Kingsville Leamington Nutrient Project – Appendix I

The information in this Appendix accompanies the report entitled 'Expanding greenhouse sector in Essex County, ON and downstream water quality degradation. Kingsville Leamington Nutrient Project 2012-2022', prepared by the Essex Region Conservation Authority.

Location and Watershed Information

Most sites are located in watersheds within the municipal boundaries of Leamington or Kingsville, ON (**Table 1**). The project began in 2012 with 14 sites (n=6 non-greenhouse and n=8 greenhouse influenced streams). Over the course of the project, some new sites have been added and while most site locations have remained unchanged, others were relocated or paused for various reasons. Additional sites have been added to capture areas with rapid greenhouse expansion. Detailed explanations of changes to site locations are provided below Table 1.

Table 1 - Site Locations, number of samples (routine only), start and end year

Station	Watershed	Latitude	Longitude	#Samples	Start Year	End Year
KLN 01	Mervin Drain	42.09509217	-82.44677234	193	2012	2022
KLN 02	West Two Creek	42.092435	-82.47368882	181	2012	2022
KLN 03	Muddy Creek	42.08044604	-82.489164	179	2012	2022
KLN 04*	Lebo Creek	42.07160897	-82.52361325	190	2012	present
KLN 05*	Sturgeon Creek	42.03251495	-82.56494839	109	2012	2018
KLN 05_ISCO*	Sturgeon Creek	42.04550468	-82.57462577	107	2017	present
KLN 06*	Judson Morse Dr.	42.0380794	-82.64175372	149	2012	2022
KLN 07*	Rawley Drain	42.03893125	-82.64515849	151	2012	2022
KLN 09*	Esseltine Drain	42.03971488	-82.66140445	138	2012	2022
KLN 10*	Albert Gunning	42.03986054	-82.67677621	191	2012	2022
KLN 11*	Lane Drain	42.03791072	-82.69485904	199	2012	present
KLN 12*	Mill Creek	42.02785472	-82.74209475	115	2012	2018
KLN 12_ISCO*	Mill Creek	42.0397062	-82.74415565	105	2017	present
KLN 12B*	Mill Creek	42.0473855	-82.72329574	97	2016	present
KLN 13	Wigle Creek	42.05323839	-82.75953053	190	2012	present
KLN 14	Cedar Creek	42.05372186	-82.85539568	85	2012	2016
KLN 14B	Cedar Creek	42.05433135	-82.86723495	119	2016	2022
KLN 15	Dolson Creek	42.00552532	-82.84038613	188	2012	2022
RR 07*	Ruscom River	42.172077	-82.604717	37	2020	present
RR 08	Ruscom River	42.181312	-82.653625	39	2020	present

*indicates greenhouse influence

- KLN 14 was relocated to a site further west in 2016. The original site was on a very small roadside drain that was frequently dry. The new site is within the main western branch of Cedar Creek.
- KLN 12B was added in 2016 to capture water quality immediately downstream of greenhouse expansion. There has been some drain maintenance and construction at this site that has altered the shape of the channel and caused short periods of limited access.
- Prior to installation of ISCO autosamplers in 2017, engineering studies were conducted in Sturgeon Creek, Lane Drain and Mill Creek to ensure that site locations were far enough upstream to be away from the backwater influence of Lake Erie. This resulted in the relocation of the Sturgeon Creek (KLN 05 to KLN 05_ISCO) and Mill Creek (KLN 12 to KLN 12_ISCO) sites further upstream. This allows for more reliable load calculations.
- On August 26, 2021 there was an explosion in the town of Wheatley due to a gas leak. As a result, access to KLN 02 was blocked due to ongoing safety concerns for several months. Sampling resumed March 22, 2022, once access to the site was deemed safe.
- Sampling at KLN 09 ceased February 4, 2020 due to construction. Sampling resumed June 20, 2022. It should be noted that the streambed and banks have undergone significant alteration with the addition of concrete blocks to the stream bed and erosion control to the banks.
- In October 2020 additional sampling locations were added to routine monitoring in the Ruscom watershed to capture the growth of the greenhouse sector northward. RR 07 is located in the east branch of the Ruscom River where expansion of the greenhouse sector is growing at a fast rate. RR 08 is located in the west branch of the Ruscom River where the land use remains largely field agriculture. These sites were sampled every two weeks, and there is a level logger at RR 07.
- This report includes data collected up to September 30, 2022 (at the end of water year 2021/2022). As of March 2023, sampling has ceased at nine locations due to a loss of funding. Two of the sites are also sampled for PWQMN so they will continue once a month (KLN14B and KLN 03) through that program, four of the sites would likely be discontinued anyway (KLN 01 and KLN 02 are non-greenhouse sites with no observable trends in 10 years of data; KLN 06 and KLN 07 are sites with very small watersheds), leaving three sites that we would like to sample but aren't able to at this time (KLN 15, KLN 09 and KLN 10).
- Sampling has been reduced to once a month at KLN 04, KLN 05_ISCO, KLN 11, KLN 12B, KLN 12_ISCO, KLN 13, RR 07 and RR 08 as of April 2023

Watershed delineations were refined in 2018 using up to date drainage networks and improved digital elevation models (DEM). These new watershed delineations are integrated into ERCA's mapping tools (**Figure 1**). In addition, the upstream watershed delineation for each sampling location was delineated (**Figure 2**).

