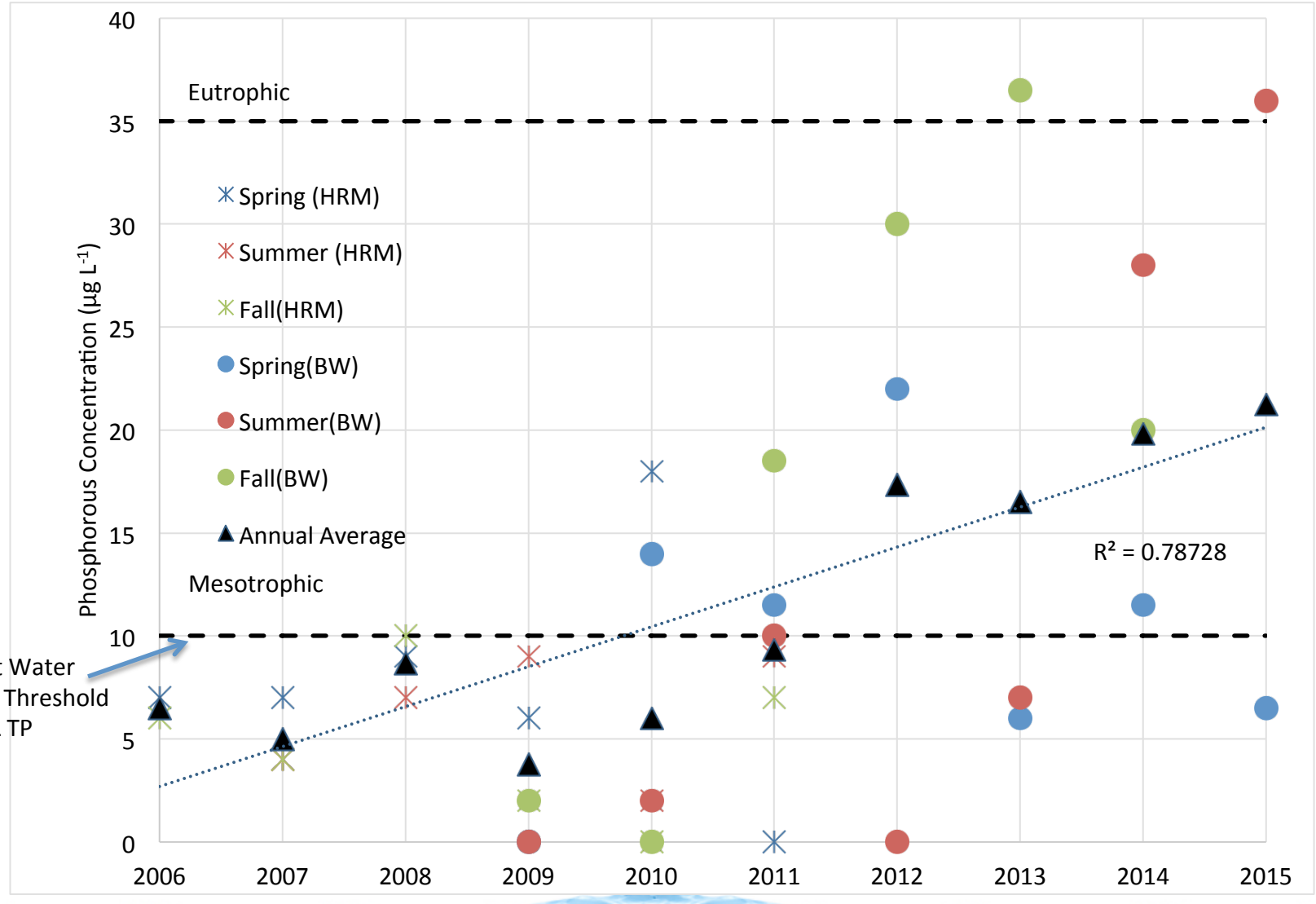
Paper Mill Lake Watershed

- Bedford West
- Bedford South
- Large Upstream Forested Watershed
- Larry Uteck Interchange
- Gateway Materials Quarry


