Appendix A. Water quality data for 2005

Fanshawe Lake: sampling site at the dam (F1), in the middle of the reservoir (F2) and close to the inflow (F3)

mob, 1 m above bottom

Fanshawe Lake

Date	Site	Depth (m)	Layer	Secchi (m)	TP (mg/L)	Nitrate (mg/L)	Chlorophyll (µg/L)	Rower's Journal
13-Jul-05	F1	1	euphotic	1.8	0.025	3.2	4.5	no algae
13-Jul-05	F1	8	8m		0.036			
13-Jul-05	F1	mob	bottom		0.087			
13-Jul-05	F2	1	euphotic	1.5	0.029	2.7	3.9	
13-Jul-05	F3	mob	euphotic	1.45	0.04	2.5		
22-Jul-05	F1			0.75				no algae
22-Jul-05	F2			0.9				
22-Jul-05	F3			0.65				
29-Jul-05	F1	1	euphotic	2.2	0.151	2.9	4.7	no algae
29-Jul-05	F1	8	8m		0.145			
29-Jul-05	F2	1	euphotic	2.1	0.259	2.7	6.7	
29-Jul-05	F3	mob	euphotic	1.1	0.103	2.2	8.5	
30-Jul-05	F1			2.25				no algae
30-Jul-05	F2			2.05				
30-Jul-05	F3			0.95				
10-Aug-05	F1	1	euphotic	1.4	0.051	2.2	3.2	algae clumps throughout
10-Aug-05	F1	8	8m		0.045			
10-Aug-05	F1	mob	bottom		0.174			
10-Aug-05	F2	1	euphotic	1.4	0.057	1.7	12.5	
10-Aug-05	F3	mob	euphotic	1.1	0.097	1.6	14.7	
25-Aug-05	F1	1	euphotic	1.5	0.074	1.4	16.2	tons of algae
25-Aug-05	F1	8	8m		0.043			
25-Aug-05	F1	mob	bottom		0.425			
25-Aug-05	F2	1	euphotic	2.1	0.049	1.3	26.8	
25-Aug-05	F3	mob	euphotic	0.95	0.109	1.4	62.8	
8-Sep-05	F1	1	euphotic	2.65	0.036	1.1	9.7	some algae clumps, smelly
8-Sep-05	F1	8	8m		0.04			
8-Sep-05	F1	mob	bottom		0.041			
8-Sep-05	F2	1	euphotic	0.95	0.099	0.9		
8-Sep-05	F3	mob	euphotic	0.7	0.148	0.8		
22-Sep-05	F1	1	euphotic	1.4	0.094	0.6	2.3	some algae clumps, froth
22-Sep-05	F1	8	8m		0.098			
22-Sep-05	F1	mob	bottom		0.067			
22-Sep-05	F2	1	euphotic	1.5	0.106	0.6	19.1	
22-Sep-05	F3	mob	euphotic	0.9	0.094	0.5	17.7	

Secchi disk readings for 22 and 30 July are from the Rower's Journal

Upper NRT reservoirs, at St. Mary's, Mitchell and Stratford: S1, S2, sampling location at the dam, and near the upstream end, and Fullarton Pond. ND; under detection limit (0.1 mg/L)

Date	Season	Site	Secchi (m)	TP (mg/L)	Nitrate (mg/L)	Chlorophyll (ug/L)
13-Jul-05	3	Mary's		0.052	1.9	
13-Jul-05	3	Mitchell		0.094	2.8	
13-Jul-05	3	Fullarton		0.031	3.3	
15-Jul-05	3	S1		0.410	ND	7.7
15-Jul-05	3	S2		0.182	0.9	17.1
28-Jul-05	3	Mary's		0.096	1.1	
28-Jul-05	3	Mitchell		0.084	4.3	18.1
28-Jul-05	3	Fullarton		0.579	1.6	
28-Jul-05	3	S1	0.63	0.095	1.7	20.4
28-Jul-05	3	S2	0.73	0.216	1.8	20.0
10-Aug-05	3	Mary's		0.201	1.3	
10-Aug-05	3	Mitchell		0.090	1.3	15.3
10-Aug-05	3	Fullarton		0.280	0.3	
12-Aug-05	3	S1	0.51	0.258	0.7	97.3
12-Aug-05	3	S2	0.48	0.164	ND	
25-Aug-05	3	Mary's		0.098	0.9	
25-Aug-05	3	Mitchell		0.085	4.3	5.2
25-Aug-05	3	Fullarton		0.019	1.4	
25-Aug-05	3	S1	0.33	0.161	1.6	259.0
25-Aug-05	3	S2	0.48	0.170	1.7	52.8
8-Sep-05	3	Mary's		0.118	0.7	
8-Sep-05	3	Mitchell		0.042	2.4	35.4
8-Sep-05	3	Fullarton		0.029	1.5	
8-Sep-05	3	S1	0.43	0.121	1.0	
8-Sep-05	3	S2	0.48	0.127	1.0	49.1
22-Sep-05	3	Mary's		0.111	0.3	
22-Sep-05	3	Mitchell		0.126	0.5	19.8
22-Sep-05	3	Fullarton		0.312	1.1	
22-Sep-05	3	S1	0.53	0.137	0.8	31.4
22-Sep-05	3	S2	0.23	0.153	0.6	88.8
6-Oct-05	4	Mary's		0.116	0.4	
6-Oct-05	4	Mitchell		0.105	7.4	14.1
6-Oct-05	4	Fullarton		0.283	2.3	
6-Oct-05	4	S1	0.43	0.089	5.3	14.4
6-Oct-05	4	S2	0.48	0.158	4.0	12.1

