Aquatic Enhancement
& Survey, Inc.

2008 Water Quality Sampling Report
Steuben County Lakes Council
Steuben County, Indiana

December 2, 2008

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Acknowledgements

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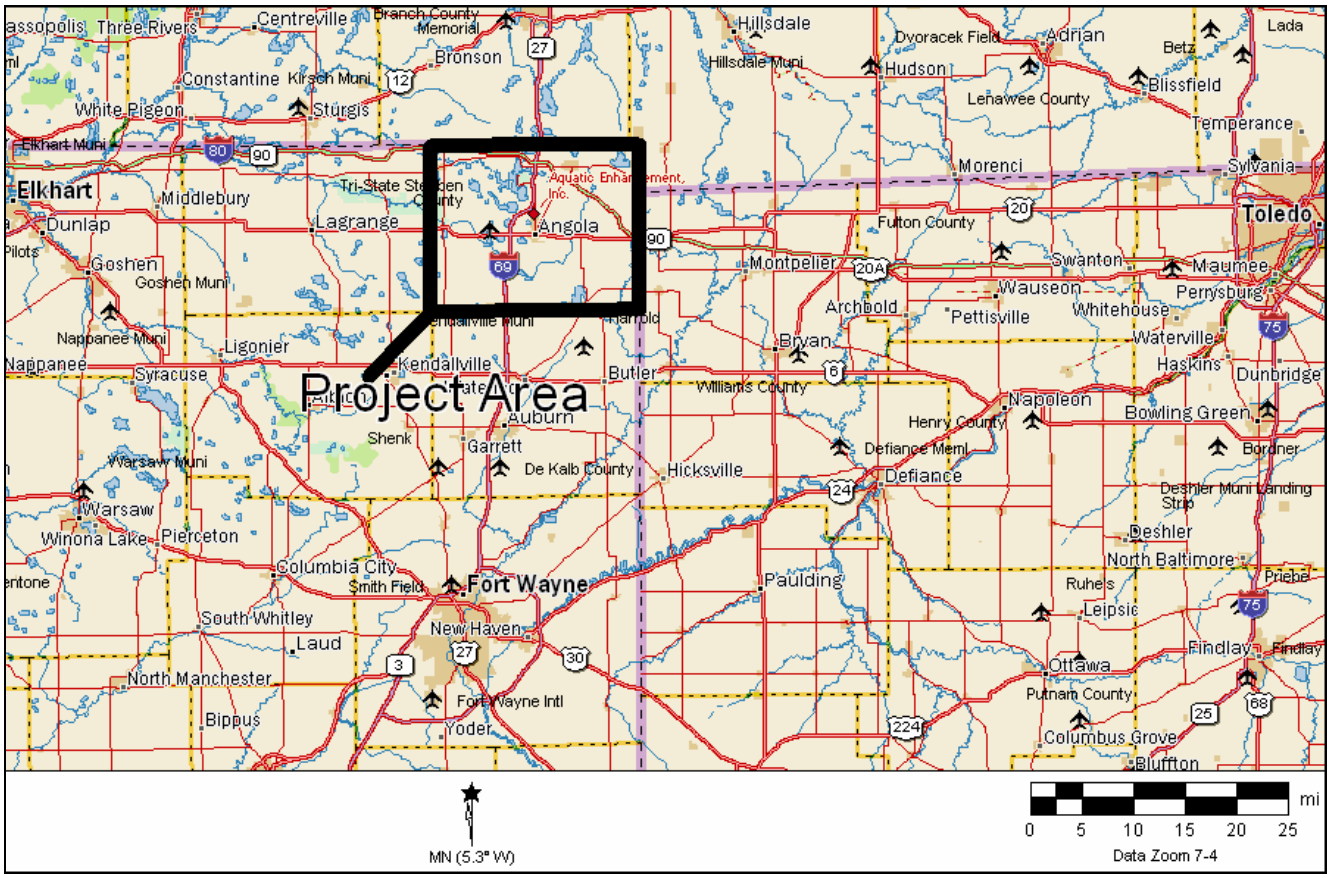

Figure 1 Northeast Indiana project location map

1. Project Overview and Purpose:

This project was performed by Aquatic Enhancement & Survey, Inc. under contract with the Steuben County Lakes Council (SCLC). For this project basic water quality data and stream flow (discharge) measurements were collected from several small tributary streams flowing through Steuben County, Indiana. (See figure 1 above for Steuben County general location) Samples were also collected from Pigeon Creek and three lake basins in Steuben County. Sampling was completed in May through November 2008. Sampling sites along Pigeon River/Pigeon Creek included stream sections near the inlets and outlets of Pigeon Lake, Long Lake, Bower Lake, Golden Lake, and Hogback Lake. Other Pigeon Creek sites included S. Bill Deller Rd., S. Meridian Rd., and U.S. 327 (See fig. 2 and 5 below or the air photo in Fig. 9). Figure two below displays sampling locations and associated surface water features for the whole of Steuben County. Figures three through six below are provided to show sampling sites and associated surface water features at a higher resolution for each respective quadrant of the county. Figures seven through ten below show air photos of each county quadrant and its respective sampling sites. Measured parameters included total phosphorus, total suspended solids, pH, dissolved oxygen, temperature, specific conductance, E-coli, and a basic measurement of stream flow-rate at each sampling site having measurable flow. Total phosphorus and total suspended solids loading figures were calculated for each site at which these

measurements were detectible and a flow measurement was taken. The purpose of the sampling was to gain a basic understanding of the fate and source of contaminants in these systems with a goal of directing future sampling or directing remediation of watershed point and non-point pollution sources. Table one below provides a site key showing brief written descriptions of each numbered sampling site. Collected data and calculated loading rates are provided in tables two, three, and four below.

2. Methods:

All samples collected were grab samples. Samples were placed on ice immediately after collection. All samples held overnight were refrigerated. Measurements for temperature and dissolved oxygen were taken in the field using a YSI 85 Dissolved Oxygen, Temperature, Conductivity, and Salinity Meter. Measurements of pH were taken in the field using an Oakton pH 6 Acorn Series meter. Both meters were calibrated at the beginning of each sampling day. Where possible stream flows were calculated using measurements of the stream cross-sectional area and stream velocity. Stream flow cross sectional area was calculated by measuring stream width using a marked section of rope, tape measure, or laser rangefinder and calculating average stream depth by measuring depth at multiple equidistant points using a tape measure, measuring staff, or sonar unit. Laboratory analysis for all samples was completed by A & L Great Lakes Laboratories, Inc., 3505 Conestoga Dr., Fort Wayne, Indiana 46808, Brighton Analytical, L.L.C. 2105 Pless Drive, Brighton Michigan, 48114, or Sherry Laboratories, 2121 East Washington Blvd., Fort Wayne, Indiana 46803-1328. Quality Assurance Procedures and EPA method codes are available upon request.