2005


2016

Recent Water Quality Monitoring Data: Upward Trend in Total Phosphorus

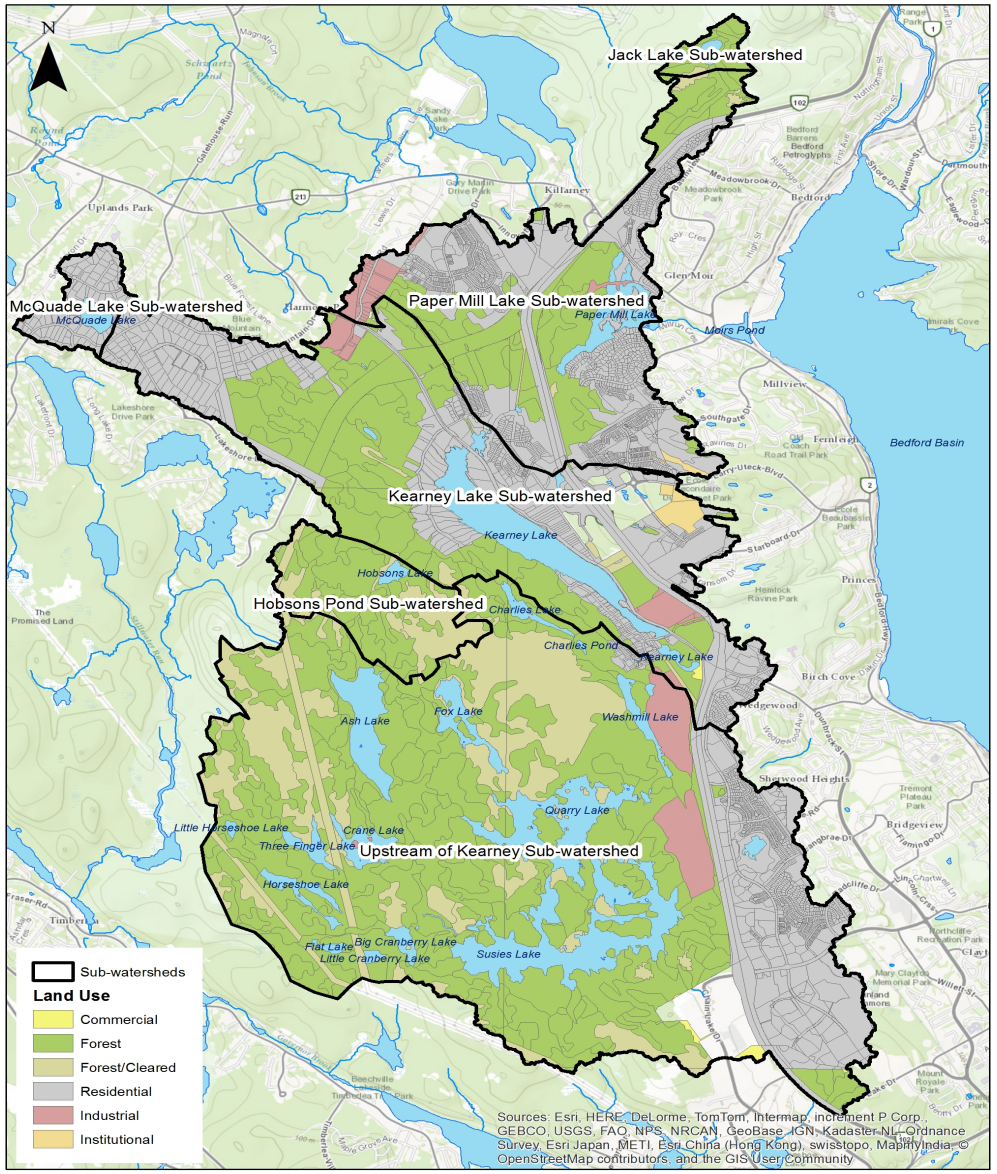


Scope of Work

1. Identify sources of phosphorus to Paper Mill Lake and Kearney Lake.
    - Recommend practical means to validate estimates of phosphorus loading coefficients.
2. Assess the relative role of internal vs external loading of phosphorus.
3. Design water quality monitoring program for Bedford West subdivision to determine if P is increasing over time, both over the entire subdivision and on a sub-area by sub-area basis.
4. Recommend methodology to characterize trophic status, which may or may not be limited to the use of Total Phosphorus.
5. Outline potential consequences of adopting alternative water quality management thresholds.

Question 1 - What are the largest sources of P loading?

- Conducted sensitivity analysis with updated computer model (Scott and Hart, 2004)