Wildwood and Pittock Reservoir: sampling site at the dam (Dam), in the middle of the reservoir (Mid) and near the inflow (Upper); ND, under detection limit (0.1 mg/L)

		Wildwood Reservoir				**Pittock Reservoir**			
Date	Site	Secchi (m)	TP (mg/L)	Nitrate (mg/L)	Chl (ug/L)	Secchi (m)	TP (mg/L)	Nitrate (mg/L)	Chl (ug/L)
15-Jul-05	Dam	1.60	0.038	2.2	6.7	0.75	0.054	1.6	4.3
15-Jul-05	Mid	1.50	0.050	2.2		0.55	0.104	1.4	
15-Jul-05	Upper	0.70				0.26			
29-Jul-05	Dam	1.10	0.132	1.2	5.9	1	0.136	3.4	13.1
29-Jul-05	Mid	0.85	0.209	1.1		0.9	0.072	3.6	
29-Jul-05	Upper	0.80				0.9			
12-Aug-05	Dam	1.10	0.148	0.6	32.9	0.7	0.099	2.5	42.6
12-Aug-05	Mid	0.70	0.061	0.9		0.6	0.1	2.2	
12-Aug-05	Upper	0.45				0.35			
26-Aug-05	Dam	0.90	0.064	0.5	9	0.4	0.122	1.0	149
26-Aug-05	Mid	0.75	0.150	0.4		0.4	0.098	1.0	
26-Aug-05	Upper	0.35				0.4			
9-Sep-05	Dam	0.60	0.077	1.7	22.7	0.6	0.086	2.0	47.9
9-Sep-05	Mid	0.45	0.077	ND		0.5	0.128	1.9	
9-Sep-05	Upper	0.50				0.4			
23-Sep-05	Dam	*	0.100	ND	12.3	0.35	0.152	ND	53
23-Sep-05	Mid	0.40	0.113	ND		0.35	0.18	ND	
23-Sep-05	Upper	0.30							
5-Oct-05	Dam		0.146	ND	79.9				
5-Oct-05	Mid		0.091	ND					

*Secchi disk value of 5.5.m treated as outlier

Appendix B. LND-test with Rower's Journal

Comparison of Nitrate concentration in the outflow at Clark Road (left columns) and within the lake (right columns) with observations noted in the "Rower's Journal" in Fanshawe Lake 2005

Nitrate data:	City of London, Clark Road		Within lake, F1, sampled by UTRCA		
Date	Nitrate (mg/L)	Algae Journal	Date	Nitrate (mg/L)	Algae Journal
10-Jan	8.68		13-Jul	3.2	no algae
17-Jan	8.08		29-Jul	2.9	no algae
7-Feb	7.14		5-Aug		Algae clumps throughout the lake
14-Mar	7.03		10-Aug	2.2	
21-Mar	6.29		25-Aug	1.4	
11-Apr	6.5		31-Aug		tons of algae
18-Apr	5.83		8-Sep	1.1	
25-Apr	4.71		9-Sep		some algae
2-May	7.09		20-Sep		some algae, poor clarity
9-May	7.42		22-Sep	0.6	
16-May	5.54		24-Sep		some
30-May	4.73				
6-Jun	4.26				
13-Jun	3.02				
20-Jun	8.36	Start of Journal: no algae			
23-Jun		*Cryptomonas sp*. bloom, a flagellate and "good" algae was observed			
27-Jun	4.84	no algae			
11-Jul	2.11	some, green-brown scum			
18-Jul	3.4	no algae			
2-Aug		no algae			
3-Aug		Algae clumps throughout the lake			
5-Aug		Algae clumps throughout the lake			
8-Aug	1.76				
15-Aug	1.15				
22-Aug	1.39				
30-Aug	1.64				
31-Aug		tons of algae			
12-Sep	1.25	some algae clumps, smelly			
19-Sep	3.42				
20-Sep		some algae clumps, froth			
26-Sep		no algae			
15-Oct		some			
17-Oct	2.96				
24-Oct	3.12				
27-Oct		no algae, poor clarity			
31-Oct	1.72				
7-Nov	2.11	no algae, o.k. clarity, end of Journal			
14-Nov	1.86				
21-Nov	11.8				
28-Nov	11.2				

Appendix C. Low-Nitrate-Days (LND) in the NTR watershed reservoirs

Comparison of LNDs as determined from nitrate concentration at the indicated WQ stations just downstream of the reservoirs, except where marked *, station is within the reservoir just upstream of dam. **, Stn 16 is 3 km below Pittock Dam.