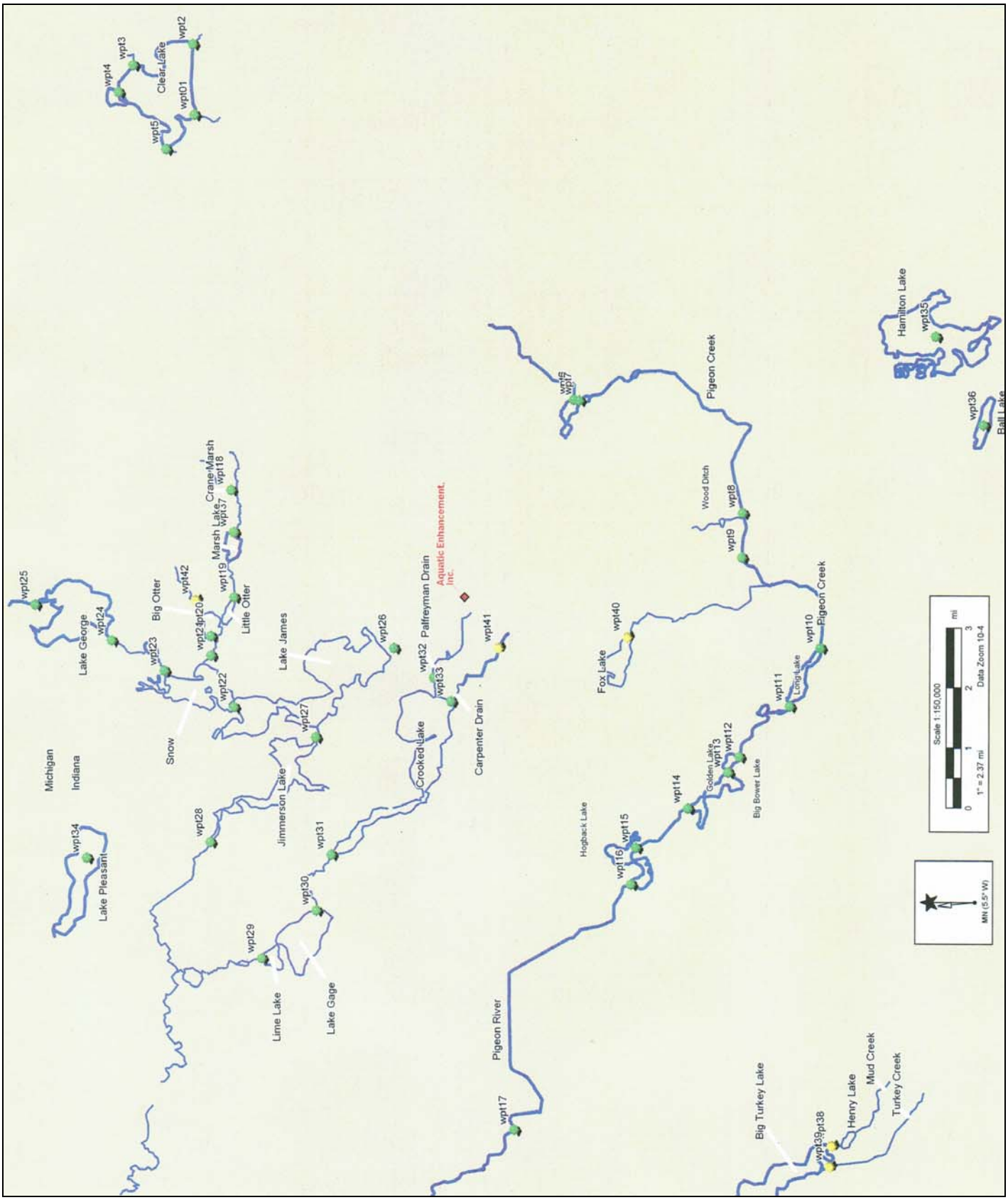

Figure 2 Steuben County-wide Sampling Map

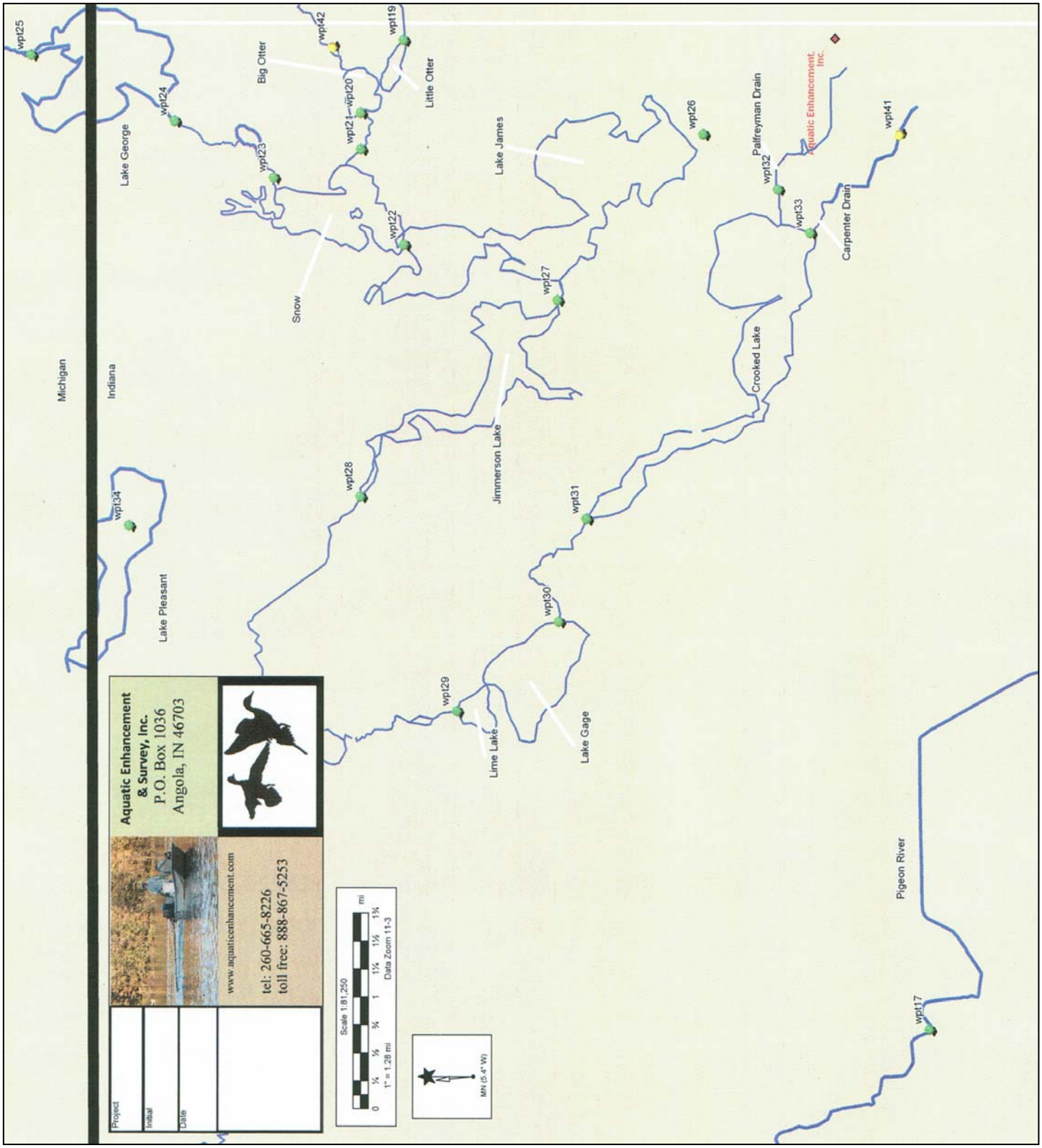

Figure 3 Northwestern Steuben County sampling sites

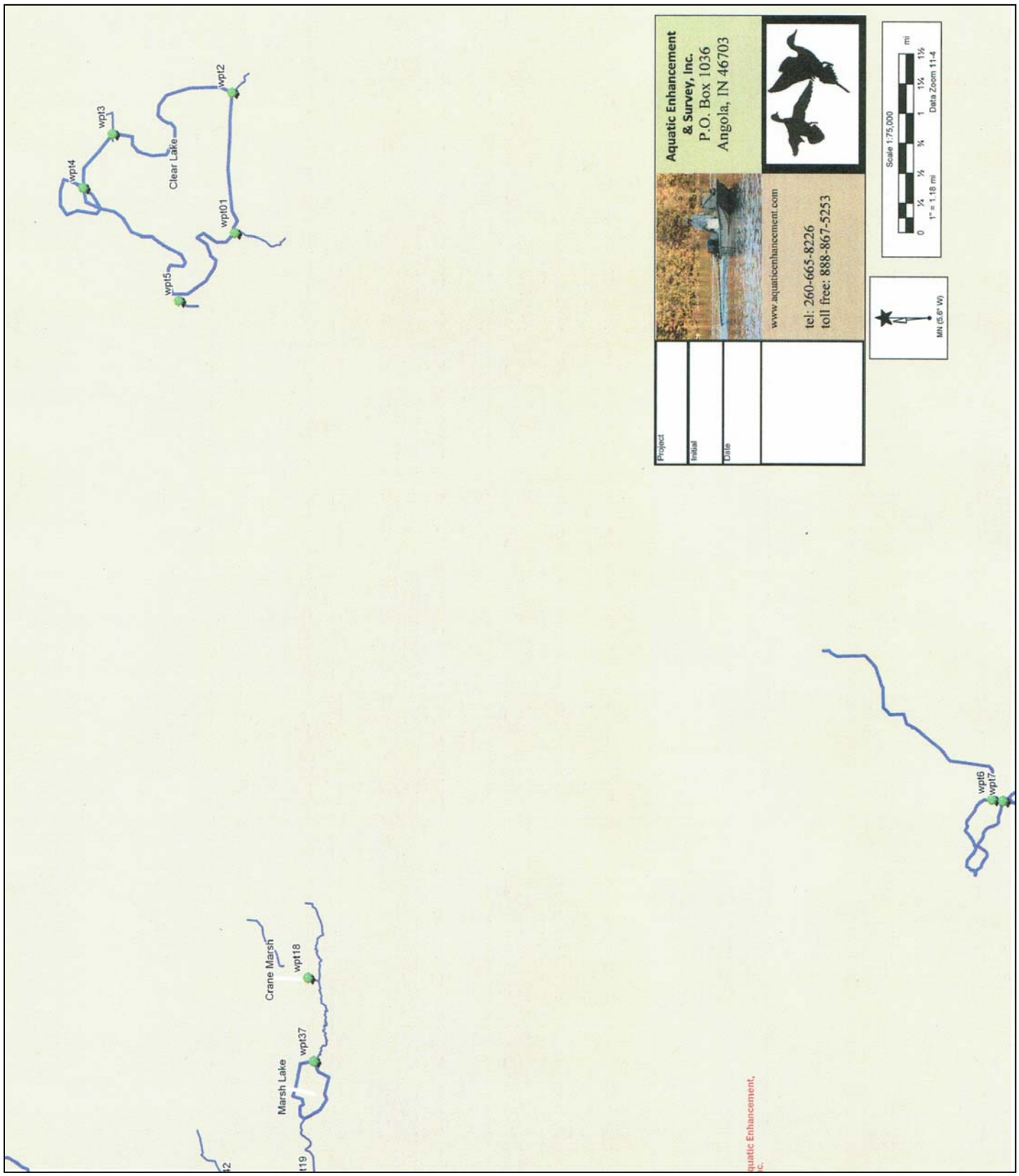

Figure 4 Northeastern Steuben County sampling sites

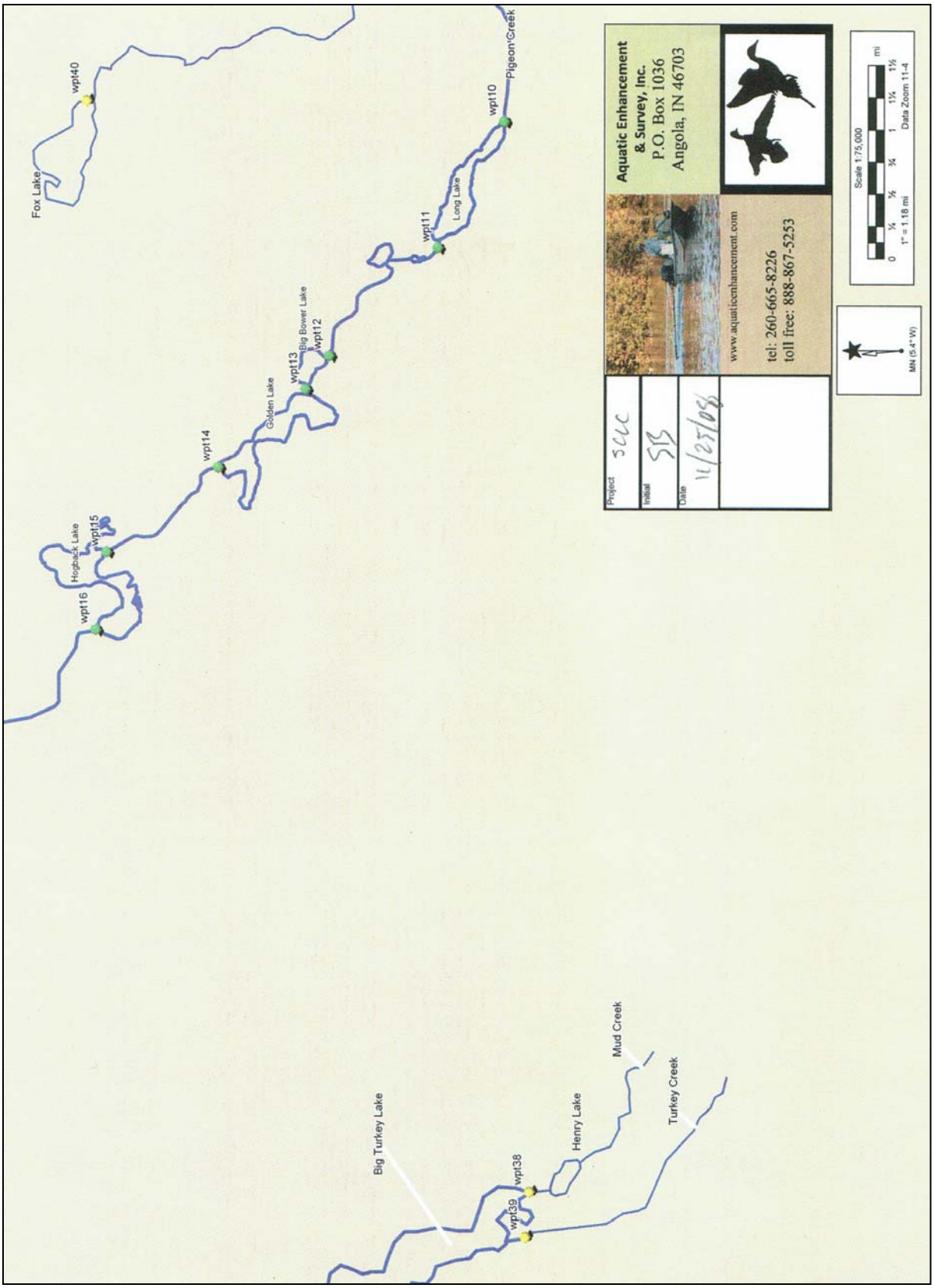

Figure 5 Southwestern Steuben County sampling sites

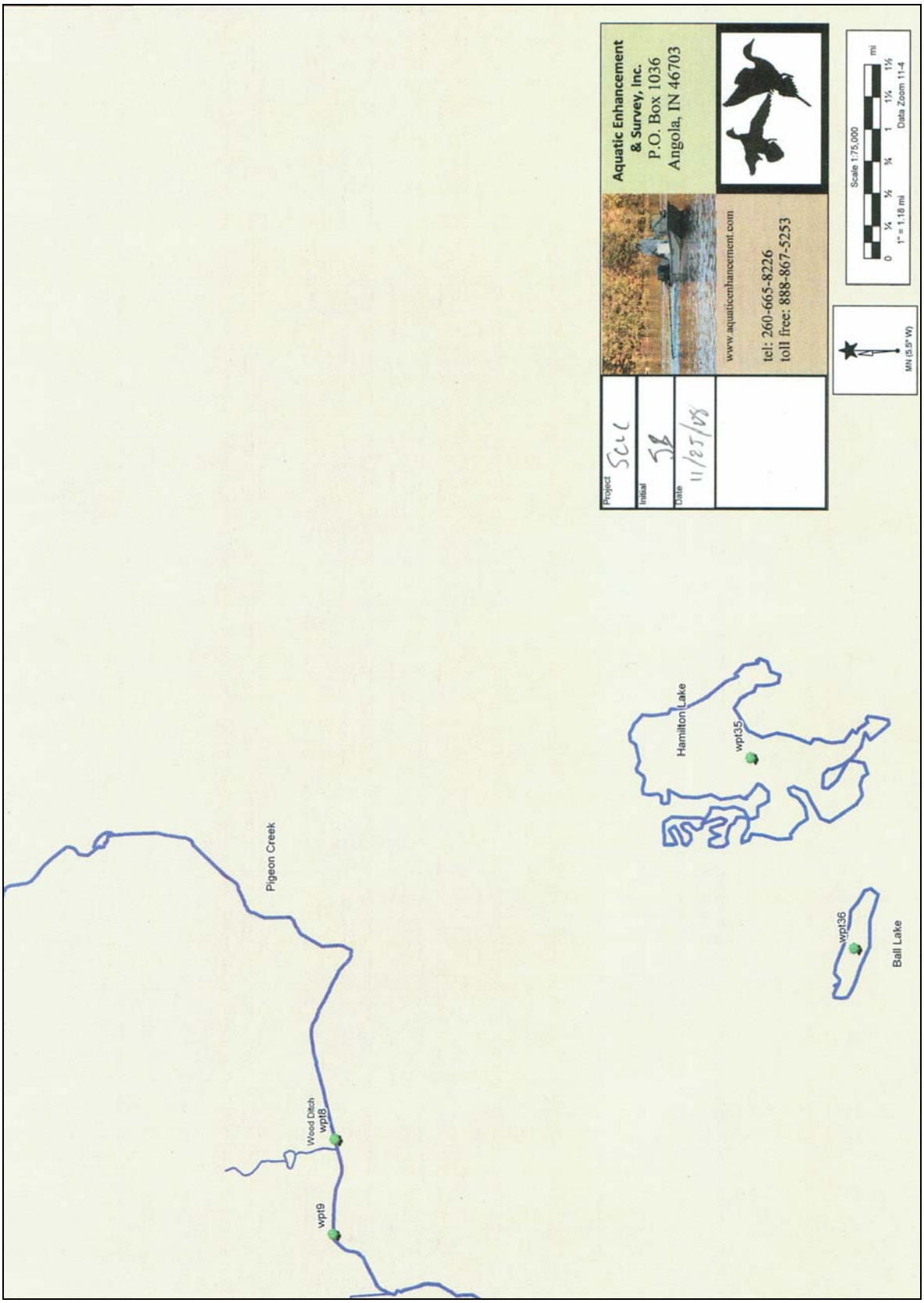

Figure 6 Southeastern Steuben County sampling sites

Figure 7 NW Steuben air photo with sampling sites

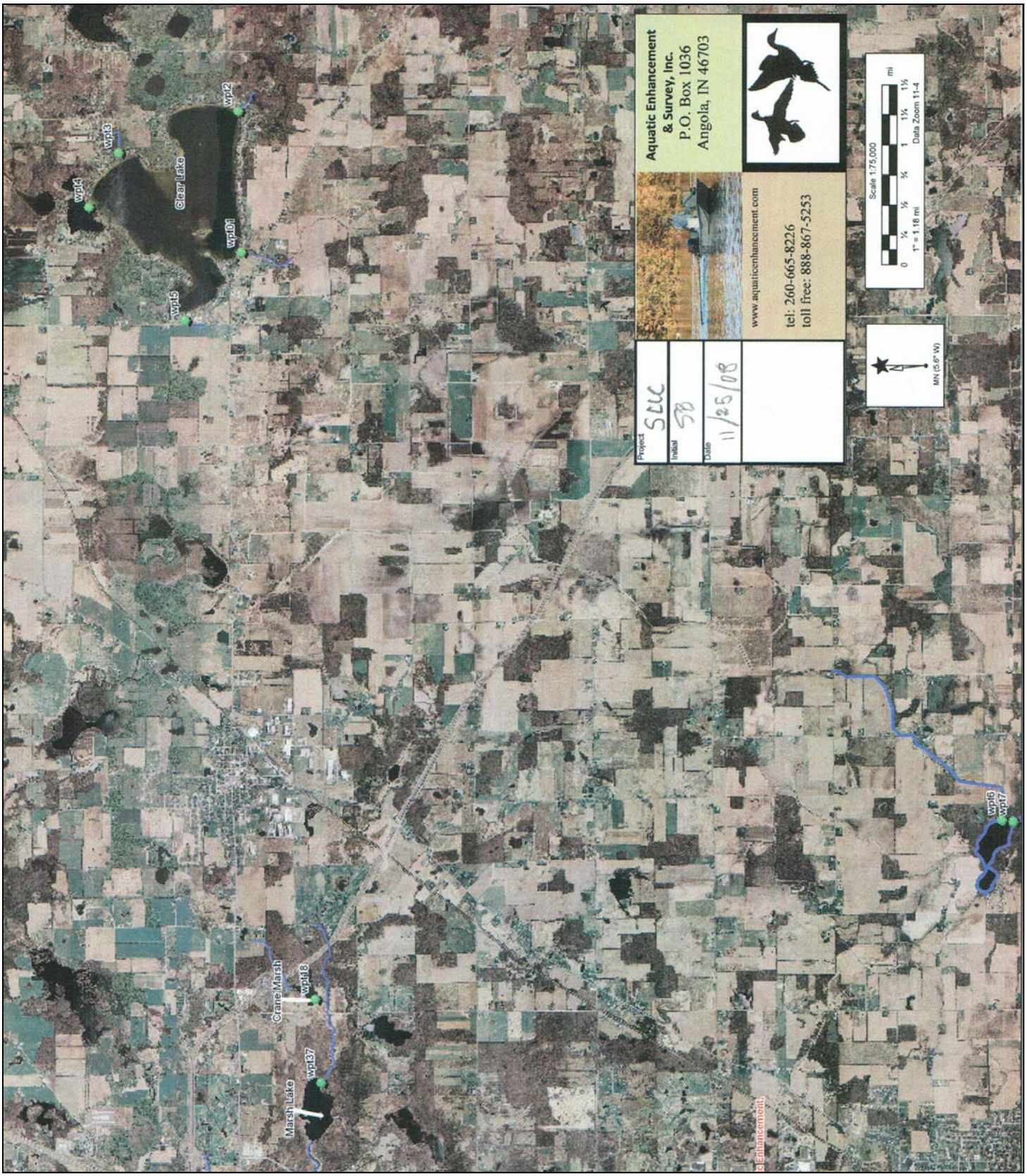

Figure 8 NE Steuben County air photo with sampling sites

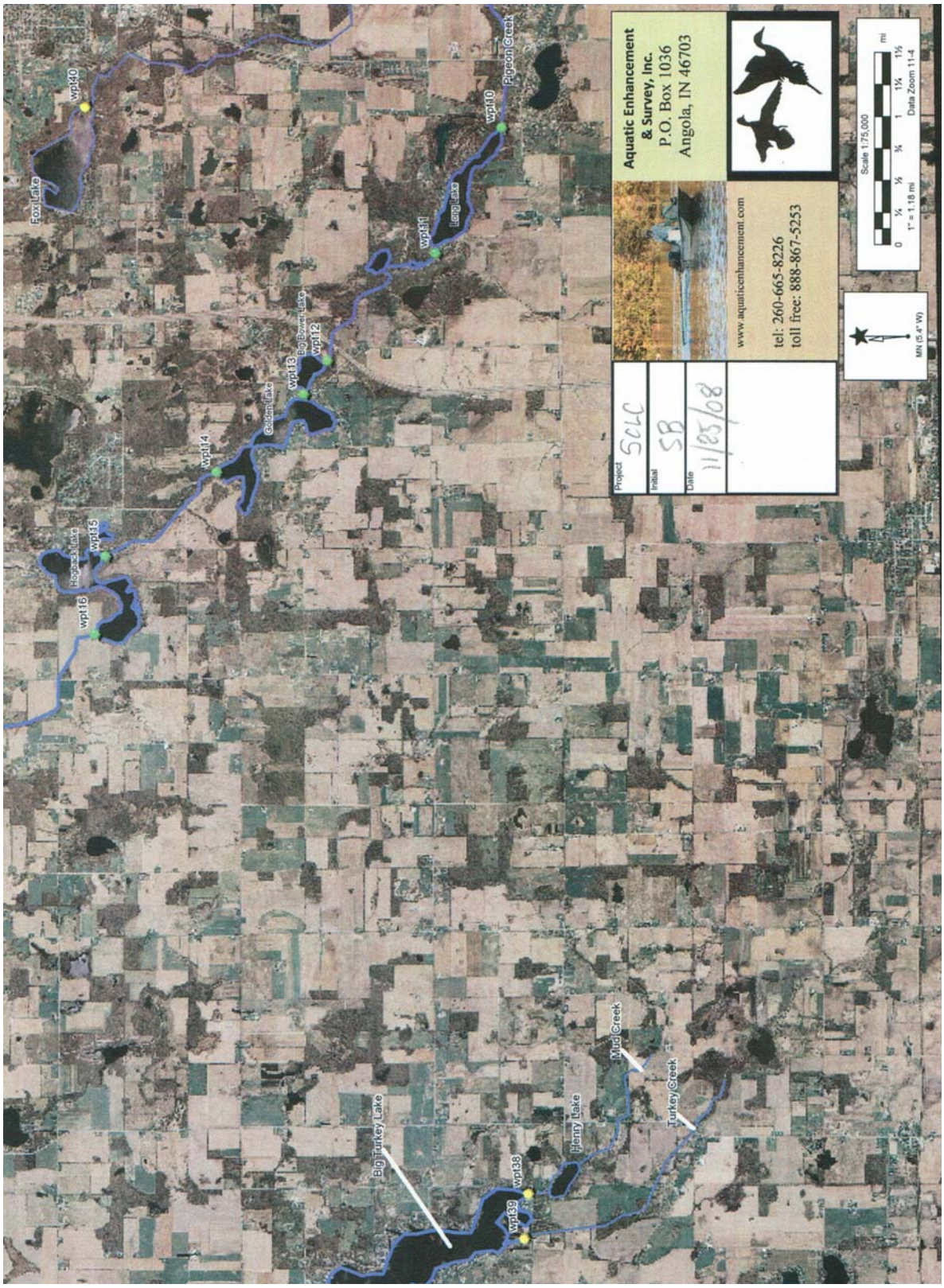

Figure 9 SW Steuben County air photo with sampling sites

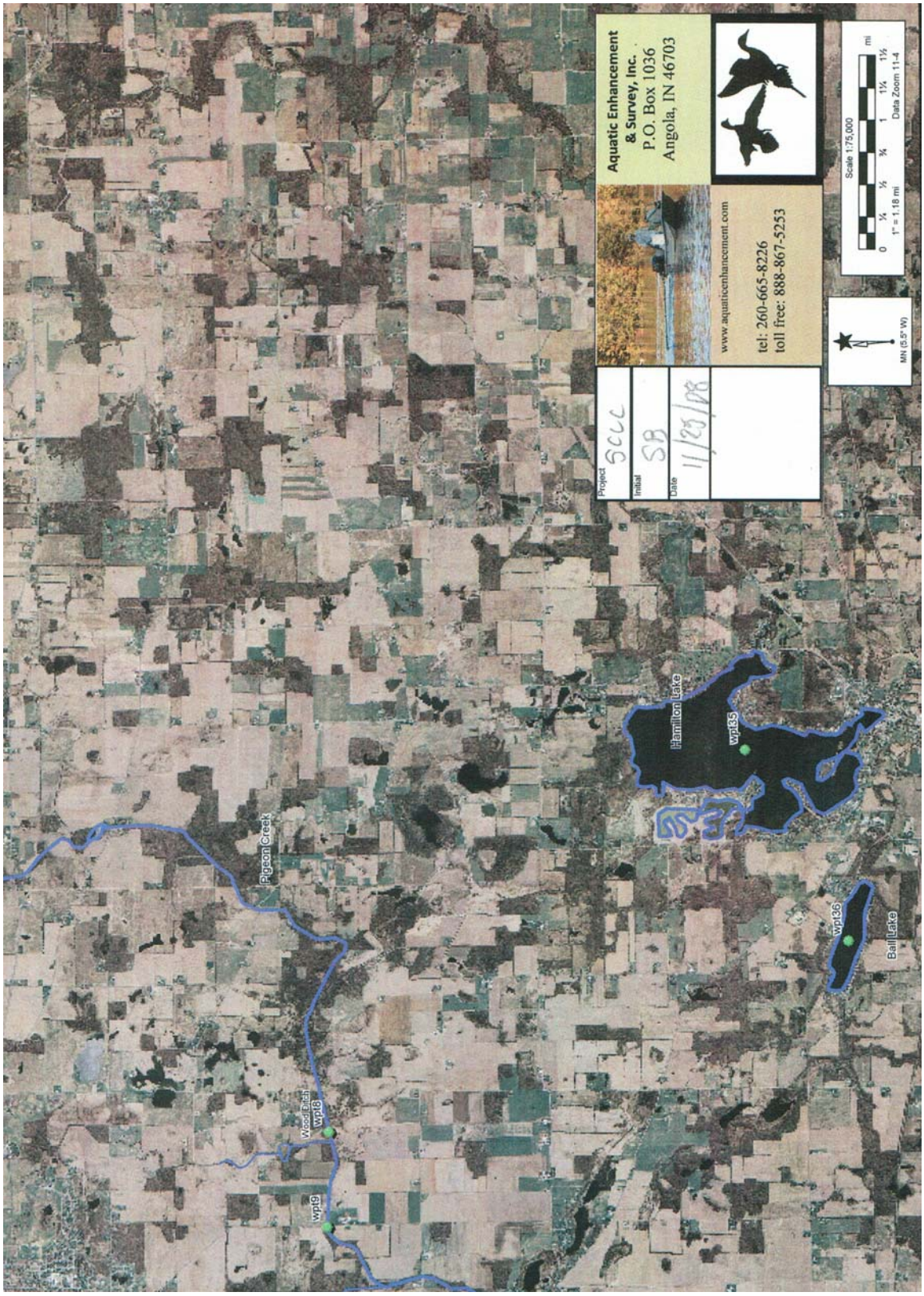

Figure 10 SE Steuben County air photo with sampling sites

Steuben County Lakes Council, Sampling Site Key

Sampling Site	Location Description
1	Cyrus Browse Ditch (Clear Lake Tributary)
2	Harry Teeters Ditch (Clear Lake Tributary)
3	Alvin Patterson Ditch (Clear Lake Tributary)
4	Clear Lake Outlet
5	Smith Drain (Clear Lake Tributary)
6	Pigeon Creek, Pigeon Lake Inlet
7	Pigeon Creek, Pigeon Lake Outlet
8	Pigeon Creek, Bill Deller Road
9	Pigeon Creek, Meridian Road
10	Pigeon Creek, Long Lake Inlet
11	Pigeon Creek, Long Lake Outlet
12	Pigeon Creek, Big Bower Lake Inlet