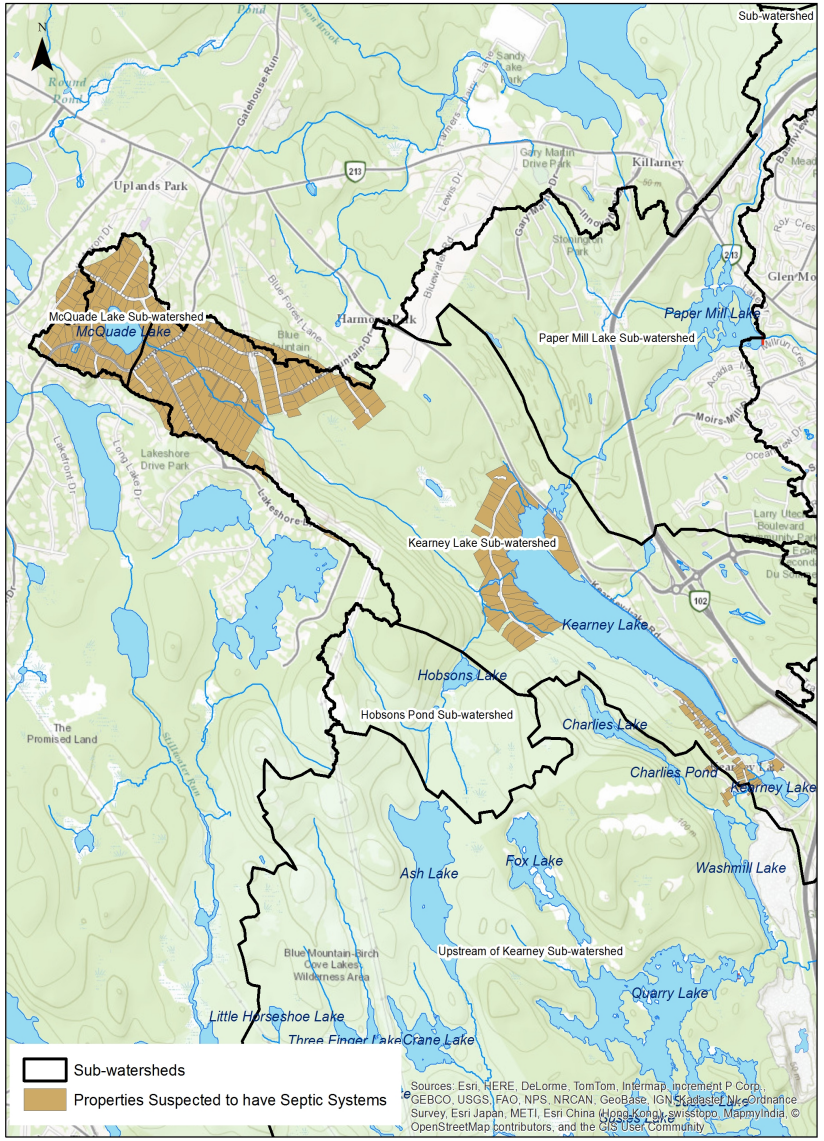
Activity (yearly)	Relative Contribution to KL ($\mu g\ L^{-1}$)	Relative Contribution to PML ($\mu g\ L^{-1}$)	Significance[a] / Uncertainty[b]
Upstream Sources	5.2	10.1	High/Med
Septic Systems	7.3	5.7	High/Med
Residential	4.8	3.2	High/High
Construction of Bedford West	2.2	1.6	Med/Med
Construction of Bedford South	1.8	1.3	Med/Med
Bedford West	1.5	1.9	Med/Med
Industrial	1.2	0.9	Low/High
Bedford South	0.6	0.5	Low/Med
Forest	0.6	0.2	Low/Med
Construction of Larry Uteck Interchange	0.4	0.2	Low/High
Atmospheric	0.3	0.1	Low/Med
Commercial	0.3	0.0	Low/High
Operation of Gateway Materials Quarry	0.1	0.2	Low/High
Institutional	0.1	0.0	Low/High
Kearney Lake Road Linear Road Work	0.1	0.0	Low/Med
Sewer Overflows	0.1	0.0	Low/Med

[a] Significance of relative contribution to KL and PML defined as $P < 1\ \mu g\ L^{-1}$ = Low, 1-3 $\mu g\ L^{-1}$ = Medium and $> 3\ \mu g\ L^{-1}$ = Highly significant.

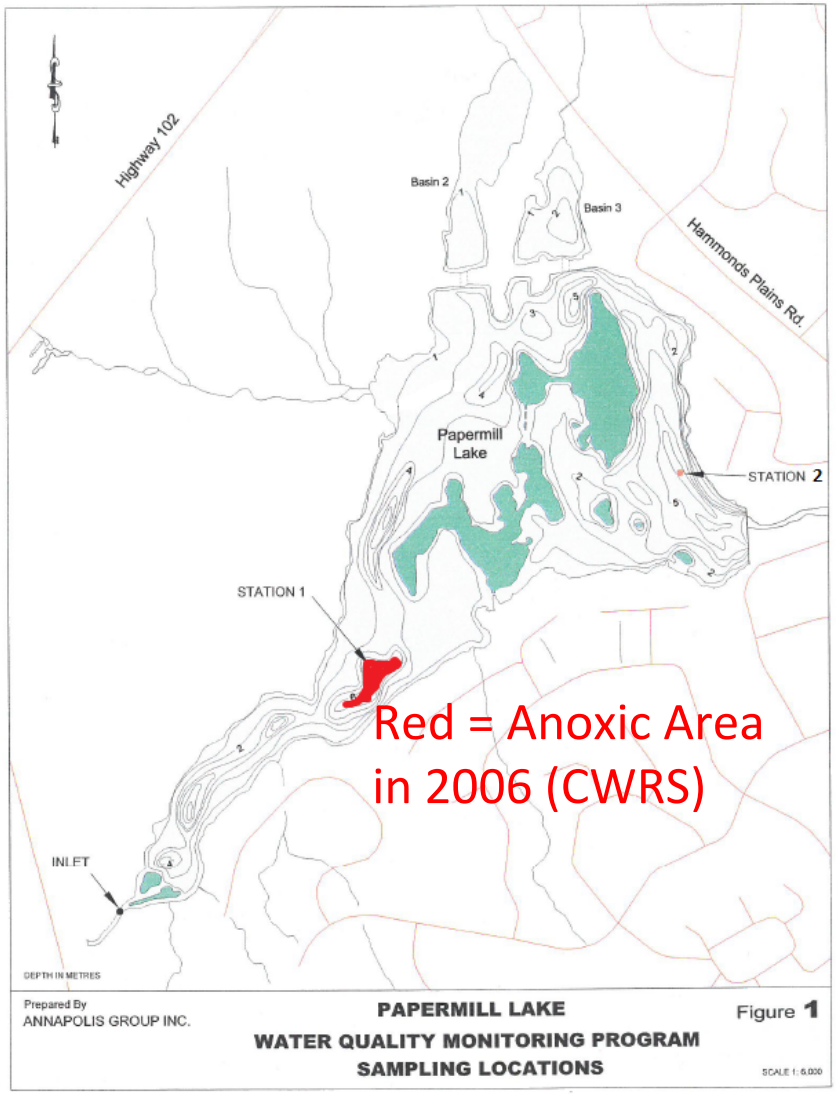
[b] Uncertainty in the relative contribution estimate to both KL and PML.