Reservoir WQ Station	Mitchell 44	Stratford 25	St. Mary's 15	Wildwood 64	Fanshawe 27	Pittock 16**, 38	
1968		1	200		119 *	103	**
1969		14	167		120 *	155	**
1970		0	102		126 *	10	**
1971		2	142		175 *	118	**
1972		20	80		121		
1973		0	127		133		
1974		14	106		74		
1975	142	5	81		101	98	
1976	146	0	122		39	132	
1977	107	0	81		112	117	
1978	56	0	51		75	122	
1979	121	0	104	101	106	113	
1980	91	0	56	119	54	77	
1981	43	0	26	66	0	77	
1982	1	3	41	72	43	41	
1983	0	0	0	103	6	56	
1984	148	0	15	71	3	76	
1985	5	0	0	101	3	1	
1986	35	1	46	87	3	46	
1987	132	93	154	135	154	100	
1988	117	82	108	123	73	128	
1989	144	38	126	100	103	64	
1990	4	0	0	5	0	1	
1991	10	10	46	140	34	143	
1992	9	1	0	0	0	0	
1993	19	0	26	123	10	111	
1994	142	0	63	63	32	73	
1995	82	0	4	70	30	59	
1996							
1997		high at Lorne					
1998	143	5		92	111	182	
1999	18	20		90	53	124	
2000	0	0		0	0	0	
2001	0	0		47	31	59	
2002	13	0		40	20	70	
2003	0	0		81	28		
2004	0	0		68	28		
2005	0	0		112	92		
2005*	4	50	102	101		72	
Average	**58**	**NA**	**75**	**81**	**61**	**82**	

NA, not applicable. Large discrepency of Station 25 with data above Stratford dam in 2005 indicate that they are not representative of lake.

Appendix D. Hypoxic and anoxic factors

The **Anoxic Factor** (AF, Nürnberg 1995) quantitatively summarizes the extent and duration of anoxia (lack of oxygen) in stratified lakes. It is based on a series of measured oxygen profiles and morphometric data and can be computed for any lake or reservoir. To render this index comparable across lakes of different sizes, AF is corrected for lake surface area by simple division. Expressed this way, AF is a ratio that represents the number of days in a year or season that a sediment area equal to the lake surface area is anoxic. Hence, its units are d/yr or d/season; i.e., summer or winter. Anoxic factors can be predicted from average phosphorus concentration and lake morphometry when DO profiles are not available.

To compute the Anoxic Factor, first, the oxycline must be determined from oxygen profiles. The criterion for anoxia is 2 mg/L. Next, the period of anoxia (t_i) must be multiplied by the corresponding area (a_i) and divided by the lake surface area (A_o) corresponding to the average elevation for that period. These terms of n, numbers of periods at different oxyclines (i.e. highest depths with 2 mg/L DO or below) are then added up. In this way, AF is comparable between lakes, like other areal measures, e.g., areal nutrient loads and fish yield.

The anoxic factor can be computed from following equation:

$$AF = \sum_{i=1}^{n} \frac{t_i \times a_i}{A_o}$$

where t_i, the period of anoxia (days),

a_i, the corresponding area (m^2),

A_o, lake surface area (m^2) corresponding to the average elevation for that period,

n, numbers of periods with different oxycline depths

When stratified lakes are classified with respect to trophic state, below 20 d/yr indicate oligotrophic conditions, 20 to 40 d/yr are usually found in mesotrophic lakes, 40 – 60 d/yr represent eutrophic conditions and above 60 d/yr is typical for hyper-eutrophic conditions.

The **Hypoxic Factor** summarizes the extent and duration of hypoxia, where DO concentration is below 5.5 mg/L, which are the guidelines for warm water biota by Environment Canada. It can be calculated from DO profiles like the anoxic factor, by substituting the oxycline depth with a depth for which the DO content is below 5.5 mg/L DO.

Appendix E. Physical Variables for Fanshawe Lake

The following two tables present the morphometric and hydrological information, including the partitioning of total “in” flows in second table

Note that years since 2000 have been revised from Freshwater Research (2005) because of new hydrological information

