Appendix A

Lake Response Model Results and Model Fit Graphs

GEM LAKE AVG YEAR — Calibration Years '00-'05, '07-'09

Water Budgets / Phosphorus Loading

Inflow from Drainage Areas

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Phosphorus Concentration [ug/L]	Loading Calibration Factor (CF)[1] [--]	Load [lb/yr]
1	Watershed	306.34	3.2	81.1	281.6	1.0	62.1
2						1.0	
3						1.0	
4						1.0	
5						1.0	
	Summation	*306.34*	*3.2*	*81.1*	*281.6*		62.1

Failing Septic Systems

	Name	Area [ac]	# of Systems	Failure [%]	Load / System	[lb/ac]	[lb/yr]
1	Watershed	306.34	13	5%	7.8	0.0	5.1
2							
3							
4							
5							
	Summation	*306.34*	*13*	*5%*		*0.0*	*5.1*

Inflow from Upstream Lakes

	Name	Discharge [ac-ft/yr]	Estimated P Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
1			-	1.0	
2			-	1.0	
3			-	1.0	
	Summation	*0*	-		*0*

Atmosphere

Lake Area [acre]	Precipitation [in/yr]	Evaporation [in/yr]	Net Inflow [ac-ft/yr]	Aerial Loading Rate [lb/ac-yr]	Calibration Factor [--]	Load [lb/yr]
21.6	32.0	32.0	0.00	0.24	1.0	5.2

Dry-year total P deposition =	0.230
Average-year total P deposition =	0.240
Wet-year total P deposition =	0.268
(Barr Engineering 2007)	

Groundwater

Lake Area [acre]	Groundwater Flux [m/yr]	Net Inflow cfs	Net Inflow [ac-ft/yr]	Phosphorus Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
21.6		0.0	0	0	1.0	0

Internal

Lake Area [acre]	Anoxic Factor [days]	Calc Anoxia	Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
21.6	47.1		0.00	1.0	0

Net Discharge [ac-ft/yr] =	**81**	**Net Load [lb/yr] =**	**72.4**

NOTES

[1] Loading calibration factor used to account for special circumstances such as wetland systems, fertilizer use, or animal waste, among others, that might apply to specific loading sources.

Lake Response Modeling for Gem Lake Avg Year

Modeled Parameter	Equation	Parameters	Value	[Units]
TOTAL IN-LAKE PHOSPHORUS CONCENTRATION				
	$P = \frac{P_i}{\left(1 + C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times T\right)}$	as f(W,Q,V) from Canfield & Bachmann (1981)		
		C_P =	1.00	[--]
		C_{CB} =	0.162	[--]
		b =	0.458	[--]
		w (total P load = inflow + atm.) =	72	[lb/yr]
		Q (lake outflow) =	81	[ac-ft/yr]
		V (modeled lake volume) =	183	[ac-ft]
		T = V/Q =	2.26	[yr]
		P_i = W/Q =	328	[ug/l]
Model Predicted In-Lake [TP]			**71.6**	**[ug/l]**
Observed In-Lake [TP]			**59.5**	**[ug/l]**
Note: The observed In-Lake TP concentration reported here excludes two sample data points from 2007.				
PHOSPHORUS SEDIMENTATION RATE				
	$P_{sed} = C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times [TP] \times V$			
		P_{sed} (phosphorus sedimentation) =	**56.6**	**[lb/yr]**
PHOSPHORUS OUTFLOW LOAD				
		W-P_{sed} =	**15.8**	**[lb/yr]**

Load Reduction Table for Gem

LOAD		MODELED IN-LAKE WATER QUALITY PARAMETERS			TROPHIC STATE INDICES (Carlson, 1980) FOR MODELED	
REDUC-TION [%]	NET LOAD [lb]	[TP] [ug/L]	P SEDIMEN-TATION [lb]	TP OUT-FLOW [lb]	TSI [TP] [--]	TSI Avg. [--]
0%	**72**	72	57	**16**	65.7	**60.8**
5%	**69**	69	53	**15**	65.3	**60.5**
10%	**65**	67	50	**15**	64.8	**60.3**
15%	**62**	65	47	**14**	64.2	**60.0**
20%	**58**	62	44	**14**	63.7	**59.7**
25%	**54**	59	41	**13**	63.1	**59.4**
30%	**51**	57	38	**13**	62.4	**59.0**
35%	**47**	54	35	**12**	61.7	**58.6**
40%	**43**	51	32	**11**	60.9	**58.2**
45%	**40**	48	29	**11**	60.1	**57.7**
50%	**36**	45	26	**10**	59.2	**57.2**
55%	**33**	42	23	**9**	58.2	**56.6**
60%	**29**	39	20	**9**	57.0	**55.9**
65%	**25**	36	17	**8**	55.7	**55.1**
70%	**22**	32	15	**7**	54.2	**54.2**
75%	**18**	28	12	**6**	52.4	**53.1**
80%	**14**	24	9	**5**	50.1	**51.7**
85%	**11**	20	7	**4**	47.1	**49.8**
90%	**7**	15	4	**3**	42.8	**47.0**
95%	**4**	9	2	**2**	35.2	**42.1**

GEM LAKE TMDL

Water Budgets

Inflow from Drainage Areas

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Phosphorus Concentration [ug/L]	Loading Calibration Factor (CF)[1] [--]	Load [lb/yr]
1	Watershed	306.34	3.2	81.1	281.6	0.80	49.7
2						1.0	
3						1.0	
4						1.0	
5						1.0	
	Summation	*306*	*3.2*	*81.1*	*281.6*		49.7

Failing Septic Systems

	Name	Area [ac]	# of Systems	Failure [%]	Load / System	[lb/ac]	[lb/yr]
1	Watershed	306.34	0	5%	7.8	0.0	0.0
2							
3							
4							
5							
	Summation	*306.34*	*0*	*5%*		*0.0*	*0.0*

Inflow from Upstream Lakes

	Name	Discharge [ac-ft/yr]	Estimated P Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
1			-	1.0	
2			-	1.0	
3			-	1.0	
	Summation	*0*	-		*0*

Atmosphere

Lake Area [acre]	Precipitation [in/yr]	Evaporation [in/yr]	Net Inflow [ac-ft/yr]	Aerial Loading Rate [lb/ac-yr]	Calibration Factor [--]	Load [lb/yr]
21.6	32.0	32.0	0.00	0.24	1.0	5.2

Dry-year total P deposition = 0.230
Average-year total P deposition = 0.240
Wet-year total P deposition = 0.268
(Barr Engineering 2007)

Groundwater

Lake Area [acre]	Groundwater Flux [m/yr]	Net Inflow cfs	Net Inflow [ac-ft/yr]	Phosphorus Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
21.6		0.0	0	0	1.0	0

Internal

Lake Area [acre]	Anoxic Factor [days]	Calc Anoxia	Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
21.6	47.1		0.00	1.0	0

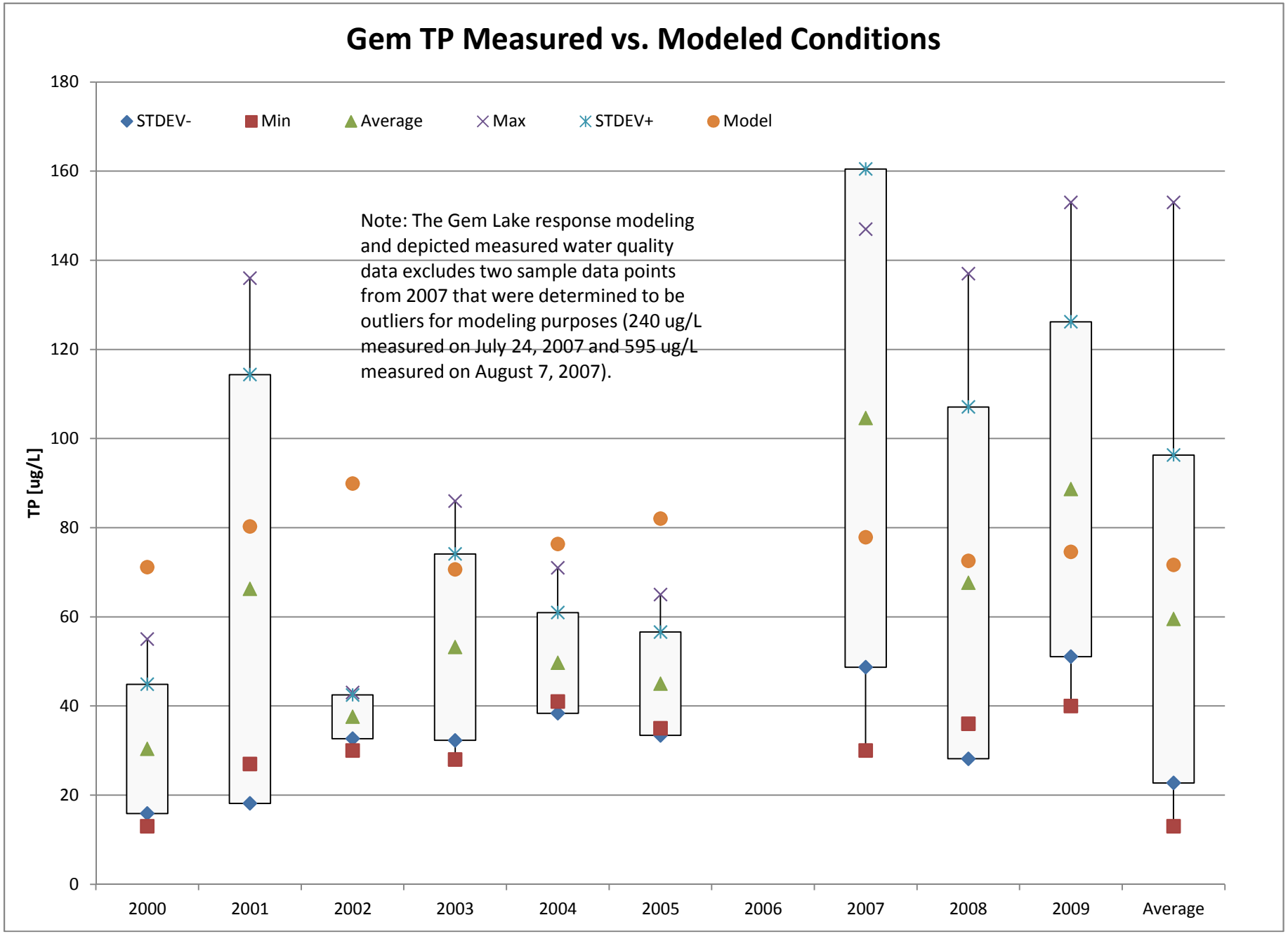
Net Discharge [ac-ft/yr] = 81 **Net Load [lb/yr] = 54.9**

NOTES

[1] Loading calibration factor used to account for special circumstances such as wetland systems, fertilizer use, or animal waste, among others, that might apply to specific loading sources.

Lake Response Modeling for Gem Lake TMDL

Modeled Parameter	Equation	Parameters	Value	[Units]
TOTAL IN-LAKE PHOSPHORUS CONCENTRATION				
		as f(W,Q,V) from Canfield & Bachmann (1981)		
		C_P =	1.00	[--]
		C_{CB} =	0.162	[--]
	$P = \frac{P_i}{\left(1 + C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times T\right)}$	b =	0.458	[--]
		W (total P load = inflow + atm.) =	55	[lb/yr]
		Q (lake outflow) =	81	[ac-ft/yr]
		V (modeled lake volume) =	183	[ac-ft]
		T = V/Q =	2.26	[yr]
		P_i = W/Q =	249	[ug/l]
Model Predicted In-Lake [TP]			**59.9**	**[ug/l]**
PHOSPHORUS SEDIMENTATION RATE				
	$P_{sed} = C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times [TP] \times V$			
		P_{sed} (phosphorus sedimentation) =	**42**	**[lb/yr]**
PHOSPHORUS OUTFLOW LOAD				
		W-P_{sed} =	**13**	**[lb/yr]**


Gem TP Measured vs. Modeled Conditions
STDEV-
Min
Average
Max
STDEV+
Model
Note: The Gem Lake response modeling and depicted measured water quality data excludes two sample data points from 2007 that were determined to be outliers for modeling purposes (240 ug/L measured on July 24, 2007 and 595 ug/L measured on August 7, 2007).
TP [ug/L]
180
160
140
120
100
80
60
40
20
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Average

EAST GOOSE LAKE AVG YEAR — Calibration Years '07-'10

Water Budgets / Phosphorus Loading

Inflow from Drainage Areas

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Phosphorus Concentration [ug/L]	Loading Calibration Factor (CF)[1] [--]	Load [lb/yr]
1	Watershed	577.55	5.5	265.9	297.0	1.0	214.8
2						1.0	
3						1.0	
4						1.0	
5						1.0	
	Summation	*578*	*5.5*	*265.9*	*297.0*		214.8

Failing Septic Systems

	Name	Area [ac]	# of Systems	Failure [%]	Load / System	[lb/ac]	[lb/yr]
1	Watershed	577.55	0	5%	7.8	0.0	0.0
2							
3							
4							
5							
	Summation	*577.55*	*0*	*5%*		*0.0*	*0.0*

Inflow from Upstream Lakes

	Name	Discharge [ac-ft/yr]	Estimated P Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
1			-	1.0	
2			-	1.0	
3			-	1.0	
	Summation	*0*	-		*0*

Atmosphere

Lake Area [acre]	Precipitation [in/yr]	Evaporation [in/yr]	Net Inflow [ac-ft/yr]	Aerial Loading Rate [lb/ac-yr]	Calibration Factor [--]	Load [lb/yr]
116.3	27.2	27.2	0.00	0.24	1.0	27.9

Dry-year total P deposition = 0.230
Average-year total P deposition = 0.240
Wet-year total P deposition = 0.268
(Barr Engineering 2007)

Groundwater

Lake Area [acre]	Groundwater Flux [m/yr]	Net Inflow cfs	Net Inflow [ac-ft/yr]	Phosphorus Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
116.0		0.006	4.4	69.0	1.0	0.8

Internal

Lake Area [acre]	Anoxic Factor [days]	Calc Anoxia	Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
116.0	71.4		24.00	1.0	1,777.2

Net Discharge [ac-ft/yr] = 270.3 **Net Load [lb/yr] = 2020.7**

NOTES

[1] Loading calibration factor used to account for special circumstances such as wetland systems, fertilizer use, or animal waste, among others, that might apply to specific loading sources.