13	Pigeon Creek, Big Bower Lake Outlet/Golden Lake Inlet
14	Pigeon Creek, Golden Lake Outlet
15	Pigeon Creek, Hogback Lake Inlet
16	Pigeon Creek, Hogback Lake Outlet
17	Pigeon Creek at 327
18	Crane Marsh Outlet, (tributary to Marsh Lake)
19	Follet Creek, Little Otter Lake Inlet
20	Follet Creek, Big Otter Lake Outlet
21	Follet Creek, Snow Lake Inlet
22	Crooked Creek (Snow Lake outlet, Inlet to James)
23	Crooked Creek at 120 (Tributary to Snow Lake)
24	Crooked Creek (Lake George Outlet)
25	Lake George NE tributary (from Silver Lake)
26	Croxton Ditch, (tributary to Lake James at Lagoona Park)
27	Crooked Creek (James Outlet, Jimmerson Inlet at 4 corners)
28	Crooked Creek (Jimmerson outlet at Nevada Mills)
29	Concorde Creek (Outlet from Lime Lake)
30	Concorde Creek (Inlet to Lake Gage)
31	Concorde Creek (Outlet from Crooked Lake)
32	Palfreyman Ditch (Tributary to Crooked Lake)
33	Carpenter Ditch (Tributary to Crooked Lake)
34	Lake Pleasant
35	Hamilton Lake
36	Ball Lake
37	Deller Ditch (Tributary to Marsh Lake)
38	Dewitt Ditch (Tributary to Big Turkey Lake)
39	Turkey Creek (Tributary to Big Turkey Lake)
40	Fox Lake Outlet
41	Palfreyman Ditch (outlet from Center Lake)
42	Walter's Lakes Drain (tributary to Big Otter Lake)

Table 1 Descriptions of numbered sampling sites

Steuben County Lakes Council, May summary of sampling Results