Figure 1 – Original watershed delineations (top) and refined watershed delineations (bottom)

Figure 2 – Upstream watershed delineations for sampling locations

In addition, each of the watersheds was intersected with available GIS layers to provide a physical description and comparison of land use, soil, surficial geology and topography. All watersheds have similar typical climate with average temperatures of 9.7-10.0°C and average precipitation of 834-840mm. However, individual storm systems can be highly localized. All watersheds have <10% natural area and most watersheds are >60% agriculture with typically <15% built up area. Exceptions to these occur in watersheds that are within Leamington (KLN 5_ISCO, KLN 6 – 10) or Kingsville (KLN 12_ISCO and KLN 12B) where there are more residential areas (**Table 2**). Additionally, we have provided summaries of surficial geology (**Table 3**) and soil (**Table 4a and 4b**) characteristics for each watershed.

Data Sources:

Watershed Area	Delineations are outputs of ArcHydro using 0.5m Lidar-Derived DEM (MNRF 2017) hydro-corrected with current ERCA drain linework. Compiled by ERCA 2018.
Elevation	Based on extent of watershed area, elevations from lidar derived DEM, MNRF 2017. Converted to CGVD28 by ERCA.
Land use	SOLRIS v 3.0 (MNRF 2019). The data covers the date ranges from 2000-2015.
Soil	Mapped by Agriculture and AgriFood Canada. Surveyed 1939, published 1949. Scale 1:63,360.
Surficial Geology	Surficial Geology of Southern Ontario MRD128-REV. Ontario Geological Survey (author). The data used in generating the map was derived from Quaternary maps, primarily at a scale of 1:50 000, completed by the OGS and Geological Survey of Canada (GSC) for most of southern Ontario over the past 40 years.
Annual Mean Temperature & Annual Precipitation	The data source is Environment Canada historic normal data from 1981 – 2010 in an 8.2-kilometre cell resolution raster. The median of the cell values is reported if 20 or more cells fall within the watershed. The mean of the cell values is reported if less than 20 cells fall within the watershed. Figure calculated using the Ontario Water Information Tool watershed characterization.

Table 2 – Watershed size, topography and land use

Site	Area (km)	Topography			Land Use		
		Max Elevation (m)	Min Elevation (m)	Fall (m)	% Natural	% Built up	% Agriculture and Rural
KLN 01	3.4	187.9	174.8	13.1	7.4	13.2	79.3
KLN 02	13.0	192.0	176.0	16.0	1.3	2.3	96.5
KLN 03	4.1	190.1	177.9	12.3	3.5	6.0	90.5
KLN 04*	22.3	203.2	177.9	25.3	5.1	8.8	86.1
KLN 05_ISCO*	15.5	230.6	176.3	54.2	7.1	33.0	59.8
KLN 06*	0.8	217.8	187.9	29.9	1.7	58.9	39.2
KLN 07*	0.6	217.5	189.0	28.5	2.8	63.3	33.3
KLN 09*	2.6	228.3	186.2	42.1	6.5	28.2	65.1
KLN 10*	1.1	205.4	189.3	16.1	5.3	35.6	58.8
KLN 11*	7.3	205.0	189.7	15.3	4.2	23.1	72.7
KLN 12_ISCO*	13.1	205.0	181.8	23.3	6.9	18.4	74.6
KLN 12B*	4.1	202.0	190.1	12.0	5.6	13.5	80.9
KLN 13	10.8	205.5	186.2	19.3	9.4	6.3	84.4
KLN 14B^	57.7	213.1	178.1	35.0	8.9	7.3	83.8
KLN 15	7.3	197.2	174.9	22.3	8.4	3.5	88.0
RR 07*	8.9	196.1	183.4	12.7	0.4	4.6	95.0
RR 08^	42.7	227.6	182.4	45.16	8.3	5.0	86.7

*indicates greenhouse influence
^KLN 14B and RR 08 do contain some small greenhouses. However, because of the larger size of these watersheds, the percent areal coverage is negligible.