Lake Response Modeling for East Goose Avg Year

Modeled Parameter	Equation	Parameters	Value	[Units]
TOTAL IN-LAKE PHOSPHORUS CONCENTRATION				
		as f(W,Q,V) from Canfield & Bachmann (1981)		
	$P = \frac{P_i}{\left(1 + C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times T\right)}$	C_P =	1.00	[--]
		C_{CB} =	0.162	[--]
		b =	0.458	[--]
		W (total P load = inflow + atm.) =	2,021	[lb/yr]
		Q (lake outflow) =	270	[ac-ft/yr]
		V (modeled lake volume) =	635	[ac-ft]
		T = V/Q =	2.35	[yr]
		P_i = W/Q =	2749	[ug/l]
Model Predicted In-Lake [TP]			**258**	**[ug/l]**
Observed In-Lake [TP]			**261.1**	**[ug/l]**
PHOSPHORUS SEDIMENTATION RATE				
	$P_{sed} = C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times [TP] \times V$			
		P_{sed} (phosphorus sedimentation) =	**1,831.4**	**[lb/yr]**
PHOSPHORUS OUTFLOW LOAD				
		W-P_{sed} =	**189.3**	**[lb/yr]**

Load Reduction Table for East Goose

LOAD		MODELED IN-LAKE WATER QUALITY PARAMETERS			TROPHIC STATE INDICES (Carlson, 1980) FOR MODELED	
REDUC-TION [%]	NET LOAD [lb]	[TP] [ug/L]	P SEDIMEN-TATION [lb]	TP OUT-FLOW [lb]	TSI [TP] [--]	TSI Avg. [--]
0%	**2,021**	258	1831	**189**	84.2	**75.1**
5%	**1,920**	250	1736	**184**	83.8	**75.0**
10%	**1,819**	242	1641	**178**	83.3	**74.8**
15%	**1,718**	234	1545	**172**	82.8	**74.6**
20%	**1,617**	226	1450	**166**	82.3	**74.4**
25%	**1,516**	217	1356	**160**	81.8	**74.2**
30%	**1,414**	209	1261	**153**	81.2	**73.9**
35%	**1,313**	200	1167	**147**	80.5	**73.6**
40%	**1,212**	191	1072	**140**	79.9	**73.3**
45%	**1,111**	181	978	**133**	79.1	**73.0**
50%	**1,010**	171	885	**126**	78.3	**72.7**
55%	**909**	160	791	**118**	77.4	**72.3**
60%	**808**	149	698	**110**	76.3	**71.8**
65%	**707**	138	606	**101**	75.2	**71.3**
70%	**606**	125	514	**92**	73.8	**70.6**
75%	**505**	112	423	**82**	72.2	**69.8**
80%	**404**	98	332	**72**	70.2	**68.8**
85%	**303**	82	243	**60**	67.6	**67.5**
90%	**202**	63	156	**46**	63.9	**65.5**
95%	**101**	40	72	**29**	57.3	**61.7**

EAST GOOSE LAKE TMDL

Water Budgets

Inflow from Drainage Areas

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Phosphorus Concentration [ug/L]	Loading Calibration Factor (CF)[1] [--]	Load [lb/yr]
1	Watershed	577.55	5.5	265.9	297.0	0.41	88.1
2						1.0	
3						1.0	
4						1.0	
5						1.0	
	Summation	*577.55*	*5.5*	*265.9*	*297.0*		*88.1*

Failing Septic Systems

	Name	Area [ac]	# of Systems	Failure [%]	Load / System	[lb/ac]	[lb/yr]
1	Watershed	577.55	0	5%	7.8	0.0	0.0
2							
3							
4							
5							
	Summation	*577.55*	*0*	*5%*		*0.0*	*0.0*

Inflow from Upstream Lakes

	Name	Discharge [ac-ft/yr]	Estimated P Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
1			-	1.0	
2			-	1.0	
3			-	1.0	
	Summation	*0*	-		*0*

Atmosphere

Lake Area [acre]	Precipitation [in/yr]	Evaporation [in/yr]	Net Inflow [ac-ft/yr]	Aerial Loading Rate [lb/ac-yr]	Calibration Factor [--]	Load [lb/yr]
116.3	27.2	27.2	0.00	0.24	1.0	27.9

Dry-year total P deposition =	0.230
Average-year total P deposition =	0.240
Wet-year total P deposition =	0.268
(Barr Engineering 2007)	

Groundwater

Lake Area [acre]	Groundwater Flux [m/yr]	Net Inflow cfs	Net Inflow [ac-ft/yr]	Phosphorus Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
116.0		0.006	4.4	69.0	1.0	0.8

Internal

Lake Area [acre]	Anoxic Factor [days]	Calc Anoxia	Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
116.0	71.4		24.00	0.04	71.1

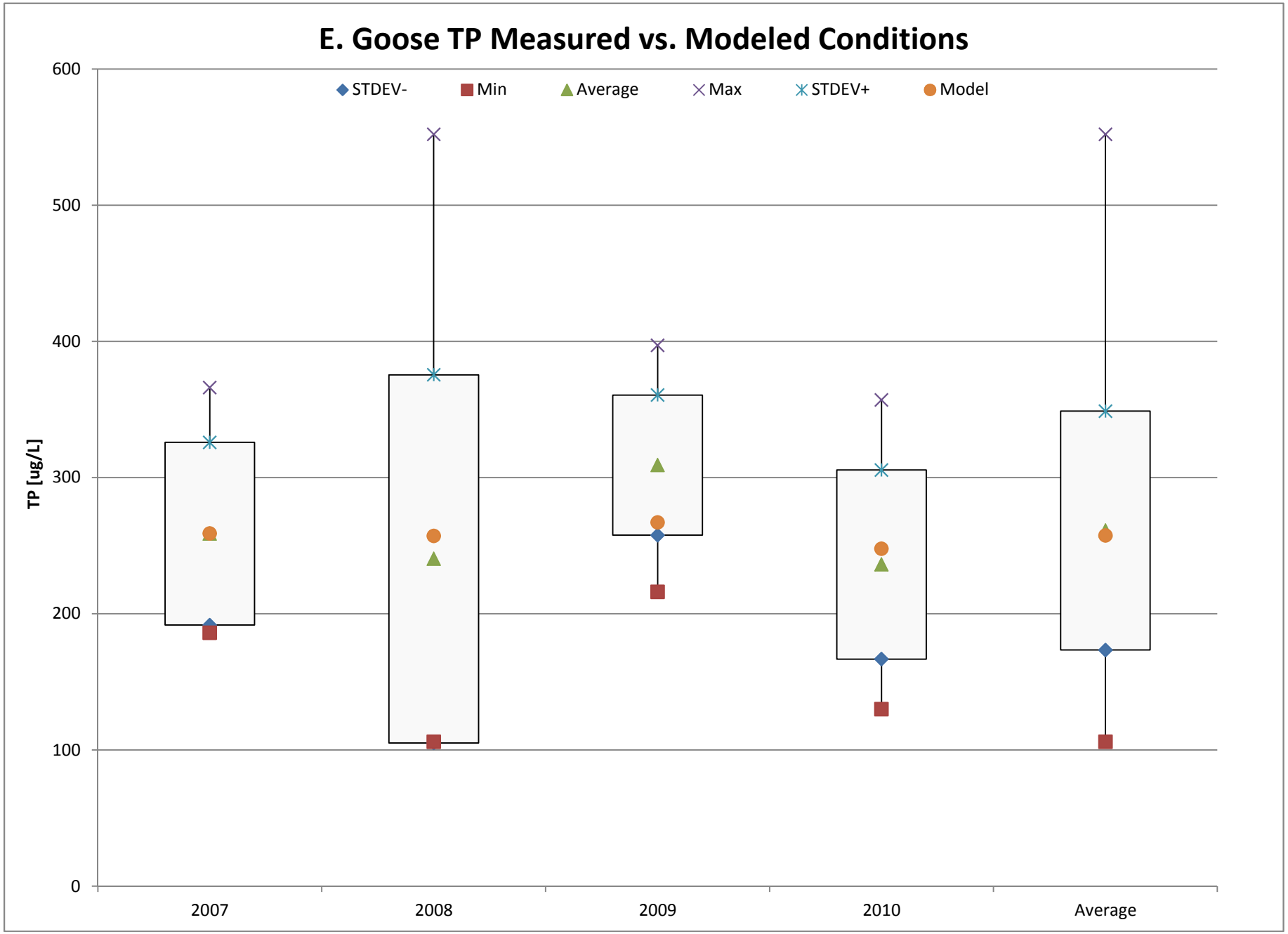
Net Discharge [ac-ft/yr] =	**270.3**	**Net Load [lb/yr] =**	**187.9**

NOTES

[1] Loading calibration factor used to account for special circumstances such as wetland systems, fertilizer use, or animal waste, among others, that might apply to specific loading sources.

TMDL Lake Response Modeling for East Goose TMDL

Modeled Parameter	Equation	Parameters	Value	[Units]
TOTAL IN-LAKE PHOSPHORUS CONCENTRATION				
		as f(W,Q,V) from Canfield & Bachmann (1981)		
	$P = \frac{P_i}{\left(1 + C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times T\right)}$	C_P =	1.00	[--]
		C_{CB} =	0.162	[--]
		b =	0.458	[--]
		W (total P load = inflow + atm.) =	188	[lb/yr]
		Q (lake outflow) =	270	[ac-ft/yr]
		V (modeled lake volume) =	635	[ac-ft]
		T = V/Q =	2.35	[yr]
		P_i = W/Q =	256	[ug/l]
Model Predicted In-Lake [TP]			**60.0**	**[ug/l]**
PHOSPHORUS SEDIMENTATION RATE				
	$P_{sed} = C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times [TP] \times V$			
		P_{sed} (phosphorus sedimentation) =	**143.8**	**[lb/yr]**
PHOSPHORUS OUTFLOW LOAD				
		W-P_{sed} =	**44.1**	**[lb/yr]**


E. Goose TP Measured vs. Modeled Conditions
STDEV-
Min
Average
Max
STDEV+
Model
TP [ug/L]
600
500
400
300
200
100
0
2007
2008
2009
2010
Average

WEST GOOSE LAKE AVG YEAR — Calibration Years '07-'10

Water Budgets / Phosphorus Loading

Inflow from Drainage Areas

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Phosphorus Concentration [ug/L]	Loading Calibration Factor (CF)[1] [--]	Load [lb/yr]
1	Watershed	238.78	7.0	139.8	290.4	1.0	110.4
2			.			1.0	
3						1.0	
4						1.0	
5						1.0	
	Summation	*238.78*	*7*	*139.8*	*290.4*		110.4

Failing Septic Systems

	Name	Area [ac]	# of Systems	Failure [%]	Load / System	[lb/ac]	[lb/yr]
1	Watershed	238.78	0	5%	7.8	0.0	0.0
2							
3							
4							
5							
	Summation	*238.78*	*0*	*5%*		*0.0*	*0.0*

Inflow from Upstream Lakes

	Name	Area [ac]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Estimated P Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
1	East Goose	577.55	5.5	270.3	257.2	1.0	189.1
2						1.0	
3					-	1.0	
	Summation			*270*	*257.2*		*189.1*

Atmosphere

Lake Area [acre]	Precipitation [in/yr]	Evaporation [in/yr]	Net Inflow [ac-ft/yr]	Aerial Loading Rate [lb/ac-yr]	Calibration Factor [--]	Load [lb/yr]
24.1	27.2	27.2	0.00	0.24	1.0	5.8

Dry-year total P deposition = 0.230
Average-year total P deposition = 0.240
Wet-year total P deposition = 0.268
(Barr Engineering 2007)

M-Foods Dairy [2]

Lake Area [acre]	Groundwater Flux [m/yr]	Net Inflow cfs	Net Inflow [ac-ft/yr]	Phosphorus Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
24.1		0.8	604.9	10.0	1.0	16.5

Internal, Sediments

Lake Area [acre]	Anoxic Factor [days]	Calc Anoxia	Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
24.1	63.2		2.00	1.0	27.2

Internal Other

	Source	Lake Area [acre]	Duration [days]		Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
1	Sediment re-suspension (e.g. boating and wind)	24.1	60.0		31.00	1.0	399.9
2						1.0	0
			Net Discharge [ac-ft/yr] =	**1015.0**		**Net Load [lb/yr] =**	**748.8**

NOTES

[1] Loading calibration factor used to account for special circumstances such as wetland systems, fertilizer use, or animal waste, among others, that might apply to specific loading sources.

[2] Non-contact cooling water sourced from groundwater. Contribution calculated based on discharge sampling and the maximum permitted flow from the facility. There is no other groundwater interaction with the lake.