Sampling Site	Sampling Date	pH	Dissolved Oxygen	Temp. Deg C.	Specific Conductance *conductivity	Total Suspended Solids (ppm)	Total Phosphorus (ppm)	E-coli (CFU/100 ml)	E-coli date	T.S.S. Loading Kg/day	Phos. Loading Kg/day	CFM discharge
1	5/22/08	7.30	9.39	12	447.9*	5	<.01	191	5/22/08	2.55	BDL	62.61
2	5/22/08	7.45	10.77	13.9	586*	1	<.01	62	5/22/08	1.49	BDL	36.69
3	5/22/08	6.83	3.44	15.1	285.6*	<1	<.01	237	5/22/08	BDL	BDL	20.88
4	5/22/08	8.08	9.70	17.2	351.1	<1	<.01	249	5/22/08	No flow	BDL	No flow
5	5/22/08	6.85	6.03	11.4	724	2	<.01	21	5/22/08	.36	BDL	4.41
6	5/23/08	7.37	8.71	12.2	658	21	<.01	130	5/22/08	820.69	BDL	958.99
7	5/23/08	7.70	9.08	15.4	617	5	<.01	10	5/23/08	327.45	BDL	1607.06
8	5/23/08	7.45	7.23	14.1	663	11	<.01	120	5/23/08	1045.12	BDL	2331.45
9	5/23/08	7.50	7.16	14.2	756	18	<.01	130	5/23/08	2410.00	BDL	3285.46
10	5/23/08	7.60	8.13	14.5	741	11	<.01	100	5/23/08	1498.76	BDL	3343.42
11	5/23/08	8	9.90	17.1	656	2	<.01	10	5/23/08	382.72	BDL	4695.72
12	5/23/08	7.70	8.87	16.4	726	6	<.01	17	5/23/08	2301.86	BDL	9414.11
13	5/23/08	7.78	9.45	17	724	4	<.01	140	5/23/08	932.56	BDL	5720.94
14	5/23/08	7.84	9.08	17.8	712	2	<.01	<3	5/23/08	680.19	BDL	8345.47
15	5/23/08	7.83	9.44	17.3	711	3	<.01	3	5/23/08	751.79	BDL	6149.28
16	5/23/08	8.10	10.93	19	668	3	<.01	3	5/23/08	808.55	BDL	6613.61