Year	Precipitation (mm/yr)	Elevation (m asl)	Volume (ha m)	Area (ha)	Flows (10^6 m^3)		tau_yrs (yrs)	tau_days (days/yr)	qs (m/yr)
					in	out			
1954	1,047	262.5	1,323.2	273.8	671.3	652.2	0.020	7.4	238.2
1955	782	262.4	1,293.5	269.8	365.2	404.1	0.032	11.7	149.8
1956	988	262.5	1,323.2	273.8	633.7	638.0	0.021	7.6	233.0
1957	962	262.5	1,323.2	273.8	599.6	611.4	0.022	7.9	223.3
1958	679	262.4	1,293.5	269.8	228.4	230.8	0.056	20.5	85.6
1959	1,003	262.5	1,323.2	273.8	639.7	677.4	0.020	7.1	247.4
1960	809	262.4	1,323.2	273.8	538.0	556.1	0.024	8.7	203.1
1961	882	262.4	1,293.5	269.8	325.3	318.1	0.041	14.8	117.9
1962	794	262.4	1,293.5	269.8	276.8	286.3	0.045	16.5	106.1
1963	544	262.4	1,293.5	269.8	320.2	328.5	0.039	14.4	121.7
1964	888	262.4	1,293.5	269.8	339.6	323.7	0.040	14.6	120.0
1965	964	262.5	1,323.2	273.8	643.1	594.7	0.022	8.1	217.2
1966	974	262.4	1,323.2	273.8	549.7	527.0	0.025	9.2	192.5
1967	1,009	262.5	1,323.2	273.8	899.5	869.5	0.015	5.6	317.5
1968	1,119	262.4	1,323.2	273.8	590.9	549.9	0.024	8.8	200.8
1969	868	262.4	1,323.2	273.8	590.4	603.7	0.022	8.0	220.5
1970	891	262.4	1,293.5	269.8	487.3	438.2	0.030	10.8	162.4
1971	699	262.4	1,293.5	269.8	430.2	408.2	0.032	11.6	151.3
1972	1,051	262.4	1,323.2	273.8	544.5	525.7	0.025	9.2	192.0
1973	942	262.5	1,323.2	273.8	621.8	610.8	0.022	7.9	223.1
1974	864	262.4	1,323.2	273.8	580.0	576.3	0.023	8.4	210.5
1975	950	262.4	1,323.2	273.8	563.4	578.9	0.023	8.3	211.4
1976	1,111	262.5	1,323.2	273.8	669.8	710.8	0.019	6.8	259.6
1977	1,003	262.5	1,323.2	273.8	633.9	643.7	0.021	7.5	235.1
1978	816	262.4	1,323.2	273.8	571.2	595.6	0.022	8.1	217.5
1979	918	262.5	1,323.2	273.8	710.4	737.7	0.018	6.5	269.4
1980	943	262.4	1,293.5	269.8	420.3	422.2	0.031	11.2	156.5
1981	979	262.4	1,323.2	273.8	559.8	576.9	0.023	8.4	210.7
1982	1,085	262.5	1,323.2	273.8	788.8	787.3	0.017	6.1	287.5
1983	1,038	262.5	1,323.2	273.8	597.5	571.1	0.023	8.5	208.6
1984	1,150	262.5	1,323.2	273.8	660.2	652.6	0.020	7.4	238.3
1985	1,177	262.6	1,353.3	277.9	917.0	875.7	0.015	5.6	315.1
1986	1,080	262.6	1,353.3	277.9	806.3	845.1	0.016	5.8	304.1
1987	842	262.4	1,293.5	269.8	455.9	446.3	0.029	10.6	165.4
1988	922	262.5	1,323.2	273.8	478.9	427.6	0.031	11.3	156.2
1989	813	262.5	1,323.2	273.8	343.5	321.2	0.041	15.0	117.3
1990	1,300	262.8	1,414.3	285.9	820.3	729.6	0.019	7.1	255.2
1991	901	262.2	1,234.9	261.0	530.2	555.3	0.022	8.1	212.8
1992	1,260	262.6	1,353.3	277.9	945.7	935.1	0.014	5.3	336.5
1993	928	262.4	1,293.5	269.8	551.6	572.5	0.023	8.2	212.2
1994	874	262.3	1,264.0	265.7	492.5	487.7	0.026	9.5	183.5
1995	959	262.4	1,293.5	269.8	656.9	631.4	0.020	7.5	234.0
1996	1,243	262.5	1,323.2	273.8	850.6	865.2	0.015	5.6	316.0
1997	995	262.5	1,323.2	273.8	660.9	669.8	0.020	7.2	244.6
1998	752	262.4	1,293.5	269.8	366.3	333.3	0.039	14.2	123.5
1999	844	262.4	1,293.5	269.8	304.0	237.9	0.054	19.8	88.2
2000	1,137	262.7	1,383.6	281.9	676.9	594.2	0.023	8.5	210.8
2001	956	262.5	1,323.2	273.8	674.3	535.2	0.025	9.0	195.5
2002	871	262.4	1,293.5	269.8	541.8	428.7	0.030	11.0	158.9
2003	990	262.4	1,293.5	269.8	630.3	576.0	0.022	8.2	213.5
2004	958	262.3	1,264.0	265.7	679.7	595.8	0.021	7.7	224.2
2005	813	262.4	1,293.5	269.8	686.7	592.9	0.022	8.0	219.8
Average	949	262.4	1,314.2	272.6	579.2	562.8	0.026	9.4	206.1
Median	953	262.4	1,323.2	273.8	590.7	576.6	0.023	8.3	211.8
Min	544	262.2	1,234.9	261.0	228.4	230.8	0.014	5.3	85.6
Max	1,300	262.8	1,414.3	285.9	945.7	935.1	0.056	20.5	336.5
n	52	52	52	52	52	52	52	52	52