Table 3 – Percentage of watershed with different permeability rates based on surficial geology material

Site	High	Medium	Low	Variable
KLN 01	3.5		89.8	6.7
KLN 02	0.5		98.9	0.7
KLN 03	0.3		99.7	
KLN 04*	2.4	13.1	83.9	0.6
KLN 05_ISCO*	98.0			2.0
KLN 06*	100.0			
KLN 07*	97.8		2.2	
KLN 09*	63.7		32.7	3.6
KLN 10*	0.6		99.4	
KLN 11*	47.4		52.6	
KLN 12_ISCO*			98.0	2.0
KLN 12B*			100.0	
KLN 13			99.3	0.7
KLN 14B	2.5		96.8	0.7
KLN 15	43.5		56.5	
RR 07*			100.0	
RR 08	23.3		76.7	

Table 4a – Soil characteristics – Percentage of watersheds with different infiltration rates and runoff potential

Site	Low runoff / high infiltration	Slow infiltration	High runoff / very slow infiltration	Bottom Land	Muck	Not mapped
KLN 01	0	48.3	41.1			10.7
KLN 02	0	0	99.2	0.8		
KLN 03	0	24.2	75.8			
KLN 04*	0.7	32.9	65.6	0.8		
KLN 05_ISCO*	37.9	53.8	2.3	2.7	3.4	
KLN 06*	42.9	42.1		1.9	13.1	
KLN 07*	42.6	42.5		6	8.9	
KLN 09*	36.7	32.9		0.3	30.1	
KLN 10*	69.7	1.6		27.6	1.1	
KLN 11*	29.2	58.6		4.5	7.7	
KLN 12_ISCO*	60.5	35.8		2.3	1.5	
KLN 12B*	7.1	50		3.2	39.6	
KLN 13	2.3	15.3	81.5	0.9		
KLN 14B	17.9	22.4	59.7	0.1		
KLN 15	34.8	60.5	0.5	2.3	1.8	
RR 07*		0.5	99.5			
RR 08	13.7	32.6	53.8			

*indicates greenhouse influence

Table 4b – Soil characteristics – Percentage of watersheds with different soil drainage characteristics

Site	Rapid	Well	Imperfect	Poor	Very Poor	Bottom Land	Not Mapped
KLN 01			48.3	41.1			10.7
KLN 02				99.2		0.8	
KLN 03				100			
KLN 04*	0.7			98.5		0.8	
KLN 05_ISCO*		37.9		56.1	3.4	2.7	
KLN 06*		42.9		42.1	13.1	1.9	
KLN 07*		42.6		42.5	8.9	6	
KLN 09*		36.7		32.9	30.1	0.3	
KLN 10*		69.7		1.6	1.1	27.6	
KLN 11*		29.2		58.6	7.7	4.5	
KLN 12_ISCO*		60.5		35.8	1.5	2.3	
KLN 12B*		7.1		50	39.6	3.2	
KLN 13		2.3		96.8		0.9	
KLN 14B		17.9		82.1		0.1	
KLN 15		34.8		61	1.8	2.3	
RR 07*				100			
RR 08	0.5	13.2		85.8	0.6		

*indicates greenhouse influence

Water Quality Analyses

Mann-Kendall trend tests, performed in RStudio using the 'trend' package, were used to determine whether significant monotonic trends occurred in annual median concentrations for each parameter from 2012-2022 at each site (**Tables 5 and 6 and Figures 3 and 4**).

Table 5 – Results of Mann-Kendall trend test on annual median TP concentration from 2012-2022 for sites with at least 8 years of data. Where there are significant trends in annual median concentration they tend to be increasing in non-greenhouse and decreasing in greenhouse influenced streams.

Site	S	p-value	Trend
KLN 01	25	0.032	Statistically significant evidence of an increasing trend p <0.05
KLN 02	15	0.211	No trend
KLN 03	15	0.211	No trend
KLN 04*	-29	0.012	Statistically significant evidence of a decreasing trend p <0.05
KLN 05_ISCO*	3	0.707	Insufficient data for trend analysis (6 water years)
KLN 06*	-25	0.032	Statistically significant evidence of a decreasing trend p <0.05
KLN 07*	-6	0.653	No trend p>0.05
KLN 09*	-29	0.012	Statistically significant evidence of a decreasing trend p <0.05
KLN 10*	3	0.858	No trend p>0.05
KLN 11*	-33	0.004	Statistically significant evidence of a decreasing trend p <0.05
KLN 12_ISCO*	-9	0.133	Insufficient data for trend analysis (6 water years)
KLN 12B*	-11	0.133	Insufficient data for trend analysis (7 water years)
KLN 13	23	0.049	Statistically significant evidence of an increasing trend p <0.05
KLN 14B	-1	1	Insufficient data for trend analysis (7 water years)
KLN 15	13	0.283	No trend p>0.05
RR 07*	3	0.296	Insufficient data for trend analysis (3 water years)
RR 08	-3	0.296	Insufficient data for trend analysis (3 water years)