17	5/28/08	7.77	8.48	15.8	677	26	<.01	86	5/28/08	8748.19	BDL	8256.50
18	5/22/08	8.73	9.99	16.2	1318	1	<.01	137	5/22/08	3.07	BDL	75.42
19	5/27/08	7.71	7.41	17.7	692	2	<.01	13	5/28/08	47.77	BDL	586.06
20	5/27/08	8.19	9.65	18.8	637	<1	<.01	<3	5/28/08	No flow	BDL	No flow
21	5/27/08	8.01	8.68	19	619	3	<.01	7	5/28/08	No flow	BDL	No flow
22	5/27/08	8.07	9.19	18	524	<1	<.01	<3	5/28/08	BDL	BDL	3737.69
23	5/27/08	8.02	9.97	21	419	1	<.01	13	5/28/08	39.24	BDL	962.80
24	5/27/08	8.26	8.70	19	397.9	1	<.01	13	5/28/08	62.08	BDL	1523.55
25	No Data											
26	5/27/08	7.90	9.16	18.2	867	2	<.01	4000	5/30/08	10.07	BDL	123.60
27	5/27/08	8.05	9.29	18	522	<1	<.01	13	5/28/08	No flow	BDL	No flow
28	5/27/08	7.74	8.10	20.6	521	2	<.01	750	5/30/08	249.40	BDL	3060
29	5/28/08	8.10	8.87	18.5	449.6	1	<.01	11	5/28/08	14.26	BDL	349.85
30	5/28/08	7.85	8.78	17.9	462.4	6	<.01	51	5/28/08	130.91	BDL	535.39
31	5/27/08	7.49	6.74	21.5	450.1	6	<.01	800	5/30/08	104.97	BDL	429.31
32	5/27/08	8.25	10.79	20.7	694	7	<.01	220	5/30/08	13.43	BDL	47.09
33	5/27/08	7.97	8.93	17.2	330.5	7	<.01	1600	5/30/08	18.55	BDL	65.02
34	5/28/08	8.33	9.75	18	410.2	<1	<.01	1	5/28/08	Lake	BDL	Lake
35	5/23/08	7.91	18.48	16.42	349.7	2	<.01	<3	5/23/08	Lake	BDL	Lake
36	5/23/08	8.00	9.54	16.3	416.6	<1	<.01	3	5/23/08	Lake	BDL	Lake
37	5/27/08	7.72	7.96	15.9	801	8	<.01	160	5/28/08	155.48	BDL	476.94