Question 1 - What are the largest sources of Phosphorus loading?

- There are several significant potential sources of phosphorus loading:
  - Septic systems
  - Runoff from residential land uses
  - Upstream loading from undeveloped land
- Sources of uncertainty
  - Residential land use phosphorus export coefficients
  - Phosphorus loading from septic systems
  - Draining of Paper Mill Lake



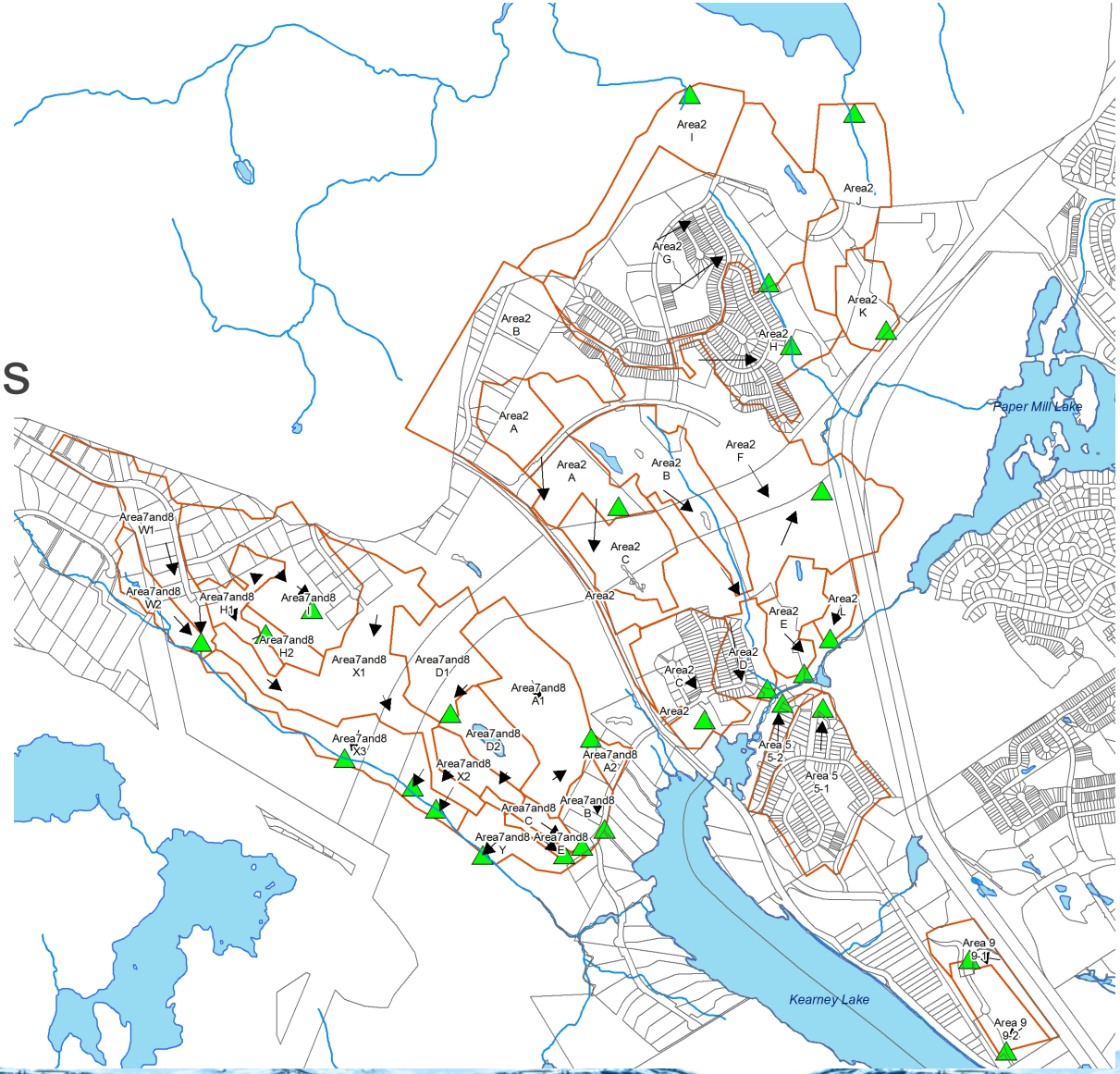
Question 2 – Is Internal Loading a Significant Factor?