Partitioned Inflows (10^6 m^3)

Year	PloverMills	Wye Creek	Precip	Immediate Runoff
1954	637.8	16.2	2.9	14.4
1955	346.5	8.8	2.1	7.8
1956	602.1	15.3	2.7	13.5
1957	569.7	14.5	2.6	12.8
1958	216.2	5.5	1.8	4.9
1959	607.8	15.5	2.7	13.7
1960	511.3	13.0	2.2	11.5
1961	308.1	7.8	2.4	6.9
1962	262.1	6.7	2.1	5.9
1963	304.1	7.7	1.5	6.8
1964	321.8	8.2	2.4	7.2
1965	611.2	15.6	2.6	13.8
1966	522.0	13.3	2.7	11.7
1967	855.7	21.8	2.8	19.3
1968	560.9	14.3	3.1	12.6
1969	561.1	14.3	2.4	12.6
1970	462.7	11.8	2.4	10.4
1971	408.7	10.4	1.9	9.2
1972	516.8	13.2	2.9	11.6
1973	590.8	15.0	2.6	13.3
1974	553.6	11.5	2.4	12.5
1975	537.4	11.3	2.6	12.1
1976	633.7	18.9	3.0	14.3
1977	592.9	24.9	2.7	13.3
1978	544.0	12.7	2.2	12.2
1979	679.6	13.0	2.5	15.3
1980	398.8	10.1	2.5	9.0
1981	529.9	15.4	2.7	11.9
1982	748.2	20.8	3.0	16.8
1983	568.7	13.2	2.8	12.8
1984	623.7	19.3	3.1	14.0
1985	868.6	25.6	3.3	19.5
1986	769.1	17.0	3.0	17.3
1987	433.0	10.8	2.3	9.7
1988	456.0	10.1	2.5	10.3
1989	325.2	8.8	2.2	7.3
1990	776.6	22.5	3.7	17.5
1991	503.7	12.8	2.4	11.3
1992	899.1	22.9	3.5	20.2
1993	524.0	13.3	2.5	11.8
1994	467.8	11.9	2.3	10.5
1995	624.4	15.9	2.6	14.0
1996	808.4	20.6	3.4	18.2
1997	628.0	16.0	2.7	14.1
1998	347.6	8.8	2.0	7.8
1999	287.9	7.3	2.3	6.5
2000	642.9	16.4	3.2	14.5
2001	640.9	16.3	2.6	14.4
2002	514.8	13.1	2.3	11.6
2003	598.9	15.2	2.7	13.5
2004	646.2	16.4	2.5	14.5
2005	653.2	16.6	2.2	14.7
Average	550.1	14.2	2.6	12.4
Median	561.0	13.8	2.6	12.6
Min	216.2	5.5	1.5	4.9
Max	899.1	25.6	3.7	20.2
n	52	52	52	52

Appendix F. Mass Balance Assumptions and Computations for Fanshawe Lake

(revised from Freshwater Research 2005)

Flows and concentrations for TP of the various external load sources to Fanshawe Lake were determined as described below. Whenever possible, loads for the period 1954 to 2005 were computed. For comparison, loads and volumetric averages were also determined for SRP.

Main Fanshawe Lake inflow and outflow: Measured flows and concentrations were provided by UTRCA. Concentrations were then volume-weighted to arrive at annual, seasonal and monthly loads.

Wye Creek: 1974 – 1990 flows were provided by the UTRCA. Based on a regression of these data with the main inflows, flows were predicted for all other years. The average of available concentration data for two years (0.083 mg/L TP for 2003, 2004) was multiplied with the flows to arrive at annual loads.

Precipitation: Precipitation height was provided. Based on values measured by the Ontario Ministry of the Environment a value of 0.030 mg/L TP was used to compute loads.

Immediate runoff: 2.25% of main inflow. (Since UTRCA indicated that the main inflow represents 95% of total flows, the immediate runoff volume was computed so that the sum of the flows besides the main inflow add up to 5%.) The Wye Creek concentration was assumed to be representative for the immediate runoff: 0.083 mg/L.

Phosphorus Loads (metric tonnes)