Table 2 May sampling results

-n/d denotes “no data”
-no flow indicates stream was dry so no data was collected on appointed day or flow was not measurable by method employed
-BDL indicates parameter was below laboratory detection limit
Indicates site had elevated e-coli count (above 250 CFU) during this round of sampling

Steuben County Lakes Council, July summary of sampling Results

Sampling Site	Sampling Date	pH	Dissolved Oxygen	Temp. Deg C.	Specific Conductance *conductivity	Total Suspended Solids (ppm)	Total Phosphorus (ppm)	E-coli (CFU/100 ml)	E-coli date	T.S.S. Loading Kg/day	Phos. Loading Kg/day	CFM discharge
1	Discontinued											
2	Discontinued											
3	Discontinued											
4	Discontinued											
5	Discontinued											
6	7-24-08	8.00	15.04	21.8	721	9	BDL	382		171.71	BDL	468.18
7	7-24-08	8.31	12.63	25.9	593	6	BDL	4		246.90	BDL	1009.80
8	7-28-08	7.84	6.76	21.6	675	8	.05	530		361.67	2.26	1109.36
9	7-28-08	7.83	6.90	21.6	827	20	.08	642		1172.20	4.69	1438.22
10	7-28-08	7.86	7.64	21.4	806	12	.09	540		513.77	3.85	1050.60
11	7-28-08	8.41	11.00	25.4	651	30	.03	8		1434.13	1.43	1173.05
12	7-28-08	7.82	7.53	25.0	683	12	.04	72		1345.44	4.48	2751.28
13	7-28-08	8.22	10.80	26.8	658	13	.05	30		991.56	3.81	1871.66
14	7-28-08	8.55	13.71	30.0	585	4	.03	8		295.28	2.21	1811.42
15	7-29-08	8.13	9.72	25.1	581	10	.05	84		759.43	3.80	1863.54
16	7-29-08	8.61	16.20	26.6	522	4	.04	30		414.93	4.15	2545.46
17	7-29-08	7.78	8.69	23.9	592	6	.02	154		815.60	2.72	3335.6
18	7-25-08	7.53	5.80	23.8	1467	BDL	.30	0		BDL	.52	42.24
19	7-25-08	7.61	6.81	25.7	657	BDL	BDL	360		BDL	BDL	629.52
20	7-25-08	8.25	10.37	26.7	615	2	BDL	6		No flow	No flow	No flow
21	7-25-08	8.06	9.27	26.4	571	8	BDL	132		No flow	No flow	No flow
22	7-25-08	8.12	8.27	26.5	525	2	BDL	2		No flow	No flow	No flow
23	7-25-08	7.51	6.86	26.3	405	BDL	BDL	60		BDL	BDL	683.99
24	7-25-08	8.27	8.03	26.9	361	BDL	BDL	20		BDL	BDL	426.59
25	7-30-08	7.23	2.91	26.3	399.5	3	.01	284		23.07	.08	188.67
26	7-30-08	8.08	10.45	21.8	820	BDL	BDL	580		BDL	BDL	83.07
27	7-25-08	8.03	7.14	25.5	511	53	BDL	20		No flow	No flow	No flow
28	7-29-08	7.71	6.71	29.5	511	3	.008	44		440.29	1.17	3601.42
29	7-30-08	8.06	7.08	27.8	448.3	15	BDL	26		32.91	BDL	53.83
30	7-30-08	7.87	7.00	26.0	492	BDL	.03	1000		BDL	.43	347.72
31	7-30-08	7.52	5.34	28.4	466.5	BDL	.01	1140		BDL	.04	106.38
32 RAIN	7-8-08	7.36	6.40	22.1	526	128	.59	4440		1671.45	7.70	320.43
33 RAIN	7-8-08	7.26	6.82	22.4	226.5	43	.181	8200		791.17	3.33	451.50
34	7-30-08	8.47	8.01	27	411	BDL	BDL	8		Lake	Lake	Lake
35	7-30-08	8.23	7.85	27.1	335.6	3	BDL	8		Lake	Lake	Lake
36	7-30-08	8.39	9.29	26.9	403.7	4	BDL	6		Lake	Lake	Lake
37	7-25-08	7.90	7.48	19.2	844	8	.02	262		124.53	.31	381.99
38	7-29-08	7.94	10.68	26.9	586	BDL	BDL	32		No flow	No flow	No flow
39	7-29-08	7.66	7.53	25.9	607	BDL	.05	132		BDL	1.36	666.77
40	7-30-08	8.05	6.18	26.2	468.9	BDL	.09	76		BDL	.05	14.42
41	7-30-08	7.60	4.95	27.6	443.3	5	.07	314		4.86	.06	23.84
42	7-30-08	7.68	7.84	20.1	754	5	.02	234		9.77	.04	47.94

Table 3 July sampling results

-n/d denotes “no data”
-no flow indicates stream was dry so no data was collected on appointed day or flow was not measurable by method employed
-BDL indicates parameter was below laboratory detection limit

Indicates site had one high e-coli count (250 CFU or above) of three samples collected in 2008

Indicates site had two high e-coli count of two samples as of July 30, 2008

Steuben County Lakes Council, September- Nov. Summary of Sampling Results
Most samples collected within 24 hours after rain events.

Site	Sampling Date	pH	Dissolved Oxygen	Temp. Deg C.	Specific Conductance *conductivity	Total Suspen. Solids (ppm)	Total Phos. (ppm)	E-coli (CFU/100 ml)	E-coli date 1	E-coli (CFU/100 ml)	E-coli date 2	T.S.S load Kg/day	P load Kg/ day	CFM
1	Discontinued													
2	Discontinued													
3	Discontinued													
4	10/6/08	7.83	7.48	16.0	330	4	.01	112	10/8/08			No flow	No flow	No flow
5	Discontinued													
6	9/14/08	7.23	6.95	19.5	575	47	.02	240	9/10/08			1445.02	.61	754.44
7	9/14/08	7.87	8.08	21.5	*559	12	.01	24	9/10/08			849.36	.70	1736.86
8	9/14/08	7.63	6.69	20.9	*553	48	.02	324	9/10/08	4660	9/15/08	6054.39	2.5	3095.14
9	9/14/08	7.55	6.55	20.1	*578	49	.03	366	9/10/08	4540	9/15/08	16645.63	5.61	4589.46
10	9/14/08	7.46	7.16	21.1	608	65	Bdl	388	9/10/08	2900	9/15/08	14858.46	BDL	5609.34
11	9/14/08	8.93	10.75	21.2	709	13	.02	840	9/15/08			2489.58	3.83	4699.30
12	9/14/08	10.19	7.8	20.7	704	20	.10	6	11/26/08			2752.00	13.76	3376.52
13	9/14/08	10.25	6.41	20.3	710	1	Bdl	6	11/26/08			1471.34	BDL	6017.44
14	9/14/08	9.79	4.12	20.2	639	7	Bdl	51	11/26/08			9086.06	BDL	4371.76
15	10/2/08	7.63	5.65	15.9	673	bdl	.05	22	10/2/08			BDL	1.21	595.57
16	10/2/08	7.57	5.19	17.6	306.4	bdl	.06	18	10/2/08			BDL	1.32	539.35
17	10/2/08	7.70	7.67	15	651	bdl	.05	86	10/2/08			BDL	5.89	2888.43
18	9/9/08	8.71	7.71	20.5	1579	11	.02	8	9/9/08			24.89	.05	55.52
19	10/3/08	7.76	17.34	16.9	720	bdl	.01	96	10/8/08			BDL	.12	293.16
20	10/3/08	8.02	8.54	18.8	636	bdl	Bdl	0	10/9/08			No flow	No flow	No flow
21	10/3/08	8.00	9.35	17.8	609	bdl	.01	30	10/9/08			No flow	No flow	No flow
22	10/3/08	7.88	7.71	18.9	527	bdl	.01	4	10/9/08			No flow	No flow	No flow
23	10/4/08	7.28	5.70	16.5	428.8	bdl	.01	174	10/8/08			BDL	2.91	7147.22
24	10/4/08	8.25	9.22	16.8	377.4	bdl	.02	36	10/8/08			BDL	.25	305.43
25	10/4/08	7.57	8.85	16	388.0	4	Bdl	176	10/8/08			51.84	BDL	318.04
26	9/4/08	8.72	7.07	20.2	451.8	14	.01	3200	9/4/08	270	10/8/08	152.92	.11	268.03
26	10/3/08	7.78	8.48	17.8	860	bdl	.01					BDL	.04	90.41
27	10/3/08	8.05	8.86	19.6	503	1	.01	68	10/8/08			58.68	.59	1440.04
28	10/3/08	7.78	8.55	15.5	498.2	bdl	.01	8	10/8/08			BDL	.81	1979.81
29	10/6/08	7.86	7.90	15.8	440.2	bdl	.01	16	10/8/08			BDL	.03	82.23
30	10/6/08	8.16	10.54	12.3	601	Bdl	Bdl	436	10/8/08			BDL	BDL	6.77
31	10/6/08	7.07	6.01	12.3	479.8	8	Bdl	86	10/8/08			No flow	No flow	No flow
32	10/6/08	8.31	12.27	15.0	767	bdl	Bdl	1820	10/8/08			BDL	BDL	18.62
33	10/6/08	8.05	9.58	13.1	522	2	.01	1500	10/8/08			.44	.002	5.38
34	10/7/08	8.07	8.80	15.6	402.3	bdl	Bdl	4	10/7/08			Lake	Lake	Lake
35	10/7/08	8.2	8.20	17.1	322.4	bdl	Bdl	16	10/7/08			Lake	Lake	Lake
36	10/7/08	8.14	8.11	16.8	415.4	4	Bdl	44	10/7/08			Lake	Lake	Lake
37	10/3/08	7.96	8.22	16.4	410.1	1	.01	312	10/8/08			16.65	.17	408.77
38	10/6/08	7.63	7	16.8	635	bdl	.01	72	10/8/08			No flow	No flow	No flow
39	10/6/08	7.78	9.65	15.1	651	Bdl	Bdl	252	10/8/08			BDL	BDL	246.25
40	10/6/08		No flow					44	9/10/08	5660	9/15/08	No flow	No flow	No flow
41	10/6/08	8.27	8.79	15.8	424.6	21	.01	520	10/8/08			7.1	.003	8.3
42	10/4/08	7.21	2.86	12	747	1	.01	68	10/8/08			No flow	No flow	No flow