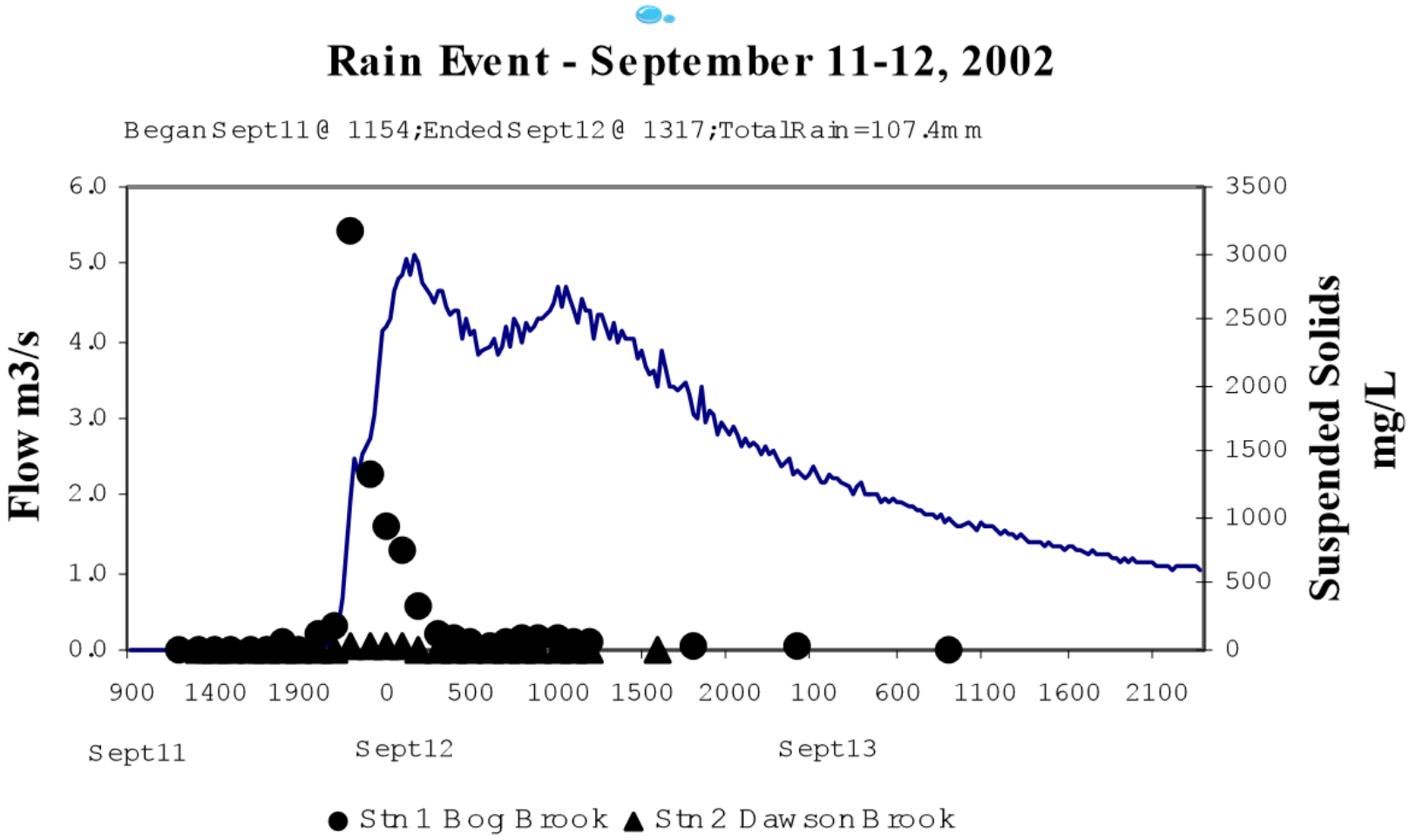


- Internal loading driven by anoxic conditions
- Areas delineated as anoxic → Only one, deep station of PML upper basin
- Internal Loading < 0.1% P Loading in the watershed