Lake Response Modeling for West Goose Avg Year

Modeled Parameter	Equation	Parameters	Value	[Units]
TOTAL IN-LAKE PHOSPHORUS CONCENTRATION				
		as f(W,Q,V) from Canfield & Bachmann (1981)		
		C_P =	1.00	[--]
		C_{CB} =	0.162	[--]
	$P = \frac{P_i}{\left(1 + C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times T\right)}$	b =	0.458	[--]
		W (total P load = inflow + atm.) =	749	[lb/yr]
		Q (lake outflow) =	1,015	[ac-ft/yr]
		V (modeled lake volume) =	105	[ac-ft]
		T = V/Q =	0.10	[yr]
		P_i = W/Q =	271	[ug/l]
Model Predicted In-Lake [TP]			**167.7**	**[ug/l]**
Observed In-Lake [TP]			**167.0**	**[ug/l]**
PHOSPHORUS SEDIMENTATION RATE				
	$P_{sed} = C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times [TP] \times V$			
		P_{sed} (phosphorus sedimentation) =	**285.9**	**[lb/yr]**
PHOSPHORUS OUTFLOW LOAD				
		W-P_{sed} =	**462.9**	**[lb/yr]**

Load Reduction Table for West Goose

LOAD		MODELED IN-LAKE WATER QUALITY PARAMETERS			TROPHIC STATE INDICES (Carlson, 1980) FOR MODELED PARAMETERS	
REDUC-TION [%]	NET LOAD [lb]	[TP] [ug/L]	P SEDIMEN-TATION [lb]	TP OUT-FLOW [lb]	TSI [TP] [--]	TSI Avg. [--]
0%	**749**	168	286	**463**	78.0	**73.5**
5%	**711**	161	268	**444**	77.4	**73.3**
10%	**674**	154	250	**424**	76.8	**73.0**
15%	**637**	147	232	**405**	76.1	**72.7**
20%	**599**	139	214	**385**	75.3	**72.4**
25%	**562**	132	197	**364**	74.6	**72.0**
30%	**524**	125	180	**344**	73.7	**71.6**
35%	**487**	117	164	**323**	72.8	**71.2**
40%	**449**	109	148	**302**	71.8	**70.7**
45%	**412**	102	132	**280**	70.8	**70.2**
50%	**374**	94	116	**258**	69.6	**69.6**
55%	**337**	85	101	**236**	68.3	**69.0**
60%	**300**	77	86	**213**	66.8	**68.2**
65%	**262**	69	72	**190**	65.1	**67.3**
70%	**225**	60	59	**166**	63.2	**66.3**
75%	**187**	51	46	**141**	60.9	**65.0**
80%	**150**	42	34	**116**	58.0	**63.4**
85%	**112**	32	23	**89**	54.3	**61.2**
90%	**75**	22	13	**62**	48.9	**58.0**
95%	**37**	12	5	**32**	39.7	**52.3**

WEST GOOSE LAKE TMDL

Water Budgets — Phosphorus Loading

Inflow from Drainage Areas

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Phosphorus Concentration [ug/L]	Loading Calibration Factor (CF)[1] [--]	Load [lb/yr]
1	Watershed	238.78	7.0	139.8	290.4	**0.24**	26.5
2			.			1.0	
3						1.0	
4						1.0	
5						1.0	
	Summation	*238.78*	*7.0*	*139.8*	*290.4*		26.5

Failing Septic Systems

	Name	Area [ac]	# of Systems	Failure [%]	Load / System	[lb/ac]	[lb/yr]
1	Watershed	238.78	0	5%	7.8	0.0	0.0
2							
3							
4							
5							
	Summation	*238.78*	*0*	*5%*		*0.0*	*0.0*

Inflow from Upstream Lakes

	Name	Area [ac]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Estimated P Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
1	East Goose	577.55	5.5	270.3	60.0	1.0	44.1
2						1.0	
3					-	1.0	
	Summation			*270.3*	*60.0*		*44.1*

Atmosphere

Lake Area [acre]	Precipitation [in/yr]	Evaporation [in/yr]	Net Inflow [ac-ft/yr]	Aerial Loading Rate [lb/ac-yr]	Calibration Factor [--]	Load [lb/yr]
24.1	27.2	27.2	0.00	0.24	1.0	5.8

Dry-year total P deposition = 0.230
Average-year total P deposition = 0.240
Wet-year total P deposition = 0.268
(Barr Engineering 2007)

M-Foods Dairy [2]

Lake Area [acre]	Groundwater Flux [m/yr]	Net Inflow cfs	Net Inflow [ac-ft/yr]	Phosphorus Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
24.1		0.8	604.9	15.0	**1.0**	24.7

Internal, Sediments

Lake Area [acre]	Anoxic Factor [days]	Calc Anoxia	Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
24.1	63.2		2.00	1.0	27.2

Internal Other

	Source	Lake Area [acre]	Duration [days]		Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
1	Sediment re-suspension (e.g. boating and wind)	24.1	60.0		31.00	0.24	96.0
2						1.0	0
		Net Discharge [ac-ft/yr] =		**1015.0**	**Net Load [lb/yr] =**		**224.2**

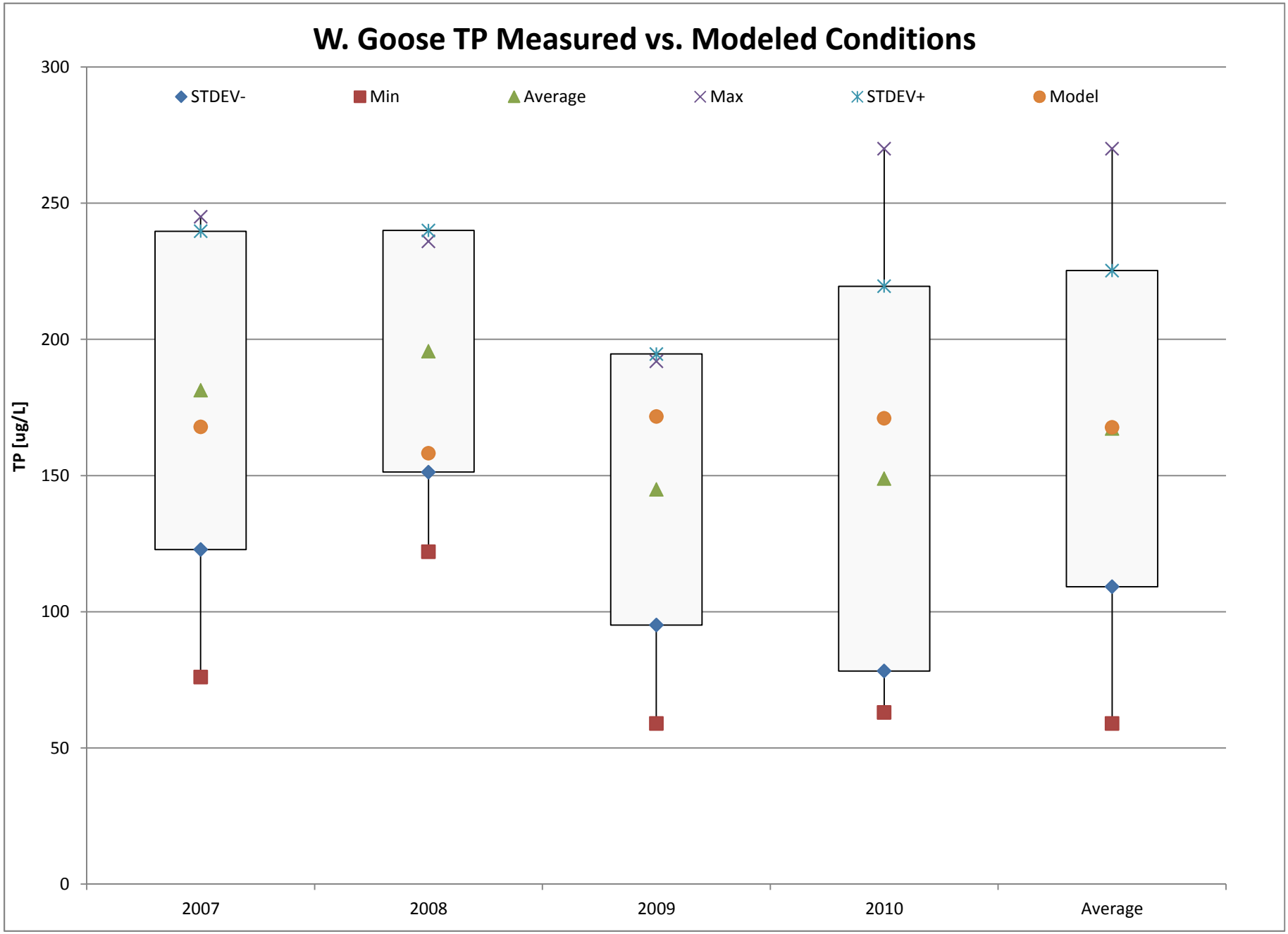
NOTES

[1] Loading calibration factor used to account for special circumstances such as wetland systems, fertilizer use, or animal waste, among others, that might apply to specific loading sources.

[2] Non-contact cooling water sourced from groundwater. Contribution calculated based on discharge sampling and the maximum permitted flow from the facility. There is no other groundwater interaction with the lake.

TMDL Lake Response Modeling for West Goose TMDL

Modeled Parameter	Equation	Parameters	Value	[Units]
TOTAL IN-LAKE PHOSPHORUS CONCENTRATION				
	$P = \frac{P_i}{\left(1 + C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times T\right)}$	as f(W,Q,V) from Canfield & Bachmann (1981)		
		C_P =	1.00	[--]
		C_{CB} =	0.162	[--]
		b =	0.458	[--]
		W (total P load = inflow + atm.) =	224	[lb/yr]
		Q (lake outflow) =	1,015	[ac-ft/yr]
		V (modeled lake volume) =	105	[ac-ft]
		T = V/Q =	0.10	[yr]
		P_i = W/Q =	81	[ug/l]
Model Predicted In-Lake [TP]			**59.9**	**[ug/l]**
PHOSPHORUS SEDIMENTATION RATE				
	$P_{sed} = C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times [TP] \times V$			
		P_{sed} (phosphorus sedimentation) =	**58.8**	**[lb/yr]**
PHOSPHORUS OUTFLOW LOAD				
		W-P_{sed} =	**165.4**	**[lb/yr]**


W. Goose TP Measured vs. Modeled Conditions
STDEV-
Min
Average
Max
STDEV+
Model
TP [ug/L]
300
250
200
150
100
50
0
2007
2008
2009
2010
Average

WILKINSON LAKE AVG YEAR Calibration years '01-'05, '07-'09

Water Budgets

Inflow from Drainage Areas

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Phosphorus Concentration [ug/L]	Loading Calibration Factor (CF)[1] [--]	Load [lb/yr]
1	Direct Watershed	2,972.82	3.6	888.3	306.5	1.0	740.4
2						1.0	
3						1.0	
4						1.0	
5						1.0	
	Summation	*2,972.82*	*4*	*888.3*	*306.5*		*740.4*

Failing Septic Systems

	Name	Area [ac]	# of Systems	Failure [%]	Load / System	[lb/ac]	[lb/yr]
1	Direct Watershed	2,972.82	0	5%	7.8	0.0	0.0
2							
3							
4							
5							
	Summation	*2,972.82*	*0*	*5%*		*0.0*	*0.0*

Inflow from Upstream Lakes

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Estimated P Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
1	Birch Lake	517.89	9	387.7	32.5	1.0	34.3
2	Gilfillan	531.35	0	0	148.0	1.0	0
3	Amelia	533.47	3	147.6	38.8	1.0	15.6
	Summation			*535*	*73.1*		*49.8*

Atmosphere

Lake Area [acre]	Precipitation [in/yr]	Evaporation [in/yr]	Net Inflow [ac-ft/yr]	Aerial Loading Rate [lb/ac-yr]	Calibration Factor [--]	Load [lb/yr]
97.1	31.8	31.8	0.00	0.24	1.0	23.3

Dry-year total P deposition = 0.230
Average-year total P deposition = 0.240
Wet-year total P deposition = 0.268
(Barr Engineering 2007)

Groundwater

Lake Area [acre]	Groundwater Flux [m/yr]	Net Inflow cfs	Net Inflow [ac-ft/yr]	Phosphorus Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
97.1		0.01	7.5	69.0	1.0	1.4

Internal

Lake Area [acre]	Anoxic Factor [days]	Calc Anoxia	Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
97.1	59.8		1.00	1.0	51.8

Net Discharge [ac-ft/yr] = 1431.0 **Net Load [lb/yr] = 866.8**

NOTES

[1] Loading calibration factor used to account for special circumstances such as wetland systems, fertilizer use, or animal waste, among others, that might apply to specific loading sources.

Lake Respons Modeling for Wilkinson Calibration Years '01-'05, '07-'09

Modeled Parameter	Equation	Parameters	Value	[Units]
TOTAL IN-LAKE PHOSPHORUS CONCENTRATION				
	$P = \frac{P_i}{\left(1 + C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times T\right)}$	as f(W,Q,V) from Canfield & Bachmann (1981)		
		C_P =	1.00	[--]
		C_{CB} =	0.162	[--]
		b =	0.458	[--]
		W (total P load = inflow + atm.) =	867	[lb/yr]
		Q (lake outflow) =	1,431	[ac-ft/yr]
		V (modeled lake volume) =	165	[ac-ft]
		T = V/Q =	0.12	[yr]
		P_i = W/Q =	223	[ug/l]
Model Predicted In-Lake [TP]			**139.4**	**[ug/l]**
Observed In-Lake [TP]			**148.8**	**[ug/l]**
PHOSPHORUS SEDIMENTATION RATE				
	$P_{sed} = C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times [TP] \times V$			
		P_{sed} (phosphorus sedimentation) =	**324.2**	**[lb/yr]**
PHOSPHORUS OUTFLOW LOAD				
		W-P_{sed} =	**542.5**	**[lb/yr]**

Load Reduction Table for Wilkinson

LOAD		MODELED IN-LAKE WATER QUALITY PARAMETERS			TROPHIC STATE INDICES (Carlson, 1980) FOR MODELED PARAMETERS	
REDUC-TION [%]	NET LOAD [lb]	[TP] [ug/L]	P SEDIMEN-TATION [lb]	TP OUT-FLOW [lb]	TSI [TP] [--]	TSI Avg. [--]
0%	**867**	139	324	**543**	75.3	**71.0**
5%	**823**	134	304	**520**	74.7	**70.7**
10%	**780**	128	283	**497**	74.1	**70.3**
15%	**737**	122	263	**474**	73.4	**70.0**
20%	**693**	116	243	**450**	72.7	**69.6**
25%	**650**	110	223	**427**	71.9	**69.1**
30%	**607**	103	204	**402**	71.0	**68.7**
35%	**563**	97	185	**378**	70.1	**68.1**
40%	**520**	91	167	**353**	69.2	**67.6**
45%	**477**	84	149	**328**	68.1	**66.9**
50%	**433**	78	131	**302**	66.9	**66.2**
55%	**390**	71	114	**276**	65.6	**65.4**
60%	**347**	64	98	**249**	64.1	**64.5**
65%	**303**	57	82	**222**	62.4	**63.4**
70%	**260**	50	67	**193**	60.5	**62.1**
75%	**217**	42	52	**165**	58.1	**60.6**
80%	**173**	35	39	**135**	55.3	**58.6**
85%	**130**	27	26	**104**	51.5	**56.1**
90%	**87**	18	15	**72**	46.2	**52.6**
95%	**43**	10	6	**38**	36.9	**46.5**

WILKINSON LAKE TMDL

Water Budgets

Inflow from Drainage Areas

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Phosphorus Concentration [ug/L]	Loading Calibration Factor (CF)[1] [--]	Load [lb/yr]
1	Direct Watershed	2,972.82	3.6	888.3	306.5	**0.264**	195.5
2						1.0	
3						1.0	
4						1.0	
5						1.0	
	Summation	*2,972.82*	*4*	*888.3*	*306.5*		195.5

Failing Septic Systems

	Name	Area [ac]	# of Systems	Failure [%]	Load / System	[lb/ac]	[lb/yr]
1	Direct Watershed	2,972.82	0	5%	7.8	0.0	0.0
2							
3							
4							
5							
	Summation	*2,972.82*	*0*	*5%*		*0.0*	*0.0*

Inflow from Upstream Lakes

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Estimated P Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
1	Birch Lake	517.89	9.0	387.7	32.5	**1.0**	34.3
2	Gilfillan	531.35	0.0	0	**60.0**	1.0	0
3	Amelia	533.47	3.3	147.6	38.8	**1.0**	15.6
	Summation			*535*	*43.8*		*49.8*