Table 4 Late season sampling results

-n/d denotes “no data”
-no flow indicates stream was dry so no data was collected on appointed day or flow was not measurable by method employed
-BDL indicates parameter was below laboratory detection limit

Indicates site had one high e-coli count of three samples collected in 2008
Indicates site had two high e-coli count of three samples collected in 2008
Indicates site had three high e-coli count of three samples collected in 2008
Indicates site had four high e-coli count of four samples collected in 2008

3. Results: May Sampling

Stream and lake sampling was performed at 36 sites between May 22 and May 27th. Samples collected in May represented baseline flow conditions (not collected during or immediately after a rain event). Table five below contains averages of stream data from the Indiana Department of Environmental Management's (IDEM) probabilistic data set. The data used to calculate these averages was collected from Indiana Streams within the St. Joseph River watershed from year 2000 to 2005. This dataset also includes some data from streams included in the 2008 Steuben County Lakes Council dataset. Because there is no single established set of standards for stream water quality the data is provided for comparison. Most of the collection sites included in the 2008 SCLC data are also within the St. Joseph River watershed and therefore represent somewhat similar soil types, topography, and land uses. This allows a judgment to be made as to whether the 2008 SCLC samples were "below average", "average" or "above average" in terms of Indiana stream water quality.

Parameter	IDEM Mean Stream Data
	St. Joseph Wtrshd 2000-2005
pH	n/d
D.O. (ppm)	7.14
Temp. (deg C)	19.91
Specific conductance umho/cm	764.19
Total Suspended Solids (ppm)	36
Total Phosphorus (ppm)	0.382
E-coli (CFU/100ml)/(MPN)	1895.58
Tss Loading Kg/day	n/d
Total Phos. Loading Kg/day	n/d

Table 5 Average of IDEM-collected probabilistic Indiana stream data for the St Joseph River Watershed 2000-2005

Measurements of pH were made in the field at 36 sampling sites in May. Measurements ranged from 6.83 at Alvin Patterson Ditch to 8.73 at the outlet of Crane Marsh. Most showed normal measurements. Sites three and five at Clear Lake at 6.83 and 6.85 (Alvin Patterson Ditch and Smith Drain respectively) were slightly acidic but should not be construed as a significant problem. Dissolved oxygen levels were healthy at all sampled sites during May and were capable of sustaining fish and other gill breathing aquatic life. Temperatures at all sites were also normal and reflected climatic conditions at the time. Specific conductance measures the presence of certain dissolved ions which encourage the conductance of electric current in water. May data for specific conductance from 35 of the 36 sites was relatively close to the IDEM dataset average and could be considered normal. Site number 18, the outflow from Crane Marsh showed an unusually high specific conductance of 1318 umho/cm. This is well above the IDEM dataset average of

764 for other St. Joseph River watershed streams. It is unknown why the Crane Marsh conductance was elevated. The figure may be influenced by the arrangement of the overflow structure to draw water from the lower strata of the marsh. It's possible that more dissolved ions are present in the marshes' lower hypolimnetic waters than in surface waters where all other samples were collected. The discharge of the Town of Fremont Pollution control facility could also influence the water quality of this marsh, however none of the other parameters measured at this location in the May sampling were unusual. No total suspended solids (TSS) measurements were unusually high in the May sampling with TSS being undetectable (below 1 ppm) at five sites. The highest measured was 26 ppm in a sample collected from Pigeon Creek near State Road 327. This was still well below the IDEM dataset average of 36 ppm. The waters at the Pigeon Creek, 327 sampling site appeared to be relatively clear at the time of sampling. Total phosphorus was undetected (below .01 ppm) in all 36 samples collected in May. The laboratory was asked to repeat analysis on several samples and same result was produced. This is an extremely low result for many of the sampling sites. The IDEM probabilistic dataset average for stream sample total phosphorus is .382 ppm. It's is unknown why phosphorus levels measured so low in the May sampling. Whereas phosphorus is the primary nutrient associated with water quality problems and excessive algal growth low phosphorus levels are typically considered beneficial. The combination of vigorous plant uptake of phosphorus and the lack of significant rainfall in the period immediately before sampling may have contributed to unusually low spring levels. Because elevated E-coli levels in stream and lake waters are unfortunately common in northern Indiana, the IDEM probabilistic dataset average for E-coli is 1896 CFU. This is typically far too high of a figure to represent safe conditions for swimming. Consecutive E-coli bacteria counts above 200-250 Colony Forming Units per milliliter (CFU) within a given period of time are often used as an indicator of unsafe swimming conditions in public areas. Four stream sites returned counts above 250 CFU in the May sampling. Croxton Ditch (tributary to Lake James) showed a count of 4000 CFU almost double the IDEM average. Crooked Creek flowing from Nevada Mills (Jimmerson Lake) also showed an elevated level of 750 CFU. Concorde Creek (the outflow from Crooked Lake) had an elevated level of 800 CFU and Carpenter Ditch (tributary to Crooked Lake) measured 1600 CFU. Because E-coli levels can be elevated by the presence of geese, ducks, and other wildlife elevated E-coli measurements in these areas can be temporary but action is warranted where high levels persist, especially if a bacterial source is in close proximity to swimming areas.

4. Results: July Sampling

Stream and lake sampling was performed at 37 sites between July 8th and July 30th. Samples collected on July 8th from Carpenter and Palfreyman drains were rain event samples. Because rain events were infrequent in July all other July samples collected were baseline flow samples. Measurements of pH were made in the field at all sampling sites. Measurements ranged from 7.23 at the northeast tributary at Lake George to 8.61 at the outlet of Hogback Lake. All were considered normal for summer measurements. Dissolved oxygen measurements ranged from 2.91 at the Northeast tributary to Lake George to 16.20 at the outlet of Hogback Lake. High measurements of both pH and dissolved oxygen at Hogback Lake are probably an indicator of a large amount of