Question 3 – Monitoring Program to track P Loading from Bedford West with a Second Objective to Validate Export Coefficients

- Approved and proposed stormwater plans
- Identified 27 outfalls for full build out
- Various BMPs
  - Swales
  - Ponds





Characteristic hydrograph with suspended solids concentration. Demonstrates the high sediment export during the rising limb of the hydrograph that quickly tapers off as easily mobilized (eroded) sediment becomes less available. (Scott & Waller 2002)

Question 3 – Monitoring Program to Track P Loading from Bedford West with a Second Objective to Validate Export Coefficients

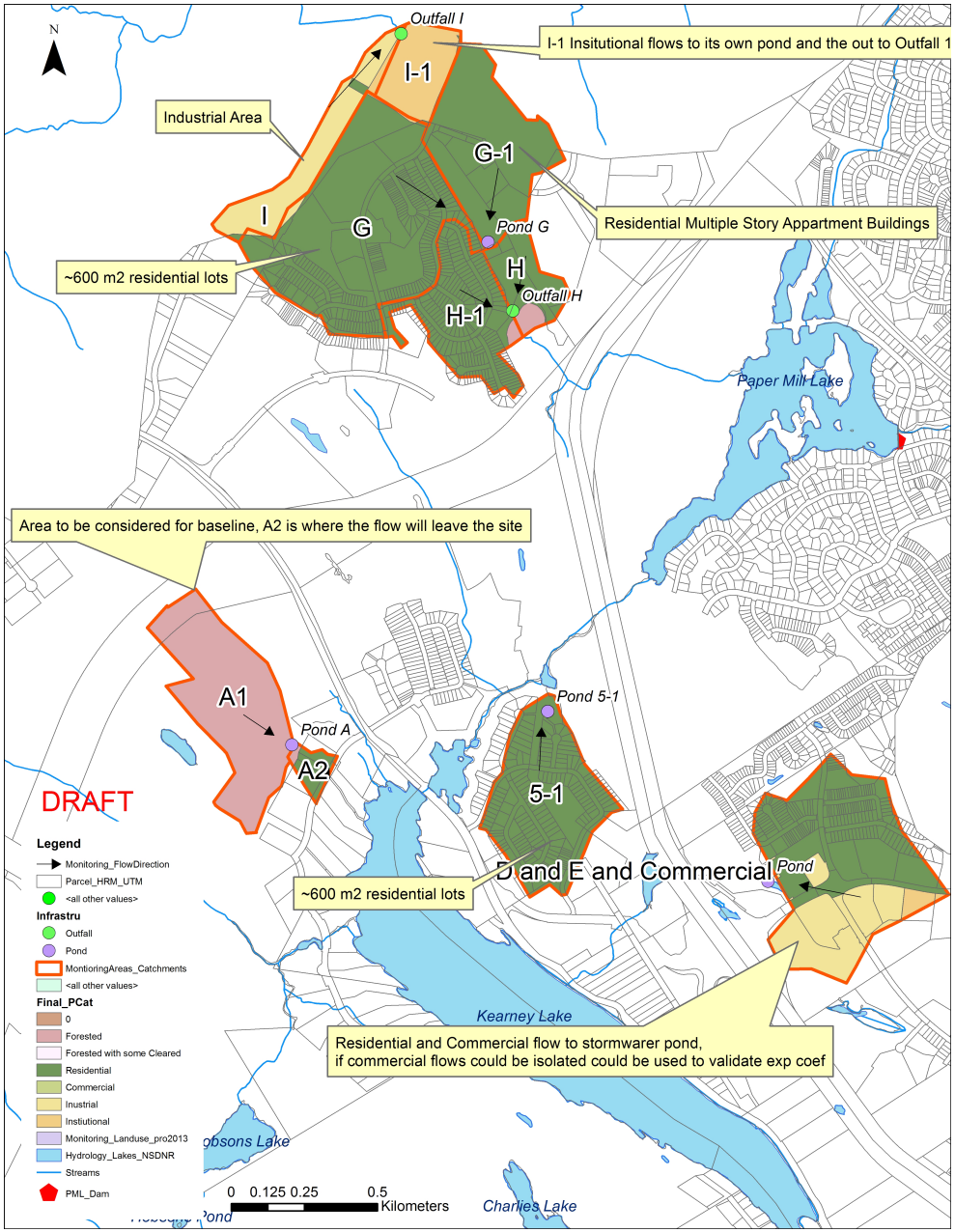
- Monitoring program required for one outfall

Auto Sampler

Cost Estimate	
Events Per Year	13
Samples Per events	8
Total Cost Per Year/Outfall	**$15,000**

Proposed Targeted Monitoring Program

- Monitor representative areas
  - Validate Phosphorus Export Coefficients
  - Validate BMP structure efficiency