Atmosphere

Lake Area [acre]	Precipitation [in/yr]	Evaporation [in/yr]	Net Inflow [ac-ft/yr]	Aerial Loading Rate [lb/ac-yr]	Calibration Factor [--]	Load [lb/yr]
97.1	31.8	31.8	0.00	0.24	1.0	23.3

Dry-year total P deposition = 0.230
Average-year total P deposition = 0.240
Wet-year total P deposition = 0.268
(Barr Engineering 2007)

Groundwater

Lake Area [acre]	Groundwater Flux [m/yr]	Net Inflow cfs	Net Inflow [ac-ft/yr]	Phosphorus Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
97.1		0.01	7.5	69.0	1.0	1.4

Internal

Lake Area [acre]	Anoxic Factor [days]	Calc Anoxia	Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
97.1	59.8		1.00	1.0	51.8

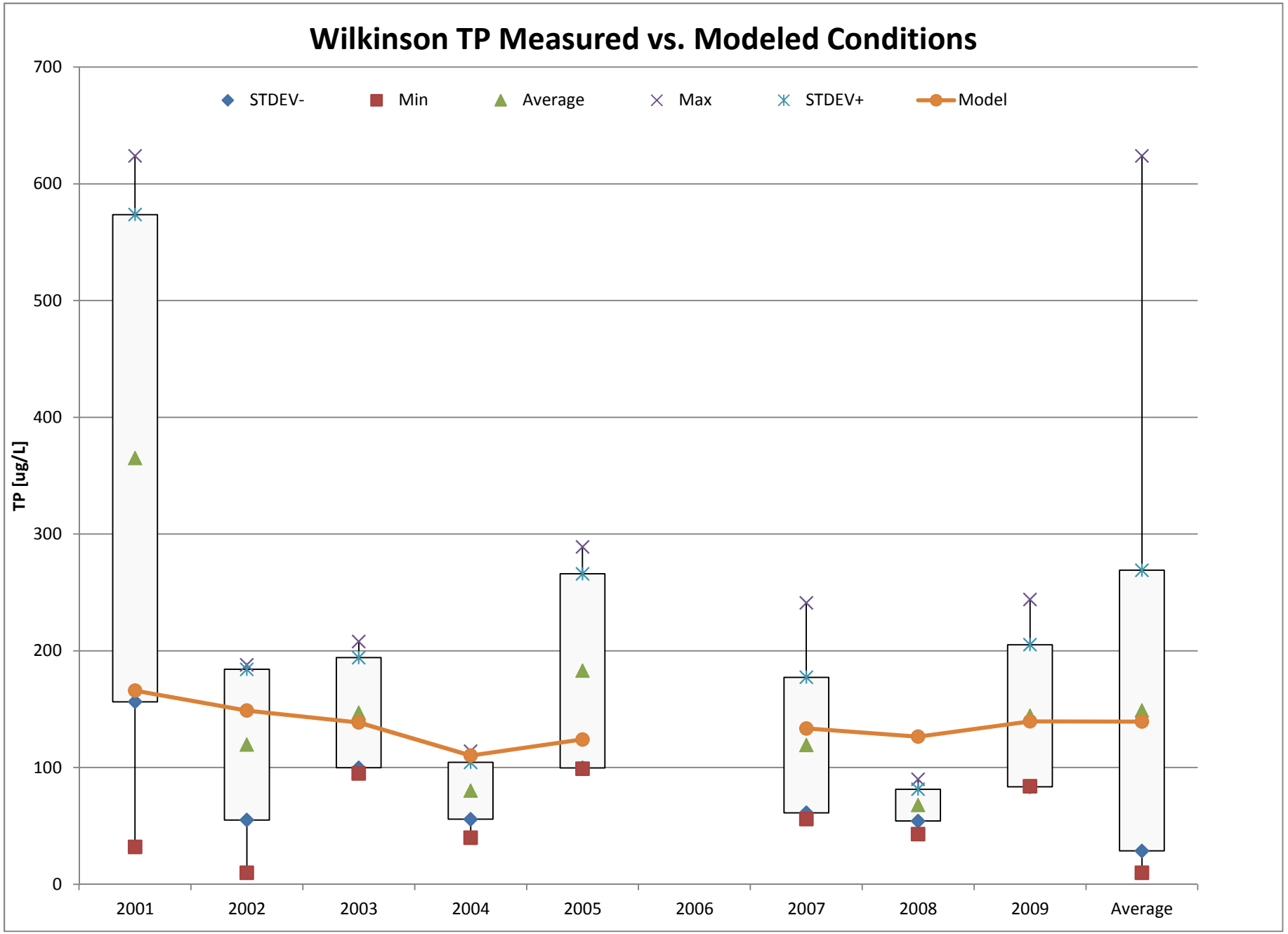
Net Discharge [ac-ft/yr] = 1431.0 **Net Load [lb/yr] = 321.8**

NOTES

[1] Loading calibration factor used to account for special circumstances such as wetland systems, fertilizer use, or animal waste, among others, that might apply to specific loading sources.

Lake Response Modeling for Wilkinson Lake TMDL

Modeled Parameter	Equation	Parameters	Value	[Units]
TOTAL IN-LAKE PHOSPHORUS CONCENTRATION				
	$P = \frac{P_i}{\left(1 + C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times T\right)}$	as f(W,Q,V) from Canfield & Bachmann (1981)		
		C_P =	1.00	[--]
		C_{CB} =	0.162	[--]
		b =	0.458	[--]
		W (total P load = inflow + atm.) =	322	[lb/yr]
		Q (lake outflow) =	1,431	[ac-ft/yr]
		V (modeled lake volume) =	165	[ac-ft]
		T = V/Q =	0.12	[yr]
		P_i = W/Q =	83	[ug/l]
Model Predicted In-Lake [TP]			**59.9**	**[ug/l]**
PHOSPHORUS SEDIMENTATION RATE				
	$P_{sed} = C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times [TP] \times V$			
		P_{sed} (phosphorus sedimentation) =	**88.6**	**[lb/yr]**
PHOSPHORUS OUTFLOW LOAD				
	W-P_{sed} =		**233.3**	**[lb/yr]**


Wilkinson TP Measured vs. Modeled Conditions
STDEV-
Min
Average
Max
STDEV+
Model
TP [ug/L]
700
600
500
400
300
200
100
0
2001
2002
2003
2004
2005
2006
2007
2008
2009
Average

Gilfillan Lake Avg Year — Calibration Years '06-'10

Water Budgets / Phosphorus Loading

Inflow from Drainage Areas

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Phosphorus Concentration [ug/L]	Loading Calibration Factor (CF)[1] [--]	Load [lb/yr]
1	Watershed	531.35	1.15	51	122.5	1.0	17.0
2						1.0	
3						1.0	
4						1.0	
5						1.0	
	Summation	*531.35*	*1*	*51*	*122.5*		*17.0*

Failing Septic Systems

	Name	Area [ac]	# of Systems	Failure [%]	Load / System	[lb/ac]	[lb/yr]
1	Watershed	531.35	39	8%	7.8	0.0	24.3
2							
3							
4							
5							
	Summation	*531.35*	*39*	*8%*		*0.0*	*24.3*

Inflow from Upstream Lakes

	Name	Discharge [ac-ft/yr]	Estimated P Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
1			-	1.0	
2			-	1.0	
3			-	1.0	
	Summation	*0*	-		*0*

Atmosphere

Lake Area [acre]	Precipitation [in/yr]	Evaporation [in/yr]	Net Inflow [ac-ft/yr]	Aerial Loading Rate [lb/ac-yr]	Calibration Factor [--]	Load [lb/yr]
99.2	27.9	25.5	19.8	0.24	1.0	23.8

Dry-year total P deposition =	0.230
Average-year total P deposition =	0.240
Wet-year total P deposition =	0.268
(Barr Engineering 2007)	

Groundwater

Lake Area [acre]	Groundwater Flux [m/yr]	Net Inflow cfs	Net Inflow [ac-ft/yr]	Phosphorus Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
99.2		0.0	0.0	0	1.0	0

Internal

Lake Area [acre]	Anoxic Factor [days]	Calc Anoxia	Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
99.2	58.8		7.00	1.0	364.2
		Net Inflow [ac-ft/yr] =	**70.9**	**Net Load [lb/yr] =**	**429.4**

NOTES

[1] Loading calibration factor used to account for special circumstances such as wetland systems, fertilizer use, or animal waste, among others, that might apply to specific loading sources.

Lake Response Modeling for Gilfillan Lake Avg Year

Modeled Parameter	Equation	Parameters	Value	[Units]
TOTAL IN-LAKE PHOSPHORUS CONCENTRATION				
	$P = \frac{P_i}{\left(1 + C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times T\right)}$	as f(W,Q,V) from Canfield & Bachmann (1981)		
		C_P =	1.00	[--]
		C_{CB} =	0.162	[--]
		b =	0.458	[--]
		W (total P load = inflow + atm.) =	429	[lb/yr]
		Q (lake outflow; for Gilfillan Lake, outflow is to groundwater)* =	125	[ac-ft/yr]
		V (modeled lake volume) =	359.10	[ac-ft]
		T = V/Q =	2.86	[yr]
		P_i = W/Q =	1259	[ug/l]
Model Predicted In-Lake [TP]			**147.6**	**[ug/l]**
Observed In-Lake [TP]			**138.3**	**[ug/l]**
PHOSPHORUS SEDIMENTATION RATE				
	$P_{sed} = C_P \times C_{CB} \times \left(\frac{W_P}{V}\right)^b \times [TP] \times V$			
		P_{sed} (phosphorus sedimentation) =	**379.1**	**[lb/yr]**
PHOSPHORUS OUTFLOW LOAD				
		W-P_{sed} =	**50.3**	**[lb/yr]**

* Outflow is to groundwater. Augmentation was not occurring during the calibration period and is not reflected in the existing conditions modeled inflows or lake volume. For Gilfillan Lake existing conditions, inflow ≠ outflow.

Load Reduction Table for Gilfillan

LOAD		MODELED IN-LAKE WATER QUALITY PARAMETERS			TROPHIC STATE INDICES (Carlson, 1980) FOR MODELED PARAMETERS	
REDUC-TION [%]	NET LOAD [lb]	[TP] [ug/L]	P SEDIMEN-TATION [lb]	TP OUT-FLOW [lb]	TSI [TP] [--]	TSI Avg. [--]
0%	**429**	148	379	**50**	76.2	**72.2**
5%	**408**	143	359	**49**	75.7	**71.9**
10%	**386**	139	339	**47**	75.3	**71.7**
15%	**365**	134	319	**46**	74.8	**71.4**
20%	**344**	129	300	**44**	74.2	**71.1**
25%	**322**	124	280	**42**	73.7	**70.7**
30%	**301**	119	260	**41**	73.1	**70.4**
35%	**279**	114	240	**39**	72.4	**70.0**
40%	**258**	109	221	**37**	71.7	**69.6**
45%	**236**	103	201	**35**	71.0	**69.1**
50%	**215**	97	182	**33**	70.1	**68.6**
55%	**193**	91	162	**31**	69.2	**68.0**
60%	**172**	85	143	**29**	68.2	**67.3**
65%	**150**	78	124	**27**	67.0	**66.6**
70%	**129**	71	105	**24**	65.6	**65.7**
75%	**107**	63	86	**22**	63.9	**64.6**
80%	**86**	55	67	**19**	61.9	**63.2**
85%	**64**	45	49	**15**	59.2	**61.4**
90%	**43**	35	31	**12**	55.3	**58.8**
95%	**21**	22	14	**7**	48.5	**54.2**

Note: The relationship shown on this table reflects pre-augmentation conditions. To develop the load reduction to set the TMDL, the augmentation condition was added to the existing conditions model and the load reductions were taken from that condition. Therefore, the existing conditions table included here does not directly show the relationship between load reduction and in lake concentration. However, this relationship can be seen by reversing the reductions in the TMDL model.

Gilfillan Lake TMDL

Water Budgets

Phosphorus Loading

Inflow from Drainage Areas

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Phosphorus Concentration [ug/L]	Loading Calibration Factor (CF)[1] [--]	Load [lb/yr]
1	Watershed	531.35	1.2	51.1	122.5	1.0	17.0
2						1.0	
3						1.0	
4						1.0	
5						1.0	
	Summation	*531.35*	*1*	*51.1*	*122.5*		*17.0*

Failing Septic Systems

	Name	Area [ac]	# of Systems	Failure [%]	Load / System	[lb/ac]	[lb/yr]
1	Watershed	531.35	39	0%	7.8	0.0	0.0
2							
3							
4							
5							
	Summation	*531.35*	*39*	*0%*		*0.0*	*0.0*

Inflow from Upstream Lakes

	Name	Drainage Area [acre]	Runoff Depth [in/yr]	Discharge [ac-ft/yr]	Estimated P Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
1	Pleasant	99.20	6.6	54.5	54.0	1.0	8.0
2					-	1.0	
3					-	1.0	
	Summation			*54.5*	*54.0*		*8.0*

Atmosphere

Lake Area [acre]	Precipitation [in/yr]	Evaporation [in/yr]	Net Inflow [ac-ft/yr]	Aerial Loading Rate [lb/ac-yr]	Calibration Factor [--]	Load [lb/yr]
99.2	27.9	25.5	19.84	0.24	1.0	23.8

Dry-year total P deposition = 0.230
Average-year total P deposition = 0.240
Wet-year total P deposition = 0.268
(Barr Engineering 2007)

Groundwater

Lake Area [acre]	Groundwater Flux [m/yr]	Net Inflow cfs	Net Inflow [ac-ft/yr]	Phosphorus Concentration [ug/L]	Calibration Factor [--]	Load [lb/yr]
99.2		0.0	0	0	1.0	0

Internal

Lake Area [acre]	Anoxic Factor [days]	Calc Anoxia	Release Rate [mg/m^2-day]	Calibration Factor [--]	Load [lb/yr]
99.2	58.8		7.00	0.318	115.8