vegetation growth and a generally high rate of biological productivity. A low dissolved oxygen level and comparatively low pH at the tributary to Lake George is probably an indication of a high amount of vegetative decomposition in wetlands draining to that tributary. The Lake George tributaries low dissolved oxygen level probably provides impairment to fish and other gill breathing organisms in that stream. This could also have implications for aquatic life in the lake in very close proximity to the inlet. Most temperatures measured in July were normal and generally reflective of climatic conditions. Sites on Pigeon Creek, Croxton Ditch, and Walter's Lakes Drain showed relatively cool temperatures reflecting significant input from groundwater sources. Measurements of specific conductance varied from 226.5 at Carpenter Drain to 1467 at the Outlet of Crane Marsh. The measurement at Crane marsh was again far above all other readings and the IDEM average of 764. Total suspended solids measurements were low for most sites with 11 sites being below a lab detection limit of 1 ppm. Both Crooked Lake rain event sites (Carpenter and Palfreyman) were well above the IDEM average of 36 ppm with Carpenter measuring 43 ppm and Palfreyman measuring 128 ppm. The outlet from Lake James also showed an above average measurement of 53 ppm. It is unknown why this measurement was this high. Water clarity was good at the time of sample collection. With the exception of the Carpenter and Palfreyman Drain rain event samples all phosphorus measurements from July were relatively low. Fifteen sites were below a lab detection limit of .01 ppm. The Carpenter Ditch rain event measurement was .181 ppm. This was still significantly below the IDEM average of .382 ppm. Palfreyman Drain's rain event measurement was .59 ppm, significantly higher than the IDEM dataset average. E-coli bacteria measurements over 250 CFU were recorded at thirteen sites (see table 3 for all sites). Sites with high E-coli levels in July that also had elevated E-coli in the May sampling included Croxton Ditch (580 CFU), Concorde Creek/Crooked Lake Outlet (1140 CFU) and Carpenter Drain (8200 CFU). It should also be noted that the Palfreyman Drain measurement was significantly high (4440 CFU). In the July sampling the sample collected at Concord Creek near its confluence with Lake Gage was also significantly high (1000 CFU). On Pigeon Creek an elevated E-coli sample was collected above Pigeon Lake (382 CFU), and also at Bill Deller Rd. (530 CFU), at Meridian Rd. (642 CFU) and just above the confluence with Long Lake (540 CFU). It should be noted that the elevated E-coli levels in the Pigeon Creek in July extended upstream from the confluence with Wood Ditch which serves as a conduit for the Angola wastewater treatment plant effluent.

5. Results: Late Season Sampling (Sept-Nov.)

Since few opportunities to collect rain event samples occurred in July or August of 2008 sampling was extended beyond the planned August sampling period to try to incorporate more rain-event data. An attempt was made to collect rain event samples from as many sites as possible in September through November. Most of the late season samples were collected within 48 hours of rain events, however it should be noted that due to droughty conditions in July and August, runoff amounts from the landscape still appeared to be relatively small even in the severe storm conditions present during sampling conducted on September 14. This was reflected in the late season data. Measurements of pH during late season sampling ranged between 7.07 at Concorde Creek (Crooked outlet) and 10.2 at the Big Bower Lake outlet (Golden Lake inlet). A sample collected at the

Golden Lake outlet measured 10.2. The Big Bower and Golden Lake measurements were relatively high and were probably the result of rich plant and algae growth still taking place on those lakes on the September 14 sampling date. All other pH measurements were considered to be normal. Dissolved oxygen levels ranged from 17.34 ppm at Follet Creek (Little Otter Lake inlet) to 2.86 at Walter's Lake Drain. It is unknown why the Follet Creek measurement was unusually high. Extremely high Dissolved Oxygen levels are usually associated with oxygen production from growing plants and algae. The Walter's Lake Drain level may be the result of decomposition taking place in associated wetlands north of U.S. 120. The outflow from Golden Lake (Pigeon Creek) also showed a slightly low oxygen level of 4.12 ppm. Generally 5 ppm is considered sufficient to sustain most species of fish and other gill breathing aquatic organisms. All other sampling sites produced normal oxygen measurements. Temperature measurements taken in the late season sampling were considered normal and generally reflected climatic conditions at the time of sampling. Specific conductance measurements ranged between 322.4 (Hamilton Lake) and 1579 (Crane Marsh outlet). The flow from Crane Marsh again showed an unusually high specific conductance, well above all others in the sampling and the 764 IDEM average. Most total suspended solids measurements in the late season sampling were relatively low with solids below a detection limit of 1 ppm in samples from 18 sites. The highest measurements were recorded from Pigeon Creek samples collected during the severe 9/14/08 storm event, four of which were higher than the IDEM data average of 36 ppm. Total phosphorus measurements however were all surprisingly low in the late season with 12 samples under a lab detection limit of .01 ppm. The highest measurement was .06 ppm from a sample collected from the outlet of Hogback Lake. E-coli bacterial counts in excess of 250 CFU/ml were found in samples collected from Pigeon Creek (Long Lake outlet 840 CFU), Concorde Creek (inlet to Lake Gage 436 CFU), Palfreyman Ditch (1820 CFU), Carpenter Ditch (1500 CFU), Deller Ditch (tributary to Marsh Lake 312 CFU), Turkey Creek (252 CFU), and Palfreyman Ditch (downstream of Center Lake 520 CFU). To address the issue of recurring elevated E-coli counts on the Pigeon Creek upstream of Long Lake samplings were performed twice in the late season between Meridian Road and the confluence with Long Lake. The first sample collection took place on September 10. The Bill Deller Road sample (upstream of Wood Ditch) measured 324 CFU, the Meridian Road sample returned a count of 366 CFU, and the sample just upstream of Long Lake returned a count of 388 CFU. It should also be noted that a sample collected from the outlet of Long Lake this same day measured 840 CFU. The second sample collection took place on 9/15/08 within 48 hours of a large release of untreated effluent from the Angola wastewater plant to Wood Ditch due to a severe storm event. The 9/15/08 Bill Deller road sample (upstream of the Wood Ditch confluence) showed a count of 4660 CFU. The Meridian Road sample returned 4540 CFU, and the sample collected just upstream of Long Lake returned a count of 2900 CFU.

6. Conclusions

The 2008 season appeared to be a mild one in terms of nutrient and sediment runoff entering Steuben County lakes and streams. This was reflected by some area lakes showing markedly improved water quality over previous seasons. Water Clarity at Hamilton Lake was more than double that of the previous season. Dissolved oxygen,

temperature, and pH measurements taken in 2008 did not appear to demonstrate any serious water quality problems. Specific conductance consistently ran unusually high at the outlet of Crane Marsh. This is possibly due to the design and operation of the overflow structure or may reflect an unusual ion content contributed by wastewater effluent. The National Pollution Discharge Elimination System (NPDES) permit issued to the Town of Fremont plant does not require monitoring of specific conductance so information is not available about the conductance of the plant's effluent. Other parameter measurements did not seem to indicate a serious water quality problem at Crane Marsh.

Notably high total suspended solids and total phosphorus measurements were limited to the storm event samples collected from Carpenter and Palfreyman Drains near Crooked Lake. Under cost share grant funding through the Indiana Department of Natural Resources Lake and River Enhancement Program (LARE) monitoring and feasibility studies have already been initiated and completed by the Crooked Lake Association in the Carpenter and Palfreyman watersheds to help address nutrient and sediment sources. Design and construction phases have also been completed to address erosion and pollution sources in the Carpenter Drain watershed and at the 4 H park. Following up on any remaining options for remediation in the Palfreyman Drain watershed may be helpful in further reducing pollutant contributions to Crooked Lake from this waterway.

Whereas E-coli bacteria can be an indicator of hazardous conditions for swimmers in the form of waterborne pathogens, recurring high E-coli counts from the 2008 sampling should be taken seriously. This is especially true in the vicinity of recreational beaches and lakefronts. E-coli bacteria originate in the digestive tract of warm blooded animals so the presence of wildlife such as geese and ducks can cause temporary elevated levels. Areas of persistent recurrence are more likely to have a continual source in animal or human waste and should be investigated and addressed further. Concorde Creek at the inlet to Lake Gage, Concorde Creek at the outlet from Crooked Lake, Palfreyman Drain (near Crooked Lake and near Center Lake), and Deller Ditch (near Marsh Lake) all showed counts above 250 CFU in two of three samples collected. Carpenter Ditch (just upstream of Crooked Lake) had counts above 250 CFU in all of three samplings in 2008. Samples collected from Pigeon Creek at Bill Deller Road, Meridian Road, and just upstream of Long Lake had elevated counts in all of four samples collected over the course of the 2008 season. Croxton Ditch just upstream of Lake James also showed high counts in all of four samples collected. An examination of stream corridors, watershed land-use, and wastewater disposal practices combined with additional sampling may be able to better identify potential sources of the bacteria in these problem areas. The Steuben County Lakes Council or respective lake associations should investigate these problem areas further with the goal of eventually eliminating bacterial sources. In some cases funding and technical assistance may be available through the USDA Natural Resources Conservation Service, Indiana Department of Natural Resources Lake and River Enhancement Program, Steuben County Soil and Water Conservation District, or USEPA. Significant erosion was noted along Pigeon Creek upstream of Hogback Lake during sampling. Hogback Lake's data also suggests it is highly productive and relatively nutrient rich. Additionally the delta area at Hogback Lake is extremely shallow

and has probably received considerable deposition of eroded materials over the years. Options for helping stabilize the stream bank along this reach of Pigeon Creek should be investigated with the ultimate goal of providing future benefits to Hogback Lake by reducing nutrient and sediment loads and improving water quality.