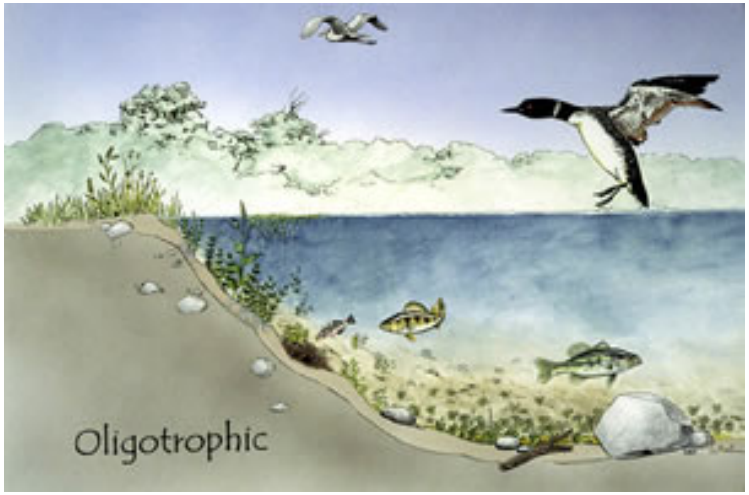
Pond 5-1

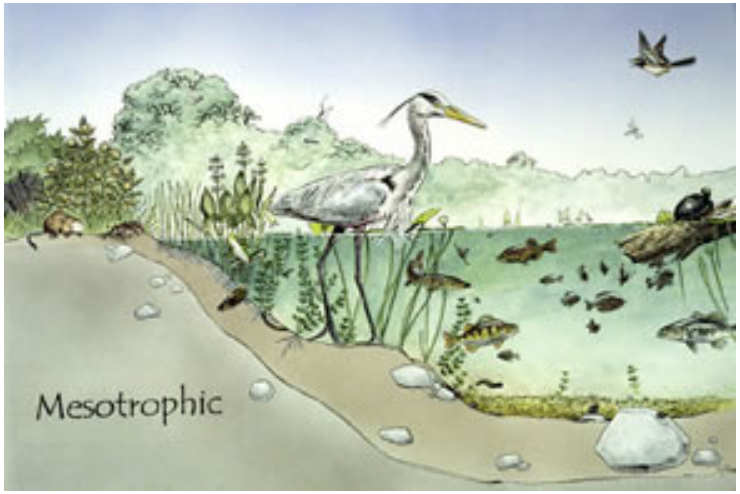
Question 4 – How should Trophic State of Waterbodies in Paper Mill Lake Watershed be Monitored?

- TP is most commonly used to define trophic state in Canada
  - Based on well documented relationship between total phosphorus and chlorophyll a

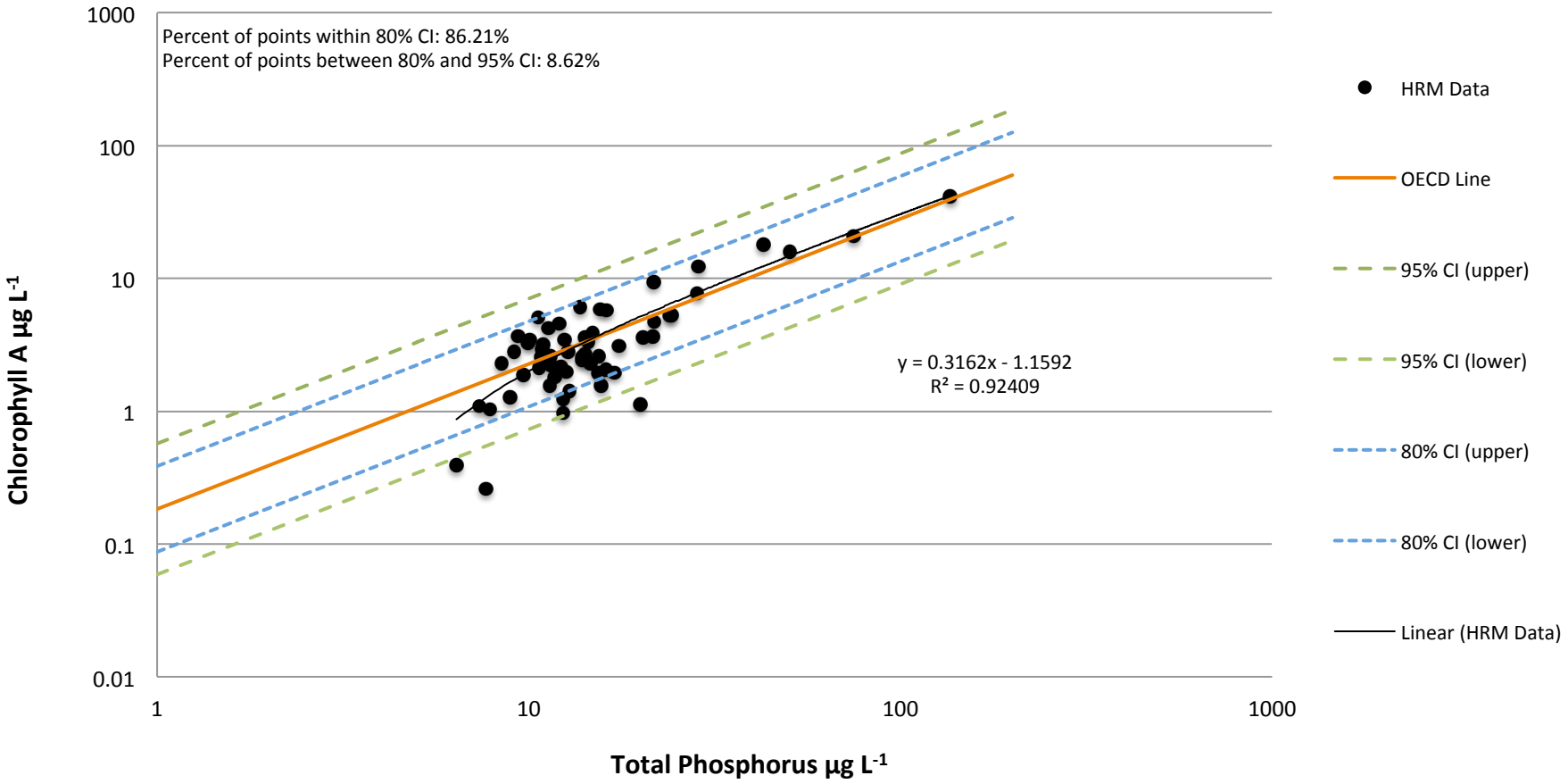
Trophic Status	Canadian Trigger Ranges Total phosphorus ($\mu g \cdot L^{-1}$)
Ultra-oligotrophic	< 4
Oligotrophic	4-10
Mesotrophic	10-20
Meso-eutrophic	20-35
Eutrophic	35-100
Hyper-eutrophic	> 100