Year	Plover Mills	Wye Creek	Precip	Runoff	Total In	Total Out	in-out Minimum internal
1954		1.350	0.086	1.193			
1955		0.733	0.063	0.648			
1956		1.274	0.081	1.126			
1957		1.205	0.079	1.065			
1958		0.457	0.055	0.404			
1959		1.286	0.082	1.137			
1960		1.082	0.066	0.956			
1961		0.652	0.071	0.576			
1962		0.555	0.064	0.490			
1963		0.644	0.044	0.569			
1964		0.681	0.072	0.602			
1965		1.293	0.079	1.143		45.7	
1966		1.105	0.080	0.976		57.7	
1967		1.811	0.083	1.600		109.8	
1968		1.187	0.092	1.049		61.1	
1969		1.187	0.071	1.049		104.1	
1970		0.979	0.072	0.865		52.3	
1971		0.865	0.057	0.764		47.1	
1972		1.094	0.086	0.967		62.7	
1973		1.250	0.077	1.105		102.5	
1974		0.960	0.071	1.035		69.1	
1975	41.3	0.937	0.078	1.005	43.3	62.9	19.5
1976	69.4	1.569	0.091	1.185	72.3	71.8	-0.4
1977	61.3	2.071	0.082	1.109	64.6	74.8	10.2
1978	39.5	1.054	0.067	1.017	41.6	54.5	12.9
1979	60.3	1.080	0.075	1.271	62.7	73.3	10.6
1980	42.8	0.836	0.076	0.746	44.4	29.5	-15.0
1981	25.3	1.277	0.080	0.991	27.7	47.1	19.4
1982	74.9	1.729	0.089	1.399	78.1	102.7	24.7
1983	28.6	1.094	0.085	1.064	30.8	41.0	10.2
1984	71.5	1.603	0.094	1.166	74.4	77.2	2.8
1985	65.6	2.129	0.098	1.625	69.5	86.9	17.4
1986	87.1	1.410	0.090	1.438	90.0	100.2	10.2
1987	26.5	0.901	0.068	0.810	28.3	34.5	6.2
1988	26.8	0.841	0.076	0.853	28.6	32.7	4.1
1989	25.8	0.727	0.067	0.608	27.2	43.8	16.7
1990	37.0	1.874	0.112	1.452	40.4	49.2	8.7
1991	40.0	1.066	0.071	0.942	42.1	47.8	5.7
1992	73.2	1.903	0.105	1.682	76.9	129.2	52.3
1993	33.2	1.109	0.075	0.980	35.4	46.5	11.1
1994	34.7	0.990	0.070	0.875	36.6	42.8	6.1
1995	21.7	1.321	0.078	1.168	24.3	60.0	35.7
1996		1.711	0.102	1.512			
1997		1.329	0.082	1.175			
1998		0.736	0.061	0.650		27.4	
1999		0.609	0.068	0.539		13.9	
2000		1.360	0.096	1.202		48.7	
2001		1.356	0.079	1.199		43.4	
2002		1.089	0.070	0.963		21.6	
2003	48.4	1.267	0.080	1.120	50.9	51.3	0.4
2004	49.9	1.367	0.076	1.209	52.6	81.5	29.0
2005	32.3	1.382	0.066	1.222	34.9	90.8	55.9
Average	46.5	1.180	0.078	1.029	49.1	61.5	14.8
Median	40.7	1.148	0.077	1.049	42.7	54.5	10.4
Min	21.7	0.457	0.044	0.404	24.3	13.9	-15.0
Max	87.1	2.129	0.112	1.682	90.0	129.2	55.9
n	24	52	52	52	24	39	24

Appendix G. Sediment Sampling and Analysis

Sediment samples were collected from five locations in the Stratford and Mitchell reservoirs and Fullarton Pond on Oct. 7, 2005. Four sediment cores for each site were taken from the dam, the shore or an anchored boat, using a "Kajak-Brinkhurst" Corer. The surface of each core was sectioned into 0-5 cm and 5-10 cm lengths; the pooled samples of each site were placed into plastic zip bags and stored on ice in the dark. Upon return to the laboratory the samples were dried and stored dry until analysis (in triplicates) in December 2005.

		GPS (NAD27)			Surface Water	
Reservoir	Site	Longitude	Latitude	Depth (m)	Temperature (C)	pH
Stratford 1	near dam	17501326E	4801980N	3.3	17.5	8
Stratford 1	middle	17501386E	4802016N	2.85		8
Mitchell	near dam	17483975E	4812799N	2.25	18.7	8.1
Mitchell	middle	17483970E	4812801N	1.95		8.1
Fullarton Pond	middle	17482873E	4802073N	0.7	17.9	8.3

Sediment samples were analyzed for % water (Standard Error, SE circa 0.02), % organic matter (SE circa 0.02), and mg/g dry weight of total phosphorus, total silicate, total aluminum, total calcium, total iron, and total manganese.

Sample	Sediment layer	Water content (% of FM)	Organic Matter (% of DM)	P (mg/gDM)	SE	Al (mg/gDM)	SE
Stratford, dam	**0-5 cm**	**71.1**	**10.4**	**1.62**	0.03	**20.01**	0.49
Stratford, dam	**5-10 cm**	**64.4**	**10.0**	**1.62**	0.02	**19.48**	0.28
Stratford, middle	**0-5 cm**	**64.0**	**10.2**	**1.53**	0.01	**17.77**	0.19
Stratford, middle	**5-10 cm**	**57.3**	**9.9**	**1.60**	0.02	**21.03**	0.31
Mitchell, dam	**0-5 cm**	**54.5**	**6.8**	**1.18**	0.01	**11.86**	0.22
Mitchell, dam	**5-10 cm**	**52.8**	**6.9**	**1.14**	0.00	**10.38**	0.12
Mitchell, middle	**0-5 cm**	**59.4**	**5.9**	**1.08**	0.01	**10.46**	0.21
Mitchell, middle	**5-10 cm**	**46.9**	**6.5**	**1.09**	0.02	**10.90**	0.28
Fullerton, middle	**0-5 cm**	**77.6**	**8.1**	**0.79**	0.01	**6.30**	0.09
Fullerton, middle	**5-10 cm**	**76.3**	**7.7**	**0.69**	0.01	**4.39**	0.07