Net Inflow [ac-ft/yr] = 125.4 **Net Load [lb/yr] = 164.7**

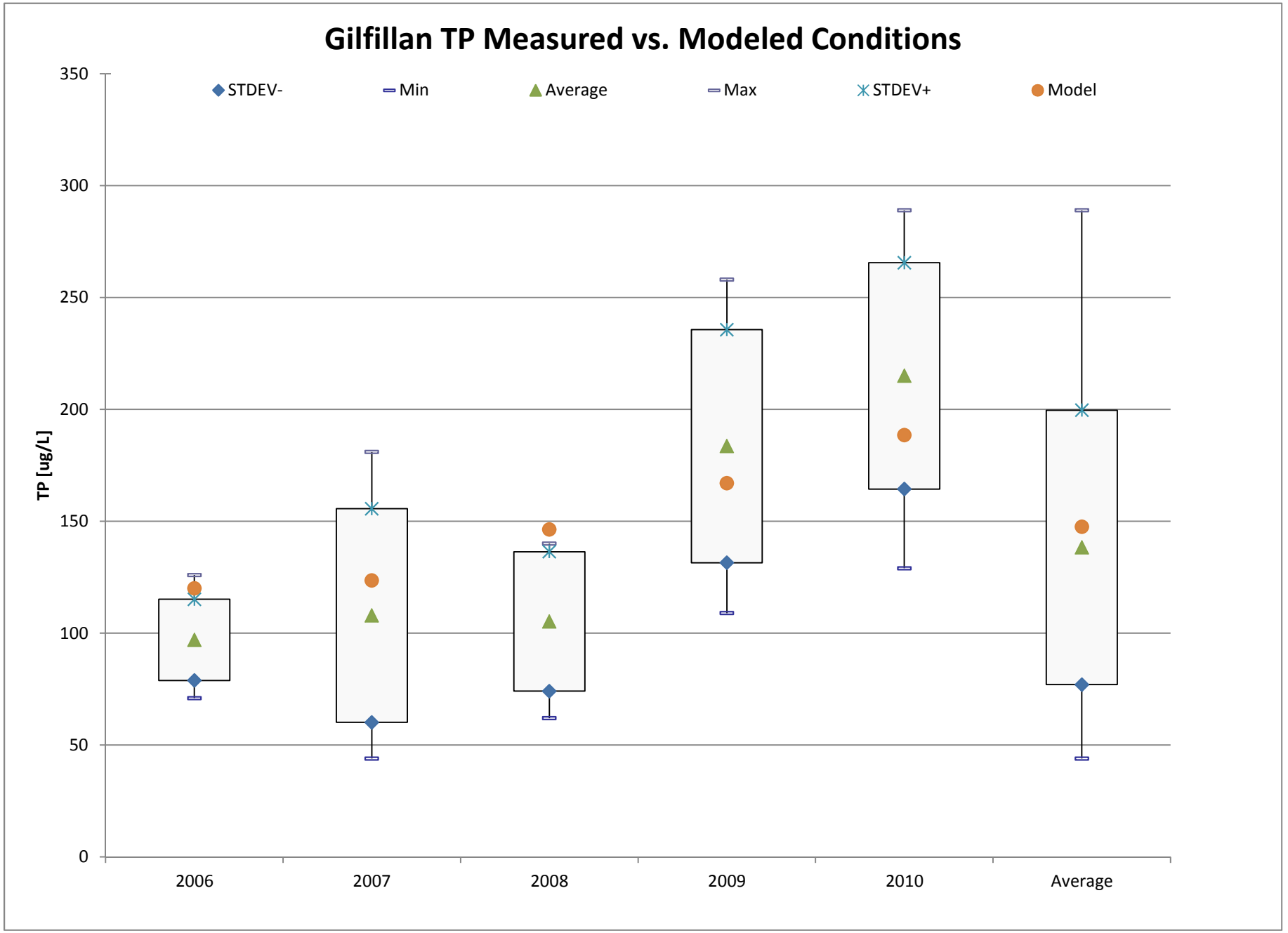
NOTES

[1] Loading calibration factor used to account for special circumstances such as wetland systems, fertilizer use, or animal waste, among others, that might apply to specific loading sources.

Lake Response Modeling for Gilfillan Lake TMDL

Modeled Parameter	Equation	Parameters	Value	[Units]
TOTAL IN-LAKE PHOSPHORUS CONCENTRATION				
		as f(W,Q,V) from Canfield & Bachmann (1981)		
		C_P =	1.00	[--]
		C_{CB} =	0.162	[--]
		b =	0.458	[--]
		W (total P load = inflow + atm.) =	165	[lb/yr]
		Q (lake outflow; for Gilfillan Lake, outflow is to groundwater)* =	125	[ac-ft/yr]
		V (modeled lake volume) =	714	[ac-ft]
		T = V/Q =	5.69	[yr]
		P_i = W/Q =	483	[ug/l]
Model Predicted In-Lake [TP]			**60.0**	**[ug/l]**
PHOSPHORUS SEDIMENTATION RATE				
		P_{sed} (phosphorus sedimentation) =	**144.2**	**[lb/yr]**
PHOSPHORUS OUTFLOW LOAD				
	W-P_{sed} =		**20.5**	**[lb/yr]**

* Outflow is to groundwater. The TMDL condition model includes inflow from augmentation from Pleasant Lake. The lake volume reflects conditions under augmentation. For the TMDL model, inflow = outflow.


Gilfillan TP Measured vs. Modeled Conditions
STDEV-
Min
Average
Max
STDEV+
Model
TP [ug/L]
350
300
250
200
150
100
50
0
2006
2007
2008
2009
2010
Average

Appendix B

WLA Partitioning Summary Tables and Other Information Tables

Table B.1: Impaired Waters Sub-watershed Areas

Waterbody	Total Subwatershed Area (Includes Lake Surface Area) ID#		Lake Surface Area (acres)	Subwatershed Area (Excluding Lake Surface) (acres)
Gem Lake	2011505	327.94	21.6	306.34
East Goose Lake	2011504	693.85	116.3	577.55
West Goose Lake	20115044	262.88	24.1	238.78
Gilfillan Lake	2007902	630.55	99.2*	531.35
Wilkinson	2007901 (Birch Lake)	640.83		
	2007903 (Amelia Lake)	691.33		
	2007902 (Gilfillan Lake)	630.55		
	2007904	3069.92	97.1	2972.82
	Total	5032.63	97.1	4935.53
Lambert Creek	2011504	693.85		
	2011505	327.94		
	20115044	262.88		
	20115055	3657.95		
	Total	4942.62		

* Varies over calibration period due to lake level changes

Sources: Lake Areas were calculated from shorelines digitized from 2010 Aerial Photos

Subwatersheds were delineated to each lake/stream outlet based on topographic maps

Table B.2: Total Watershed Areas & Land Use Breakdowns (Includes Lake Surface Area)

Impaired Water (Subwatershed Identification[1])	Gem Lake (2011505)		East Goose Lake (2011504)		West Goose Lake (20115044)		Lake Gilfillan (2007902)		Lake Wilkinson (2007901, 2007902, 2007903, 2007904)		Lambert Creek (2011504, 2011505, 20115044, 20115055)	
Land Use	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%
Agricultural	12.44	4%	0.0	0%	0.0	0%	0.0	0%	313.83	6%	39.31	1%
Commercial	35.70	11%	43.36	6%	18.66	7%	14.59	2%	168.16	3%	221.44	4%
Industrial	0.0	0%	0.0	0%	15.45	6%	0.05	0.01%	145.03	3%	161.72	3%
Institutional	0.0	0%	46.65	7%	0.0	0%	7.68	1%	54.50	1%	150.25	3%
Major Highway	10.78	3%	18.77	3%	17.94	7%	0.0	0%	166.00	3%	140.36	3%
Mixed Use	0.13	0.04%	0.0	0%	0.0	0%	0.0	0%	29.86	1%	11.99	0.24%
Multi-Family Residential	0.0	0%	49.10	7%	6.82	3%	53.39	8%	204.17	4%	305.16	6%
Open Water	32.26	10%	112.46	16%	27.96	11%	118.55	19%	545.48	11%	264.83	5%
Park and Recreation	0.21	0.07%	11.46	2%	36.54	14%	58.47	9%	964.92	19%	312.08	6%
Single Family Residential	89.32	27%	402.20	58%	74.33	28%	326.69	52%	1213.44	24%	2168.18	44%
Undeveloped	147.09	45%	9.85	1%	65.17	25%	51.14	8%	1227.26	24%	1167.31	24%
Total	327.95	100%	693.85	100%	262.87	100%	630.55	100%	5032.65	100%	4942.63	100%

Source: 2005 Met Council Land Use Database

1 Subwatershed identification numbers originated from the DNR Lakeshed HU_ID. Identification numbers were modified as necessary during GIS mapping and data processing to provide unique IDs for each subwatershed.

Table B.3 Gem Lake Land Use Areas by MS4

Area Downstream of Boundary Condition (Subwatershed ID# 2011505)	TOTAL	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Landuse Category/ MS4	**Acres**					**%**			
Agricultural	12.44	11.81		0.63		3.86%		0.21%	
Commercial	35.70	29.50		3.59	2.62	9.63%		1.17%	0.86%
Industrial	0.00								
Institutional	0.00								
Major Highway	10.78	5.33	5.45			1.74%	1.78%		
Mixed Use	0.13			0.13				0.04%	
Multi-Family Residential	0.00								
Open Water*	10.66	10.66				3.48%			
Park and Recreation	0.21	0.21				0.07%			
Single Family Residential	89.32	81.73		2.02	5.58	26.68%		0.66%	1.82%
Undeveloped	147.09	145.20		0.85	1.05	47.40%		0.28%	0.34%
TOTAL	306.35	284.43	5.45	7.22	9.24	92.85%	1.78%	2.36%	3.02%

* Excludes Lake Area

Table B.4 Goose Lake - East Land Use Areas by MS4

Area Downstream of Boundary Condition (Subwatershed ID# 2011504)	TOTAL	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Landuse Category/ MS4	**Acres**					**%**			
Agricultural	0.00								
Commercial	43.36	3.16		4.07	36.13	0.54%		0.70%	6.21%
Industrial	0.00								
Institutional	46.65			0.76	45.88			0.13%	7.89%
Major Highway	18.77	0.11	17.59		1.07	0.02%	3.03%		0.18%
Mixed Use	0.00					0.00%			
Multi-Family Residential	49.10			0.48	48.63	0.00%		0.08%	8.36%
Open Water*	0.00					0.00%		0.00%	0.00%
Park and Recreation	11.46			1.09	10.36			0.19%	1.78%
Single Family Residential	402.20	0.31		24.08	377.80	0.05%		4.14%	64.98%
Undeveloped	9.85			0.74	9.10			0.13%	1.57%
TOTAL	581.39	3.59	17.59	31.23	528.98	0.62%	3.03%	5.37%	90.99%

* Excludes Lake Area

Table B.5 Goose Lake - West Land Use Areas by MS4

Area Downstream of Boundary Condition (Subwatershed ID# 20115044)	TOTAL	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Landuse Category/ MS4	**Acres**					**%**			
Agricultural	0.00								
Commercial	18.66			2.56	16.11			1.07%	6.75%
Industrial	15.45			2.79	12.66			1.17%	5.30%
Institutional	0.00								
Major Highway	17.94		17.72	0.21	0.01		7.42%	0.09%	0.01%
Mixed Use	0.00								
Multi-Family Residential	6.82	0.82		1.25	4.74	0.35%		0.52%	1.99%
Open Water*	3.86	3.86				1.62%			
Park and Recreation	36.54	36.53		0.01		15.30%		0.00%	
Single Family Residential	74.33	56.35		8.28	9.69	23.60%		3.47%	4.06%
Undeveloped	65.17	45.85		3.16	16.16	19.20%		1.32%	6.77%
TOTAL	238.77	143.42	17.72	18.25	59.38	60.07%	7.42%	7.64%	24.87%

* Excludes Lake Area

Table B.6 Lake Gilfillan Land Use Areas by MS4

Area Downstream of Boundary Condition (Subwatershed ID# 20115044)	TOTAL	North Oaks City MS4	Vadnais Heights City MS4	Ramsey County	White Bear Township MS4	North Oaks City MS4	Vadnais Heights City MS4	Ramsey County	White Bear Township MS4
Landuse Category/ MS4	**Acres**					**%**			
Agricultural	0.00								
Commercial	14.59		3.62	2.10	8.87		0.68%	0.39%	1.67%
Industrial	0.05		0.05				0.01%		
Institutional	7.68			1.23	6.44			0.23%	1.21%
Major Highway	0.00								
Mixed Use	0.00								
Multi-Family Residential	53.39	9.16		0.18	44.05	1.72%		0.03%	8.29%
Open Water*	19.35	5.49	3.93	0.96	8.97	1.03%	0.74%	0.18%	1.69%
Park and Recreation	58.47	43.35		0.41	14.71	8.16%		0.08%	2.77%
Single Family Residential	326.69	295.37	19.08	10.61	1.64	55.59%	3.59%	2.00%	0.31%
Undeveloped	51.14	14.83	16.56	3.73	16.02	2.79%	3.12%	0.70%	3.02%
TOTAL	531.35	368.20	43.23	19.21	100.70	69.30%	8.14%	3.62%	18.95%

* Excludes Lake Area

Table B.7 Lake Wilkinson Land Use Areas by MS4

Area Downstream of Boundary Condition (Subwatershed ID# 2007904)	TOTAL	Anoka County	Lino Lakes City MS4	MNDOT	North Oaks City MS4	Ramsey County	White Bear Lake City MS4	White Bear Township MS4	Anoka County	Lino Lakes City MS4	MNDOT	North Oaks City MS4	Ramsey County	White Bear Lake City MS4	White Bear Township MS4
Landuse Category/ MS4	**Acres**								**%**						
Agricultural	157.40	1.96	95.66		17.89	0.75		41.14	0.07%	3.22%		0.60%	0.03%		1.38%
Commercial	29.85	0.02	0.05		1.84	0.72	11.15	16.07	0.001%	0.002%		0.06%	0.02%	0.37%	0.54%
Industrial	124.71					2.16	5.66	116.90					0.07%	0.19%	3.93%
Institutional	32.57				5.78	1.29		25.50				0.19%	0.04%		0.86%
Major Highway	74.40			72.78			0.01	1.61			2.45%			0.00%	0.05%
Mixed Use	29.86					0.29	28.56	1.01					0.01%	0.96%	0.03%
Multi-Family Residential	74.41				9.48	1.48	19.94	43.50				0.32%	0.05%	0.67%	1.46%
Open Water*	49.03				23.65			25.38				0.80%			0.85%
Park and Recreation	896.26		0.03		496.31	12.25	34.70	352.97		0.001%		16.69%	0.41%	1.17%	11.87%
Single Family Residential	639.32	2.24	22.45		365.21	10.76	23.39	215.28	0.08%	0.76%		12.28%	0.36%	0.79%	7.24%
Undeveloped	865.01	6.11	132.83		418.31	23.22	31.30	253.24	0.21%	4.47%		14.07%	0.78%	1.05%	8.52%
TOTAL	2972.84	10.34	251.03	72.78	1338.46	52.92	154.71	1092.61	0.35%	8.44%	2.45%	45.02%	1.78%	5.20%	36.75%