CCME, 2004





Mean TP and corresponding chlorophyll *a* values based on average TP:Chla relationship for 58 lakes in the Halifax Regional Municipality. Data was collected from 2006-2011.



Question 4 – How should Trophic State of Waterbodies in Paper Mill Lake Watershed be Monitored?

- Proposed approach
  - Chlorophyll a as primary trophic state metric
  - Continue to monitor phosphorus as it is a key driver of trophic state

Chlorophyll a Monitoring Program	
Sampling Season	Ice free to fall turn over
Sampling Frequency	Bi-weekly
Locations	2 in lake deep stations
Samples per Station	3 (shallow, middle and deep)

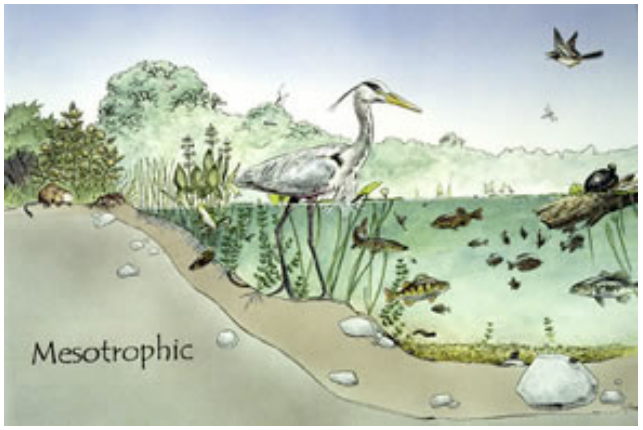
Question 5 –What are consequences of adopting different thresholds?

- Current threshold = 10 ug/L Total Phosphorus
  - Assumed boundary between Oligotrophic and Mesotrophic state
- Potential thresholds could include
  - TP
  - Chlorophyll a
  - Both
- Dual Threshold Approach
  - Chlorophyll a
    - Direct indicator of trophic state
  - Total Phosphorus
    - Primary watershed-based driver of trophic state

Parameter	Threshold	Trophic State
Phosphorus	10 ug/L	Oligotrophic
	15 ug/L	Mesotrophic
	25 or 50% increase	Depends on baseline
Chlorophyll a	2.5 ug/L	Oligotrophic
	8 ug/L	Mesotrophic

Question 5 –What are consequences of adopting different thresholds?

- Potential consequences of shift to mesotrophic state
  - Increased risk of Harmful Algae Blooms (HAB)
  - Lower dissolved oxygen and potential shifts in dominant fish species



Recommendations

1. Chlorophyll a should be the trophic state indicator for Paper Mill Lake and Kearney Lake
   - Total Phosphorus used as indicator of eutrophication pressure from development activities
2. Resume deep station sampling with appropriate spatial/ temporal sampling frequency
3. Individual developments should not be regulated based on trophic state indicators in a lake
4. Undertake targeted study to validate
   a. Phosphorus export coefficients
   b. BMP treatment performance