Sample	Sediment layer	Ca (mg/gDM)	SE	Fe (mg/gDM)	SE	Mn (mg/gDM)	SE	Si (mg/gDM)	SE
Stratford, dam	**0-5 cm**	**113.41**	1.65	**28.89**	0.42	**0.68**	0.01	**34.46**	1.74
Stratford, dam	**5-10 cm**	**103.16**	1.28	**28.70**	0.37	**0.67**	0.01	**34.85**	0.55
Stratford, middle	**0-5 cm**	**111.09**	0.58	**25.68**	0.19	**0.61**	0.00	**30.21**	0.48
Stratford, middle	**5-10 cm**	**91.67**	0.95	**29.44**	0.32	**0.63**	0.01	**34.89**	0.88
Mitchell, dam	**0-5 cm**	**100.69**	0.91	**16.39**	0.23	**0.52**	0.01	**24.24**	0.67
Mitchell, dam	**5-10 cm**	**100.60**	0.52	**15.23**	0.11	**0.51**	0.00	**20.33**	0.57
Mitchell, middle	**0-5 cm**	**100.73**	1.04	**14.36**	0.22	**0.48**	0.00	**21.64**	0.53
Mitchell, middle	**5-10 cm**	**102.21**	1.74	**14.88**	0.32	**0.48**	0.01	**21.04**	0.47
Fullerton, middle	**0-5 cm**	**260.05**	3.96	**7.45**	0.10	**0.25**	0.00	**12.30**	0.19
Fullerton, middle	**5-10 cm**	**280.16**	3.33	**5.92**	0.09	**0.23**	0.00	**9.55**	0.23

Appendix H. Reservoir Treatment Option Decision Criteria

Assembled by Chris Harrington with input by the members of the Project Management Team

Reservoir Treatment Option Decision Criteria: ***FEB. 11, 2005***

When proposing treatment options to improve water quality in Fanshawe Lake a range of criteria need to be considered. The decision criteria reflect the multiple functions and uses associated with Fanshawe reservoir and how it is operated. The criteria listed below must be considered when looking at treatment options to ensure current functions are maintained and to ensure improvements in the reservoir are considered in combination with downstream effects.

Criteria	Description
1. Compatibility with flood control operations	The Upper Thames River Conservation Authority (UTRCA) in conjunction with its municipal partners owns, operates and maintains a system of structures that reduce damages caused by flooding. The primary purpose of Fanshawe Dam and Reservoir is to assist in flood control efforts to reduce the risk of loss of lives and property damages due to flooding. Fanshawe Dam can reduce flood peaks downstream by up to 40%. Treatment options must consider the flood control function of Fanshawe Dam and Reservoir as paramount respecting the intended purpose of the structure.
2. Water quality improvement	Protection and enhancement of water quality is a core business function entrenched in UTRCA's mission statement. The UTRCA has worked to implement upstream diffuse source pollution control over the last 25 years. Efforts to improve water quality in the watershed will continue through ongoing collaborative efforts to implement best management practices and conduct research and monitoring. Poor water quality in the three UTRCA managed reservoirs (Fanshawe, Wildwood and Pittock) has been a concern for the past two decades. It is recognized that treatment may be necessary to improve water quality in the reservoirs. Reservoir water quality varies from summer to summer depending on flow conditions. Indicators of poor water quality conditions in the reservoirs include elevated phosphorus and chlorophyll concentrations (correlated with algal growth) and decreased oxygen concentration. While improved water quality in the reservoirs is desired it needs to be considered in conjunction with downstream conditions. Treatment options must consider overall water quality conditions and avoid improving reservoir conditions at the expense of downstream conditions.