* Excludes Lake Area

Table B.8 Lambert Creek Land Use Areas by MS4

Area Downstream of Boundary Condition (Subwatershed ID# 20115055)	TOTAL	Gem Lake City MS4	MNDOT	Ramsey County	Vadnais Heights City MS4	White Bear Lake City MS4	White Bear Township MS4	Gem Lake City MS4	MNDOT	Ramsey County	Vadnais Heights City MS4	White Bear Lake City MS4	White Bear Township MS4
Landuse Category/ MS4	**Acres**							**%**					
Agricultural	26.87			2.94	23.93					0.08%	0.65%		
Commercial	122.25			8.26	77.63	35.39	0.98			0.23%	2.12%	0.97%	0.03%
Industrial	146.22			3.56	35.43	56.85	50.38			0.10%	0.97%	1.55%	1.38%
Institutional	103.49	1.72		4.81	16.07	78.04	2.85	0.05%		0.13%	0.44%	2.13%	0.08%
Major Highway	97.15		79.24	7.17	3.91	6.83			2.17%	0.20%	0.11%	0.19%	
Mixed Use	11.86			0.12	7.45	0.42	3.87			0.00%	0.20%	0.01%	0.11%
Multi-Family Residential	248.99			4.57	131.35	41.16	71.92			0.12%	3.59%	1.13%	1.97%
Open Water	92.14				1.32	0.38	90.44				0.04%	0.01%	2.47%
Park and Recreation	263.86	18.96		7.58	168.00	40.48	28.84	0.52%		0.21%	4.59%	1.11%	0.79%
Single Family Residential	1602.03	86.30		39.66	819.44	475.94	180.69	2.36%		1.08%	22.40%	13.01%	4.94%
Undeveloped	943.07	67.39		22.66	629.85	58.62	164.55	1.84%		0.62%	17.22%	1.60%	4.50%
TOTAL	3657.95	174.38	79.24	101.33	1914.37	794.12	594.52	4.77%	2.17%	2.77%	52.33%	21.71%	16.25%

Sources (Tables B.1 to B.8): Met Council 2005 Land Use Database

T:\2255 VLAWMO\08_TMDL\Report\[Tables.xlsx]Landuse by subwatershed

	Table B.9: Percent Watershed Area by MS4								
Lake	Anoka County	Gem Lake City MS4	Lino Lakes City MS4	MNDOT	North Oaks City MS4	Ramsey County	Vadnais Heights City MS4	White Bear Lake City MS4	White Bear Township MS4
Gem		92.85%		1.78%		2.36%		3.02%	
Goose - East		0.62%		3.03%		5.37%		90.99%	
Goose - West		60.07%		7.42%		7.64%		24.87%	
Lake Gilfillan					69.30%	3.62%	8.14%		18.95%
Lake Wilkinson	0.35%		8.44%	2.45%	45.02%	1.78%		5.20%	36.75%
Lambert Creek		4.77%		2.17%		2.77%	52.33%	21.71%	16.25%

Table B.10: P8 Model Results Summary

Waterbody	Subwatershed ID#	Annual Average Runoff Volume (ac-ft/yr)	Annual Average Runoff Depth (in/yr)
Gem Lake	2011505	81	3.2
East Goose Lake	2011504	266	5.5
West Goose Lake	20115044	140	7
Gilfillan Lake	2007902	51	1.2
Wilkinson	2007901	388	9.0
	2007903	148	3.3
	2007904	888	3.6

*** Source: P8 model**

Table B.11: Watershed Phosphorus Loading

			Phosphorus Concentration (ug/l)		Phosphorus Load (lbs/yr)		Phosphorus Export (lbs/acre/yr)	
Waterbody	**Subwatershed ID#**	**Subwatershed Area*** (acres)**	**Benchmark**	**TMDL**	**Benchmark**	**TMDL**	**Benchmark**	**TMDL**
Gem Lake	2011505	306.34	281.6	225.2	62.1	49.7	0.203	0.162
East Goose Lake	2011504	577.55	297.0	121.8	214.8	88.1	0.372	0.152
West Goose Lake	20115044	238.78	290.4	69.7	110.4	26.5	0.462	0.111
Gilfillan Lake	2007902	531.35	122.5	122.5	17.0	17.0	0.032	0.032
Wilkinson	2007901* (Birch Lake)	517.89	32.5	32.5	34.3	34.3	0.066	0.066
	2007903* (Amelia Lake)	533.47	38.8	38.8	15.6	15.6	0.029	0.029
	2007904	2972.82	306.5	80.9	740.4	195.5	0.249	0.066
	2007902 Gilfillan Lake**	531.35	148.0	60.0	0.0	0.0	0	0

* Measured Lake Outflow

** Gilfillan Lake did not discharge during the calibration period

*** Excludes lake surface area

Table B.12: Lake Water Budgets

			Average Annual Watershed Runoff		Discharge from Upstream Lakes***	Precipitation*		M-Foods Dairy, LLC		Groundwater		Evaporation		Surface Outflow		Σ inputs + Σ outputs (ac-ft/yr)
Waterbody	Calibration Years	Recommended Baseline	ac-ft/yr	in/yr over watershed	ac-ft/yr	in/yr over lake surface	ac-ft/yr	in/yr over lake surface	ac-ft/yr	in/yr over lake	ac-ft/yr	in/yr over lake	ac-ft/yr	in/yr over lake	ac-ft/yr	
Gem Lake	2000-2005 and 2007-2009	2007	81.1	3.2	-	32.0	57.6	-	-	0.0	0.0	(32.0)	(57.6)	(45.0)	(81.0)	0.1
East Goose Lake	2007-2009	2007	265.9	5.5	-	27.2	263.6	-		0.5	4.4	(27.2)	(263.6)	(27.9)	(270.0)	0.3
West Goose Lak	2007-2010	2007	139.8	7	270.3	27.2	54.6	301.2	604.9	-	-	(27.2)	(54.6)	(505.4)	(1015.0)	(0.0)
Gilfillin Lake**	2006-2010	2007	51.1	1.2	-	27.9	230.2	-	-	(15.2)	(125.4)	(25.5)	(210.4)	0.0	0.0	(54.5)
Wilkinson Lake	2001-2005 and 2007-2009	2007	888.3	3.6	535.0	31.8	257.3	-	-	0.9	7.5	(31.8)	(257.3)	(176.8)	(1431.0)	(0.2)

* Average precipitation varies due to variation in calibration years

** Gilfillan Lake level/ volume was declined over the calibration period (pumping to augment the lake and artificially raise the lake level was not performed). A more recent calibration period was used to reflect changing lake levels and lake volumes through calibration period (evident in water balance). The loss modeled translates into about 6.6 inches per year based on an average condition observed over the calibration period

*** For Wilkinson lake, calculated based on 9 in/yr of runoff over the Birch Lake sub-watershed and 3.3 in/yr of runoff over the Amelia Lake sub-watershed

Table B.13: Lake Phosphorus Budgets

	Phosphorus Sources							Phosphorus Sinks		
	Watershed	Septic Systems	Upstream Lakes	Atmosphere	M-Foods Dairy, LLc.	Groundwater	Internal	Phosphorus Sedimentation	Lake Outflow	Σ sources + Σ sinks
Waterbody	**lbs/yr**									
Gem Lake	62.1	5.1	0.0	5.2	-	0.0	0.0	(56.6)	(15.8)	0.0
East Goose Lake	214.8	0.0	0.0	27.9	-	0.8	1777.2	(1831.4)	(189.3)	0.0
West Goose Lake	110.4	0.0	189.1	5.8	16.5	-	427.1	(285.9)	(462.9)	0.1
Gilfillan Lake	17.0	24.3	0.0	23.8	-	0.0	364.2	(379.1)	(50.3)	(0.1)
Wilkinson Lake	740.4	0.0	49.8	23.3	-	1.4	51.8	(324.2)	(542.5)	0.0

(Source: Canfield Backmann Modeling)

Table B.14: TMDL Equations (lbs/day)

Annual TP Loading (lb/yr)	TMDL =	LA +	WLA +	MOS
Gem	54.9	5.2	47.0	2.7
Goose - East	187.9	99.8	78.7	9.4
Goose - West	224.2	173.0	40.0	11.2
Lake Gilfillan	164.7	139.4	17.0	8.3
Lake Wilkinson	321.8	126.4	179.4	16.1

Table B.15: TMDL Equations (lbs/yr)

Daily TP Loading (lb/day)	TMDL =	LA +	WLA +	MOS
Gem	0.150	0.014	0.129	0.008
Goose - East	0.514	0.273	0.215	0.026
Goose - West	0.614	0.474	0.109	0.031
Lake Gilfillan	0.451	0.382	0.047	0.022
Lake Wilkinson	0.881	0.346	0.491	0.044

Table B.16: MS4 WLA (lbs/year)

			MS4s								
Lake	WLA (lbs/yr)	M-Foods Dairy, LLC.(1)	Anoka County	Gem Lake City MS4	Lino Lakes City MS4	MNDOT	North Oaks City MS4	Ramsey County	Vadnais Heights City MS4	White Bear Lake City MS4	White Bear Township MS4
Gem	47.0	-	-	23.9	-	5.2	-	9.0	-	8.9	-
Goose - East	78.7	-	-	2.2	-	7.9	-	3.9	-	64.7	-
Goose - West	40.0	24.7	-	2.8	-	3.6	-	1.6	-	7.3	-
Lake Gilfillan	17.0	-	-	-	-	-	14.7	0.5	0.1	-	1.7
Lake Wilkinson	179.4	-	0.1	-	1.2	47.2	26.4	1.8	-	35.1	67.6

(1) WLA may be expanded in the future. See Section 6.1.3

Table B.17: MS4 WLA (lbs/day)

			MS4s								
Lake	**WLA (lbs/day)**	**M-Foods Dairy, LLC.(1)**	**Anoka County**	**Gem Lake City MS4**	**Lino Lakes City MS4**	**MNDOT**	**North Oaks City MS4**	**Ramsey County**	**Vadnais Heights City MS4**	**White Bear Lake City MS4**	**White Bear Township MS4**
Gem	0.129	-	-	0.065	-	0.014	-	0.025	-	0.025	-
Goose - East	0.215	-	-	0.006	-	0.022	-	0.011	-	0.176	-
Goose - West	0.109	0.068	-	0.007	-	0.010	-	0.004	-	0.020	-
Lake Gilfillan	0.047	-	-	-	-	-	0.041	0.001	<0.001	-	0.005
Lake Wilkinson	0.491	-	<0.001	-	0.003	0.129	0.072	0.006	-	0.096	0.185

(1) WLA may be expanded in the future. See Section 6.1.3

Table B.18: SUMMARY DATA FOR GEM LAKE SUBWATERSHED

	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4	Overall	
Resultant CN	64	78	81	78	65	
Resultant Area (ac)	284.4	5.5	7.2	9.2	306.35	
% Area	93%	2%	2%	3%	100%	
Overall % Impervious	20%	46%	54%	45%		
Overall Impervious Area (ac)	57.76	2.51	3.88	4.12	68.27	
S	5.73	2.82	2.39	2.79		
SRO (inches)	0.021	0.233	0.305	0.237	0.796	<--Calculate SRO using SCS Method=(P-0.2S)^2/(P+0.8S)
RO Volume (ac-ft)	0.489	0.106	0.184	0.183	0.961	Where S=(1000/CN)-10
% SRO= Proposed Partition of Existing Loads	50.86%	11.02%	19.11%	19.01%	100.00%	And Runoff Event P (inches)= 1.5

Table B.19: Gem Lake Nutrient Sources by Category (lbs TP/ year)

	Watershed	Septics	Internal	Precipitation & Groundwater	Total	TP Concentration (ug/L)
Average Year	62	5	0	5	72	72
W/ Reductions	50	0	0	5	55	60
% Reduction	20%	100%	NA	0%	24%	16%

(Source: Canfield Bachmann Model)

Table B.20: Gem Lake Overall CN calcs

Lake	Subwatershed ID	Landuse Type:	Area (ac)	Impervious Area (%)	Impervious Area (ac)	Impervous CN	Pervious Area (%)	Pervious Area (ac)	Pervious CN	Resultant CN-Categorical CN for Gem Lake Sub by Landuse
Gem Lake	2011505	Agricultural	12.44	5%	0.62	98	95%	11.82	61	63
Gem Lake	2011505	Commercial	35.70	85%	30.35	98	15%	5.36	61	92
Gem Lake	2011505	Major Highway	10.78	46%	4.96	98	54%	5.82	61	78
Gem Lake	2011505	Mixed Use	0.13	85%	0.11	98	15%	0.02	69	94
Gem Lake	2011505	Open Water								
Gem Lake	2011505	Park and Recreation	0.21	12%	0.03	98	88%	0.19	55	60
Gem Lake	2011505	Single Family Residential	89.32	34%	30.37	98	66%	58.95	64	76
Gem Lake	2011505	Undeveloped	147.09	0%	0.00	98	100%	147.09	55	55
		Total	295.68		66.43			229.25		
					22.47%			77.53%		

Table B.21: Gem Lake Area of Landuse Category by MS4 (acres)

Landuse Category	TOTAL AREA (AC)	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Agricultural	12.44	11.81		0.63	
Commercial	35.70	29.50		3.59	2.62
Major Highway	10.78	5.33	5.45		
Mixed Use	0.13			0.13	
Open Water	10.66	10.66			
Park and Recreation	0.21	0.21			
Single Family Residential	89.32	81.73		2.02	5.58
Undeveloped	147.09	145.20		0.85	1.05
TOTAL	306.35	284.43	5.45	7.22	9.24
		93%	2%	2%	3%

Table B. 22: CATEGORICAL CNs by Landuse for Gem Lake Subwatershed

Landuse Category	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Agricultural	63	63	63	63
Commercial	92	92	92	92
Major Highway	78	78	78	78
Mixed Use	94	94	94	94
Open Water				
Park and Recreation	60	60	60	60
Single Family Residential	76	76	76	76
Undeveloped	55	55	55	55

Based on soil types and watershed % impervious area

Table B.23: CATEGORICAL % Impervious by Landuse for Gem Lake Subwatershed

Landuse Category	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Agricultural	5%	5%	5%	5%
Commercial	85%	85%	85%	85%
Major Highway	46%	46%	46%	46%
Mixed Use	85%	85%	85%	85%
Open Water				
Park and Recreation	12%	12%	12%	12%
Single Family Residential	34%	34%	34%	34%
Undeveloped	0%	0%	0%	0%
Overall % Impervious	20%	46%	54%	45%
Overall Impervious Area (ac)	57.76	2.51	3.88	4.12