*indicates greenhouse influence

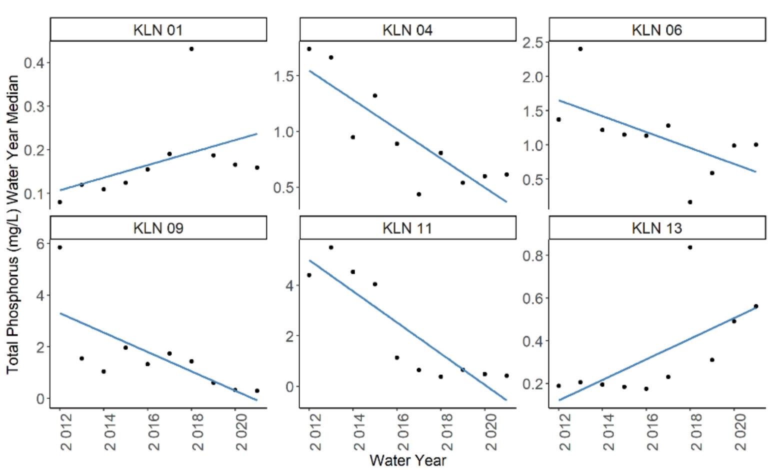

Figure 3 – Scatter plots of median annual TP concentration at sites with significant trends through time. Note that the scale of the y-axis differs between sites.

Table 6 – Results of Mann-Kendall trend test on annual median SRP concentration from 2012-2022 for sites with at least 8 years of data. Where there are significant trends in annual median concentration, they tend to be decreasing in greenhouse influenced streams.

Site	S	p-value	Trend
KLN 01	-9	0.474	No trend
KLN 02	-27	0.020	Statistically significant evidence of a decreasing trend p <0.05
KLN 03	-9	0.474	No trend
KLN 04*	-31	0.007	Statistically significant evidence of a decreasing trend p <0.05
KLN 05_ISCO*	-5	0.452	Insufficient data for trend analysis (6 water years)
KLN 06*	-29	0.012	Statistically significant evidence of a decreasing trend p <0.05
KLN 07*	-9	0.474	No trend
KLN 09*	-31	0.007	Statistically significant evidence of a decreasing trend p <0.05
KLN 10*	3	0.858	No trend
KLN 11*	-41	0.0003	Statistically significant evidence of a decreasing trend p <0.05
KLN 12_ISCO*	-5	0.452	Insufficient data for trend analysis (6 water years)
KLN 12B*	-11	0.133	Insufficient data for trend analysis (7 water years)
KLN 13	11	0.371	No trend
KLN 14B	-1	1	Insufficient data for trend analysis (7 water years)
KLN 15	-5	0.721	No trend
RR 07*	1	1	Insufficient data for trend analysis (3 water years)
RR 08	-3	0.296	Insufficient data for trend analysis (3 water years)

*indicates greenhouse influence

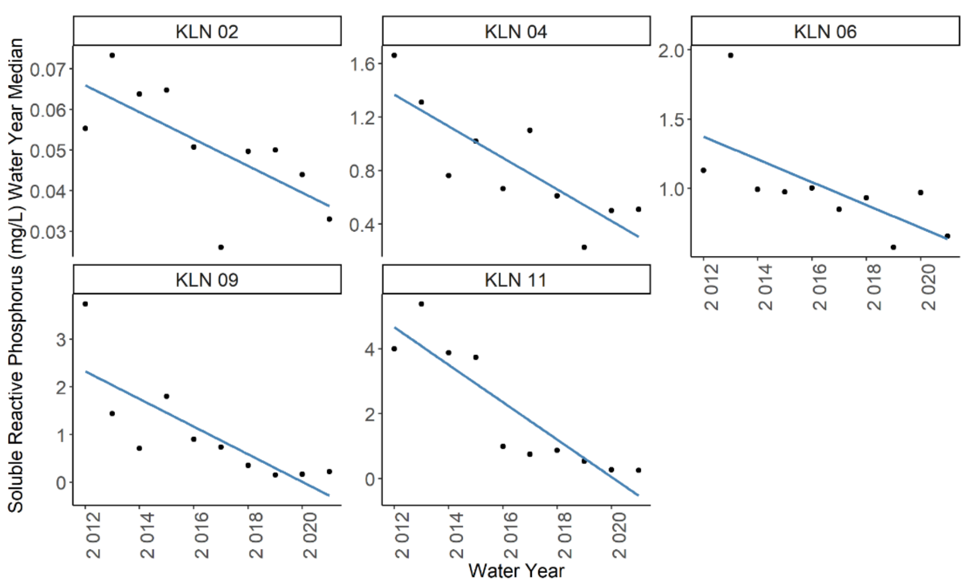

Figure 4 – Scatter plots of median annual SRP concentration at sites with significant trends through time. Note that the scale of the y-axis differs between sites.