3. Aquatic habitat improvement	The Thames River and its tributaries are rich in aquatic life, with approximately 90 species of fish, 32 species of freshwater mussels and 30 species of reptiles and amphibians. The UTRCA co-chairs a recovery team responsible for the development of the Thames River Aquatic Ecosystem Recovery Strategy aimed at improving species at risk populations and limiting threats to these species and their associated habitats. The draft recovery strategy identifies turbidity, nutrient loadings, toxic compounds, altered water flow, barriers to movement, non-native species, disturbance and thermal pollution as the main threats. At risk species including Eastern Spiny Softshell Turtle, Eastern Hognose Snake, Queen Snake, Greenside Darter, Silver Shiner and Black Redhorse are found in both the upstream and downstream subwatersheds that are divided by Fanshawe dam (Plover Mills subwatershed and The Forks subwatershed). Specifically there are significant populations of Eastern Spiny Softshell Turtles and Queen Snakes found in close proximity to the outflow of Fanshawe dam. Species at risk are sensitive to environmental change and, like a canary in a coal mine, give warning signs of overall environmental health. Threats to aquatic species and habitat need to be minimized when considering treatment options for Fanshawe reservoir.
4. Recreational opportunity	Fanshawe reservoir is the focus of many recreational activities, some of which include rowing, camping, swimming, hiking, recreational boating, fishing etc. Recreational opportunities associated with the reservoir offer an enhancement to user's quality of life and allow the demonstration of conservation and management of natural areas. Recreational users of Fanshawe reservoir are well aware of water quality issues in the reservoir and are stakeholders for improved conditions. However, treatment options could potentially impact recreational activities enjoyed by reservoir users. When evaluating treatment options effort to minimize impact to the recreational opportunities associated with the reservoir need to be considered.
5. Capital and operating costs	All cost associated with treatment options need to be considered, including capital, operating and any costs associated with altering current operations (IE. Hydro-electric power generation). Some treatment options may be prohibitive based on capital cost and/or long term operating cost. Costs associated with treatment options will need to be fiscally responsible considering available resources and the expected outcomes.

6. Public input / acceptance	The UTRCA believes strongly in partnership and community collaboration as part of our projects and programs. Engaging the community helps develop value for a healthy environment and sound resource management. Involving the community in the project early fosters support and allows them to be partners in the goals to be realized. It is expected that public input for lake treatment efforts will come from the recreational user community, but will not be limited to that group. Lake treatment options need to be considered and evaluated openly with opportunity for public input. Consultation to present stakeholders with issues, options and the scientific rationale for these options needs to be included in the process.

Appendix I. Abstract of British study by Jarvie et al 2006

Available online at www.sciencedirect.com
SCIENCE DIRECT•
ELSEVIER
Science of the Total Environment 360 (2006) 246–253
Science of the Total Environment
www.elsevier.com/locate/scitotenv

Sewage-effluent phosphorus: A greater risk to river eutrophication than agricultural phosphorus?

Helen P. Jarvie [a,*], Colin Neal [a], Paul J.A. Withers [b]

[a] *Centre for Ecology and Hydrology, Wallingford, Oxfordshire OX10 8BB, UK*
[b] *Catchment Management Group, ADAS Gleadthorpe, Meden Vale, Mansfield, Nottinghamshire NG20 9PF*

Abstract

Phosphorus (P) concentrations from water quality monitoring at 54 UK river sites across seven major lowland catchment systems are examined in relation to eutrophication risk and to the relative importance of point and diffuse sources. The over-riding evidence indicates that point (effluent) rather than diffuse (agricultural) sources of phosphorus provide the most significant risk for river eutrophication, even in rural areas with high agricultural phosphorus losses. Traditionally, the relative importance of point and diffuse sources has been assessed from annual P flux budgets, which are often dominated by diffuse inputs in storm runoff from intensively managed agricultural land. However, the ecological risk associated with nuisance algal growth in rivers is largely linked to soluble reactive phosphorus (SRP) concentrations during times of ecological sensitivity (spring/summer low-flow periods), when biological activity is at its highest. The relationships between SRP and total phosphorus (TP; total dissolved P+suspended particulate P) concentrations within UK rivers are evaluated in relation to flow and boron (B; a tracer of sewage effluent). SRP is the dominant P fraction (average 67% of TP) in all of the rivers monitored, with higher percentages at low flows. In most of the rivers the highest SRP concentrations occur under low-flow conditions and SRP concentrations are diluted as flows increase, which is indicative of point, rather than diffuse, sources. Strong positive correlations between SRP and B (also TP and B) across all the 54 river monitoring sites also confirm the primary importance of point source controls of phosphorus concentrations in these rivers, particularly during spring and summer low flows, which are times of greatest eutrophication risk. Particulate phosphorus (PP) may form a significant proportion of the phosphorus load to rivers, particularly during winter storm events, but this is of questionable relevance for river eutrophication. Although some of the agriculturally derived PP is retained as sediment on the river bed, in most cases this bed sediment showed potential for removal of SRP from the overlying river water during spring and summer low flows. Thus, bed sediments may well be helping to reduce SRP concentrations within the river at times of eutrophication risk. These findings have important implications for targeting environmental management controls for phosphorus more efficiently, in relation to the European Union Water Framework Directive requirements to maintain/improve the ecological quality of impacted lowland rivers. For the UK rivers examined here, our results demonstrate that an important starting point for reducing phosphorus concentrations to the levels approaching those required for ecological improvement, is to obtain better control over point source inputs, particularly small point sources discharging to ecologically sensitive rural/agricultural tributaries.

Keywords: Eutrophication; Water Framework Directive; Phosphorus; Sewage; Agriculture; Rivers; LOIS; Humber; Wye; Avon; Thames