Table B.24: Gem Lake P8 Input

Subwatershed	Total Subwatershed Area (ac)	Landuse Type:	Landuse area (ac)	%Imperv	Impervious Area (ac)	Perv CN
GEM 2011505	327.94	Agricultural	12.44	5%	0.62	61
		Commercial	35.70	85%	30.35	61
		Major Highway	10.78	46%	4.96	61
		Mixed Use	0.13	85%	0.11	69
	32.26	<--Total Open Water				
		Park and Recreation	0.21	12%	0.03	55
		Single Family Residential	89.32	34%	30.37	64
some new residential, wooded, wetlands-->		Undeveloped	147.09	0%	0.00	55
		Total (minus open water)	295.68	22%	66.4	**58.9**
			Directly connected	8%		

Table B.25: SUMMARY DATA FOR EAST GOOSE LAKE SUBWATERSHED

East Goose	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4	Overall	
Resultant CN	92	88	75	75	75	
Resultant Area (ac)	3.6	17.6	31.2	529.0	581.39	
% Area	1%	3%	5%	91%	100%	
Overall % Impervious	80%	66%	36%	36%		
Overall Impervious Area (ac)	2.86	11.54	11.35	191.37	217.12	
S	0.92	1.36	3.37	3.40		<--Calculate SRO using SCS Method=(P-0.2S)^2/(P+0.8S)
SRO (inches)	0.775	0.581	0.163	0.159	1.678	Where S=(1000/CN)-10
RO Volume (ac-ft)	0.232	0.852	0.423	7.010	8.517	And Runoff Event P (inches)= 1.5
% SRO= Proposed Partition of Existing Loads	2.72%	10.00%	4.97%	82.30%	100%	

Table B.26: East Goose Lake Nutrient Sources by Category (lbs TP/ year)

	Watershed	**Septics**	**Internal***	**Precipitation & Groundwater**	**Total**	**Modeled Average TP Concentrations (ug/L)**
Average Year	215	0	1,777	29	2,021	258
W/ Load Reductions	88	0	71	29	188	60
% Reduction	59%	0%	96%	0%	91%	78%

(Source: Canfield Bachmann modeling)

Table B.27: East Goose Lake Overall CN calcs

Lake	Subwatershed ID	Landuse Type:	Area (ac)	Impervious Area (%)	Imperviou s Area (ac)	Impervous CN	Pervious Area (%)	Pervious Area (ac)	Pervious CN	Resultant CN-Categorical CN for Goose Lake EAST Lake Sub by Landuse
Goose Lake EAST	2011504	Commercial	43.36	85%	36.86	98	15%	6.50	69	94
Goose Lake EAST	2011504	Institutional	46.65	30%	13.99	98	70%	32.65	61	72
Goose Lake EAST	2011504	Major Highway	18.77	66%	12.31	98	34%	6.46	69	88
Goose Lake EAST	2011504	Multi-Family Residential	49.10	65%	31.92	98	35%	17.19	61	85
Goose Lake EAST	2011504	Open Water								
Goose Lake EAST	2011504	Park and Recreation	11.46	12%	1.37	98	88%	10.08	61	65
Goose Lake EAST	2011504	Single Family Residential	402.20	30%	120.66	98	70%	281.54	61	72
Goose Lake EAST	2011504	Undeveloped	9.85	0%	0.00	98	100%	9.85	69	69
		total	581.39		217.12			364.27		
					37.34%			62.66%		

Table B.28: East Goose Area of Landuse Category by MS4 (acres)

Landuse Category	TOTAL	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Commercial	43.36	3.16	0.00	4.07	36.13
Institutional	46.65	0.00	0.00	0.76	45.88
Major Highway	18.77	0.11	17.59	0.00	1.07
Multi-Family Residential	49.10	0.00	0.00	0.48	48.63
Open Water					
Park and Recreation	11.46	0.00	0.00	1.09	10.36
Single Family Residential	402.20	0.31	0.00	24.08	377.80
Undeveloped	9.85	0.00	0.00	0.74	9.10
TOTAL	581.39	3.59	17.59	31.23	528.98
%		0.62%	3.03%	5.37%	90.99%

Table B.29: CATEGORICAL CNs by Landuse for East Goose Lake Subwatershed

Landuse Category	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Commercial	94	94	94	94
Institutional	72	72	72	72
Major Highway	88	88	88	88
Multi-Family Residential	85	85	85	85
Open Water				
Park and Recreation	65	65	65	65
Single Family Residential	72	72	72	72
Undeveloped	69	69	69	69
Resultant	92	88	75	75

Based on soil types and watershed % impervious area

Table B.30: CATEGORICAL % Impervious by Landuse for East Goose Lake Subwatershed

Landuse Category	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Commercial	85%	85%	85%	85%
Institutional	30%	30%	30%	30%
Major Highway	66%	66%	66%	66%
Multi-Family Residential	65%	65%	65%	65%
Open Water				
Park and Recreation	12%	12%	12%	12%
Single Family Residential	30%	30%	30%	30%
Undeveloped	0%	0%	0%	0%
Overall % Impervious	80%	66%	36%	36%
Overall Impervious Area (ac)	2.86	11.54	11.35	191.37

Table B.31: East Goose Lake P8 Input

Subwatershed	**Area (ac)**	**Landuse Type:**	**Landuse area (ac)**	**%Imperv**	**Perv CN**
East GOOSE 2011504	693.90	Commercial	43.36	85	69
		Institutional	46.65	30	61
		Major Highway	18.77	98	69
		Multi-Family Residential	49.10	65	61
e. GOOSE water	112.5	Open Water			
		Park and Recreation	11.46	12	61
		Single Family Residential	402.20	30	61
		Undeveloped	9.85	0	69
		Total	581.39	38.4	62.0
			Indirect	19.2	one half
			Direct	19.2	one half

Table B.32: SUMMARY DATA FOR WEST GOOSE LAKE SUBWATERSHED

West Goose	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4	Overall	
Resultant CN	68	88	78	82	74	
Resultant Area (ac)	143.4	17.7	18.3	59.4	238.77	
% Area	60%	7%	8%	25%	100%	
Overall % Impervious	15%	66%	43%	50%		
Overall Impervious Area (ac)	21.83	11.62	7.84	29.82	71.11	
S	4.80	1.36	2.74	2.18		<--Calculate SRO using SCS Method=(P-0.2S)^2/(P+0.8S)
SRO (inches)	0.054	0.581	0.245	0.348	1.229	Where S=(1000/CN)-10
RO Volume (ac-ft)	0.650	0.858	0.373	1.724	3.605	And Runoff Event P (inches)= 1.5
% SRO= Proposed Partition of Existing Loads	18.03%	23.81%	10.34%	47.82%	100%	

Table B.33: West Goose Lake Nutrient Sources by Category (lbs TP/ year)

	Watershed	M-Foods Dairy, LLC.	Septics	Internal (includes motorboating)	Precipitation & Groundwater	Total	TP Concentration (ug/L)
Average Year	110	25	0	397	6	727	164
W/ Reductions	27	25	0	123	6	225	60
% Reduction	76%	0%	0%	69%	0%	69%	64%

(Source: Canfield Bachmann modeling)

Table B.34: West Goose Lake Overall CN Calcs

Lake	Subwatershed ID	Landuse Type:	Area (ac)	Impervious Area (%)	Impervious Area (ac)	Impervous CN	Pervious Area (%)	Pervious Area (ac)	Pervious CN	Resultant CN-Categorical CN for Goose Lake WEST Sub by Landuse
Goose Lake WEST	20115044	Commercial	18.66	85%	15.86	98	15%	2.80	69	94
Goose Lake WEST	20115044	Industrial	15.45	80%	12.36	98	20%	3.09	61	91
Goose Lake WEST	20115044	Major Highway	17.94	66%	11.77	98	34%	6.17	69	88
Goose Lake WEST	20115044	Multi-Family Residential	6.82	65%	4.43	98	35%	2.39	61	85
Goose Lake WEST	20115044	Open Water	3.86							
Goose Lake WEST	20115044	Park and Recreation	36.54	12%	4.39	98	88%	32.16	61	65
Goose Lake WEST	20115044	Single Family Residential	74.33	30%	22.30	98	70%	52.03	61	72
Goose Lake WEST	20115044	Undeveloped	65.17	0%	0.00	98	100%	65.17	69	69
		total	238.77		71.11			163.81		
					29.78%			68.60%		

Table B.35: West Goose Lake Area of Landuse Category by MS4 (acres)

Landuse Category	TOTAL	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Commercial	18.66			2.56	16.11
Industrial	15.45	0.00		2.79	12.66
Major Highway	17.95	0.00	17.72	0.21	0.01
Multi-Family Residential	6.82	0.82		1.25	4.74
Open Water	3.86	3.86			
Park and Recreation	36.54	36.53		0.01	
Single Family Residential	74.33	56.35		8.28	9.69
Undeveloped	65.17	45.85		3.16	16.16
TOTAL	238.77	143.42	17.72	18.25	59.38

Table B.36: CATEGORICAL CNs by Landuse for West Goose Lake Subwatershed

Landuse Category	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Commercial	94	94	94	94
Industrial	91	91	91	91
Major Highway	88	88	88	88
Multi-Family Residential	85	85	85	85
Open Water				
Park and Recreation	65	65	65	65
Single Family Residential	72	72	72	72
Undeveloped	69	69	69	69
	68	88	78	82

Based on soil types and watershed % impervious area

Table B.37: CATEGORICAL % Impervious by Landuse for West Goose Lake Subwatershed

Landuse Category	Gem Lake City MS4	MNDOT	Ramsey County	White Bear Lake City MS4
Commercial	85%	85%	85%	85%
Industrial	80%	80%	80%	80%
Major Highway	66%	66%	66%	66%
Multi-Family Residential	65%	65%	65%	65%
Open Water				
Park and Recreation	12%	12%	12%	12%
Single Family Residential	30%	30%	30%	30%
Undeveloped	0%	0%	0%	0%
Overall % Impervious	15%	66%	43%	50%
Overall Impervious Area (ac)	21.83	11.62	7.84	29.82

Table B.38: West Goose Lake P8 Input

Subwatershed	**Area (ac)**	**Landuse Type:**	**Landuse area (ac)**	**%Imperv**	**Perv CN**
West GOOSE 20115044	262.90	Commercial	18.66	85	69
"little Goose"		Industrial	15.45	80	69
		Major Highway	17.94	98	69
		Multi-Family Residential	6.82	65	61
w. GOOSE water	28	Open Water			
		Park and Recreation	36.54	12	61
		Single Family Residential	74.33	30	61
		Undeveloped	65.17	0	69
		Total	234.91	32.7	65.0
		Indirect		10.91	One third
		Direct		21.83	two thirds

*** East Goose is also tributary to West Goose. See Tab in this file for P8 calcs**

Table B.39: SUMMARY DATA FOR GILFILLAN LAKE SUBWATERSHED

	North Oaks City MS4	Vadnais Heights City MS4	Ramsey County	White Bear Township MS4	Overall
Resultant CN	69	61	67	65	68
Area by MS4 (ac)	368.2	43.2	19.2	100.7	531.36
% Area	69%	8%	4%	19%	100%
Overall % Impervious	26%	20%	28%	28%	
Overall Impervious Area (ac)	96.34	8.84	5.44	27.74	138.35
S	4.39	6.45	4.84	5.36	
SRO (inches)	0.077	0.0067	0.0526	0.0317	0.168
RO Volume (ac-ft)	2.368	0.024	0.084	0.266	2.743
% SRO= Proposed Partition of Existing Loads	86.35%	0.88%	3.07%	9.70%	100%

<--Calculate SRO using SCS Method=(P-0.2S)^2/(P+0.8S)
Where S=(1000/CN)-10
And Runoff Event P (inches)= 1.5

Table B.40: Gilfillan Lake Nutrient Sources by Category (lbs TP/ year)

	Watershed Load	Septics	Internal	Atmospheric+ Groundwater	Augmentation	Total	Concentration (ug/L)
Existing	17	24	364	24	0	429	148
TMDL*	17	0	124	24	1	166	60
% Reduction	0%	100%	66%	0%	--	61%	59%

* Includes augmentation of clean water from Pleasant Lake
(Source: Canfield Bachmann modeling)

Table B.41: Gilfillan Lake Overall CN calcs

Lake	Subwatershed ID	Landuse Type:	Area (ac)	Impervious Area (%)	Impervious Area (ac)	Impervous CN	Pervious Area (%)	Pervious Area (ac)	Pervious CN	Resultant CN- Categorical CN for Gilfillan Lake Sub by Landuse
Lake Gilfillan	2007902	Commercial	14.59	85%	12.40	98	15%	2.19	69	94
Lake Gilfillan	2007902	Industrial	0.05	80%	0.04	98	20%	0.01	69	92
Lake Gilfillan	2007902	Institutional	7.68	30%	2.30	98	70%	5.37	61	72
Lake Gilfillan	2007902	Multi-Family Residential	53.39	37%	19.75	98	63%	33.64	61	75
Lake Gilfillan	2007902	Open Water	19.35		0.00			0.00		
Lake Gilfillan	2007902	Park and Recreation	58.47	10%	5.85	98	90%	52.63	61	65
Lake Gilfillan	2007902	Single Family Residential	326.69	30%	98.01	98	70%	228.68	61	72
Lake Gilfillan	2007902	Undeveloped	51.14	0%	0.00	98	100%	51.14	55	55
		total	531.36		138.35			373.65		
					26.04%			70.32%		

Table B.42: Gilfillan Lake Area of Landuse Category by MS4 (acres)

Landuse Category	Area (ac)	North Oaks City MS4	Vadnais Heights City MS4	Ramsey County	White Bear Township MS4
Commercial	14.59		3.62	2.10	8.87
Industrial	0.05		0.05		
Institutional	7.68			1.23	6.44
Multi-Family Residential	53.39	9.16		0.18	44.05
Open Water	19.35	5.49	3.93	0.96	8.97
Park and Recreation	58.47	43.35		0.41	14.71
Single Family Residential	326.69	295.37	19.08	10.61	1.64
Undeveloped	51.14	14.83	16.56	3.73	16.02
TOTAL	531.36	368.2	43.2	19.2	100.7
	% Area --->	69%	8%	4%	19%

Table B.43: CATEGORICAL CNs by Landuse for Gilfillan Lake Subwatershed

CN	North Oaks City MS4	Vadnais Heights City MS4	Ramsey County	White Bear Township MS4
Commercial	94	94	94	94
Industrial	92	92	92	92
Institutional	72	72	72	72
Multi-Family Residential	75	75	75	75
Open Water				
Park and Recreation	65	65	65	65
Single Family Residential	72	72	72	72
Undeveloped	55	55	55	55
Overall CN	69	61	67	65

Based on soil types and watershed % impervious area

Table B.44: CATEGORICAL % Impervious by Landuse for Gilfillan Lake Subwatershed

CN	North Oaks City MS4	Vadnais Heights City MS4	Ramsey County	White Bear Township MS4
Commercial	85%	85%	85%	85%
Industrial	80%	80%	80%	80%
Institutional	30%	30%	30%	30%
Multi-Family Residential	37%	37%	37%	37%
Open Water				
Park and Recreation	10%	10%	10%	10%
Single Family Residential	30%	30%	30%	30%
Undeveloped	0%	0%	0%	0%
Overall % Impervious	26%	20%	28%	28%
Overall Impervious Area (ac)	96.34	8.84	5.44	27.74

Table B.45: Gilfillan Lake P8 Input

Subwatershed	Area (ac)	Landuse Type:	Landuse area (ac)	%Imperv	Perv CN
Gilfillan 2007902	531.36	Commercial	14.59	85	69
		Industrial	0.05	80	69
		Institutional	7.68	30	61
		Multi-Family Residential	53.39	37	61
Gilfillan	19.35	Open Water (orig 118.55)			
All impervious indirectly connected		Park and Recreation	58.47	10	61
		Single Family Residential	326.69	30	61
		Undeveloped	51.14	0	55
		Total	512.01	27.0	60.6

Table B.46: SUMMARY DATA FOR Wilkinson Lake Subwatershed

Wilkinson	Anoka County	Lino Lakes City MS4	MNDOT	North Oaks City MS4	Ramsey County	White Bear Lake City MS4	White Bear Township MS4	Overall	
Resultant CN	60	60	83	62	64	73	66	64	
Resultant Area (ac)	10.3	251.0	72.8	1338.5	52.9	154.7	1092.6	2972.8	
% Area	0.3%	8.4%	2.4%	45.0%	1.8%	5.2%	36.8%	100.0%	
Overall % Impervious	8%	5%	47%	11%	14%	35%	20%	0%	
Overall Impervious Area (ac)	0.79	11.56	34.42	141.50	7.27	54.41	214.28	0.00	
S	6.59	6.80	2.05	6.14	5.74	3.67	5.23	5.57	<--Calculate SRO using SCS Method=(P-0.2S)^2/(P+0.8S)
SRO (inches)	0.005	0.003	0.379	0.012	0.020	0.132	0.036	0.587	Where S=(1000/CN)-10
RO Volume (ac-ft)	0.004	0.059	2.297	1.288	0.090	1.708	3.290	8.738	And Runoff Event P (inches)= 1.5
% SRO= Proposed Partition of Existing Loads	0.05%	0.68%	26.29%	14.74%	1.03%	19.55%	37.66%		

Table B.47: Wilkinson Lake Nutrient Sources by Category (lbs TP/ year)

TMDL	Watershed Load	Septics	Internal	Atmospheric+ Groundwater	Upstream Lakes	Concentration (ug/L)	Total
Existing	740	0	52	25	50	139	867
TMDL	196	0	52	25	50	60	322
% Reduction	74%	0%	0%	0%	0%	57%	63%

(Source: Canfield Bachmann modeling)

Table B.48: Wilkinson Lake Overall CN calcs

Lake	Subwatershe	**Landuse Type:**	Area (ac)	Impervious Area (%)	Impervious Area (ac)	Impervous CN	Pervious Area (%)	Pervious Area (ac)	Pervious CN	Resultant CN- Categorical CN for Wilkenson Sub by Landuse
Lake Wilkinson	2007904	Agricultural	157.40	5%	7.87	98	95%	149.53	61	63
Lake Wilkinson	2007904	Commercial	29.85	85%	25.37	98	15%	4.48	69	94
Lake Wilkinson	2007904	Industrial	124.71	80%	99.77	98	20%	24.94	69	92
Lake Wilkinson	2007904	Institutional	32.57	20%	6.51	98	80%	26.05	61	68
Lake Wilkinson	2007904	Major Highway	74.40	47%	35.19	98	53%	39.21	69	83
Lake Wilkinson	2007904	Mixed Use	29.86	85%	25.38	98	15%	4.48	69	94
Lake Wilkinson	2007904	Multi-Family Residential	74.41	37%	27.53	98	63%	46.88	61	75
Lake Wilkinson	2007904	Open Water	49.03							
Lake Wilkinson	2007904	Park and Recreation	896.26	5%	44.81	98	95%	851.45	61	63
Lake Wilkinson	2007904	Single Family Residential	639.32	30%	191.80	98	70%	447.53	61	72
Lake Wilkinson	2007904	Undeveloped	865.01	0%	0.00	98	100%	865.01	55	55
		total	2972.84		464.24			2459.56		
					15.62%			82.73%		

Table B.49: Wilkinson Lake Area of Landuse Category by MS4 (acres)

Landuse Category	TOTAL	Anoka County	Lino Lakes City MS4	MNDOT	North Oaks City MS4	Ramsey County	White Bear Lake City MS4	White Bear Township MS4
Agricultural	157.40	1.96	95.66		17.89	0.75		41.14
Commercial	29.85	0.02	0.05		1.84	0.72	11.15	16.07
Industrial	124.71					2.16	5.66	116.90
Institutional	32.57				5.78	1.29		25.50
Major Highway	74.40			72.78			0.01	1.61
Mixed Use	29.86					0.29	28.56	1.01
Multi-Family Residential	74.41				9.48	1.48	19.94	43.50
Open Water	49.03				23.65			25.38
Park and Recreation	896.26		0.03		496.31	12.25	34.70	352.97
Single Family Residential	639.32	2.24	22.45		365.21	10.76	23.39	215.28
Undeveloped	865.01	6.11	132.83		418.31	23.22	31.30	253.24
TOTAL	2972.84	10.34	251.03	72.78	1338.46	52.92	154.71	1092.60

Table B.50: CATEGORICAL CNs by Landuse for Wilkenson Lake Subwatershed

Landuse Category	Anoka County	Lino Lakes City MS4	MNDOT	North Oaks City MS4	Ramsey County	White Bear Lake City MS4	White Bear Township MS4
Agricultural	63	63	63	63	63	63	63
Commercial	94	94	94	94	94	94	94
Industrial	92	92	92	92	92	92	92
Institutional	68	68	68	68	68	68	68
Major Highway	83	83	83	83	83	83	83
Mixed Use	94	94	94	94	94	94	94
Multi-Family Residential	75	75	75	75	75	75	75
Open Water							
Park and Recreation	63	63	63	63	63	63	63
Single Family Residential	72	72	72	72	72	72	72
Undeveloped	55	55	55	55	55	55	55
	60	60	83	62	64	73	66

Based on soil types and watershed % impervious area

Table B.51: CATEGORICAL % Impervious by Landuse for Wilkinson Lake Subwatershed

Landuse Category	Anoka County	Lino Lakes City MS4	MNDOT	North Oaks City MS4	Ramsey County	White Bear Lake City MS4	White Bear Township MS4
Agricultural	5%	5%	5%	5%	5%	5%	5%
Commercial	85%	85%	85%	85%	85%	85%	85%
Industrial	80%	80%	80%	80%	80%	80%	80%
Institutional	20%	20%	20%	20%	20%	20%	20%
Major Highway	47%	47%	47%	47%	47%	47%	47%
Mixed Use	85%	85%	85%	85%	85%	85%	85%
Multi-Family Residential	37%	37%	37%	37%	37%	37%	37%
Open Water							
Park and Recreation	5%	5%	5%	5%	5%	5%	5%
Single Family Residential	30%	30%	30%	30%	30%	30%	30%
Undeveloped	0%	0%	0%	0%	0%	0%	0%
Overall % Impervious	8%	5%	47%	11%	14%	35%	20%
Overall Impervious Area (ac)	0.79	11.56	34.42	141.50	7.27	54.41	214.28

Table B.52: Wilkinson Lake P8 Input

Subwatershed	**Area (ac)**	**Landuse Type:**	**Landuse area (ac)**	**%Imperv**	**Perv CN**	
Wilkinson 2007904	3069.94	Agricultural	157.40	5	61	
		Commercial	29.85	85	69	
		Industrial	124.71	80	69	
		Institutional	32.57	20	61	
		Major Highway	74.40	98	69	
		Mixed Use	29.86	85	69	
		Multi-Family Residential	74.41	37	61	
Wilkinson	97.1	Open Water	49.03			
		Park and Recreation	896.26	5	61	
	3069.94	Single Family Residential	639.32	30	61	
		Undeveloped	865.01	0	55	
		Total	2972.84	16.9	58.9	
		Direct		8.44		
		Indirect		8.44		split 50/50

Table B.53: SUMMARY DATA FOR Lambert Creek Subwatershed

Lambert Creek	Gem Lake City MS4	MNDOT	Ramsey County	Vadnais Heights City MS4	White Bear Lake City MS4	White Bear Township MS4	Overall	
Resultant CN	73	86	76	74	75	64	73	
Resultant Area (ac)	174.4	79.2	101.3	1914.4	794.1	594.5	3658.0	
% Area	4.8%	2.2%	2.8%	52.3%	21.7%	16.3%	100.0%	
Overall % Impervious	0%	0%	0%	0%	0%	0%	0%	<--Calculate SRO using SCS Method=(P-0.2S)^2/(P+0.8S)
Overall Impervious Area (ac)	0.16	0.59	0.30	0.22	0.33	0.21	0.00	Where S=(1000/CN)-10
S	3.68	1.62	3.17	3.45	3.41	5.56	3.70	And Runoff Event P (inches)= 1.5
SRO (inches)	0.131	0.494	0.185	0.154	0.158	0.025	1.147	
SRO (ac-ft)	22.85	39.17	18.77	293.99	125.32	15.02	515.11	
SRO %	4.44%	7.60%	3.64%	57.07%	24.33%	2.92%	100.00%	

Table B.54: Lambert Creek Overall CN calcs

Waterbody	Subwatershed ID	**Landuse Type:**	Area (ac)	Impervious Area (%)	Impervious Area (ac)	Impervous CN	Pervious Area (%)	Pervious Area (ac)	Pervious CN	Resultant CN- Categorical CN for Lambert Creek Sub by Landuse
Lambert Creek	20115055	Agricultural	26.87	12%	3.22	98	88%	23.65	61	65
Lambert Creek	20115055	Commercial	122.25	85%	103.91	98	15%	18.34	69	94
Lambert Creek	20115055	Industrial	146.22	80%	116.98	98	20%	29.24	69	92
Lambert Creek	20115055	Institutional	103.49	30%	31.05	98	70%	72.44	61	72
Lambert Creek	20115055	Major Highway	97.15	59%	57.13	98	41%	40.03	69	86
Lambert Creek	20115055	Mixed Use	11.86	34%	4.03	98	66%	7.83	64	76
Lambert Creek	20115055	Multi-Family Residential	248.99	37%	92.13	98	63%	156.86	61	75
Lambert Creek	20115055	Open Water	92.14	0%	0.00	98	100%	92.14		0
Lambert Creek	20115055	Park and Recreation	263.86	12%	31.66	98	88%	232.20	55	60
Lambert Creek	20115055	Single Family Residential	1602.03	30%	480.61	98	70%	1121.42	61	72
Lambert Creek	20115055	Undeveloped	943.07	0%	0.00	98	100%	943.07	78	78
		total	3657.95		920.72			2737.23		
					25.17%			74.83%		

Table B.55: Lambert Creek Area of Landuse Category by MS4 (acres)

Landuse Category	TOTAL	Gem Lake City MS4	MNDOT	Ramsey County	Vadnais Heights City MS4	White Bear Lake City MS4	White Bear Township MS4
Agricultural	26.87			2.94	23.93		
Commercial	122.25			8.26	77.63	35.39	0.98
Industrial	146.22			3.56	35.43	56.85	50.38
Institutional	103.49	1.72		4.81	16.07	78.04	2.85
Major Highway	97.15		79.24	7.17	3.91	6.83	
Mixed Use	11.86			0.12	7.45	0.42	3.87
Multi-Family Residential	248.99			4.57	131.35	41.16	71.92
Open Water	92.14				1.32	0.38	90.44
Park and Recreation	263.86	18.96		7.58	168.00	40.48	28.84
Single Family Residential	1602.03	86.30		39.66	819.44	475.94	180.69
Undeveloped	943.07	67.39		22.66	629.85	58.62	164.55
TOTAL	3657.95	174.38	79.24	101.33	1914.37	794.12	594.52

Based on soil types and watershed % impervious area

Table B.56: CATEGORICAL CNs by Landuse for Lambert Creek Subwatershed

Landuse Category	Gem Lake City MS4	MNDOT	Ramsey County	Vadnais Heights City MS4	White Bear Lake City MS4	White Bear Township MS4
Agricultural	65	65	65	65	65	65
Commercial	94	94	94	94	94	94
Industrial	92	92	92	92	92	92
Institutional	72	72	72	72	72	72
Major Highway	86	86	86	86	86	86
Mixed Use	76	76	76	76	76	76
Multi-Family Residential	75	75	75	75	75	75
Open Water	0	0	0	0	0	0
Park and Recreation	60	60	60	60	60	60
Single Family Residential	72	72	72	72	72	72
Undeveloped	78	78	78	78	78	78
Composite CN	73	86	76	74	75	64

Table B.57: CATEGORICAL % Impervious by Landuse for Lambert Creek Subwatershed

Landuse Category	Gem Lake City MS4	MNDOT	Ramsey County	Vadnais Heights City MS4	White Bear Lake City MS4	White Bear Township MS4
Agricultural	12%	12%	12%	12%	12%	12%
Commercial	85%	85%	85%	85%	85%	85%
Industrial	80%	80%	80%	80%	80%	80%
Institutional	30%	30%	30%	30%	30%	30%
Major Highway	59%	59%	59%	59%	59%	59%
Mixed Use	34%	34%	34%	34%	34%	34%
Multi-Family Residential	37%	37%	37%	37%	37%	37%
Open Water	0%	0%	0%	0%	0%	0%
Park and Recreation	12%	12%	12%	12%	12%	12%
Single Family Residential	30%	30%	30%	30%	30%	30%
Undeveloped	0%	0%	0%	0%	0%	0%
Overall % Impervious	16%	59%	30%	22%	33%	21%
Overall Impervious Area (ac)	28.68	46.59	30.42	421.44	266.01	127.58

Notes (Appendix B Tables):

Tables exclude lake surface area

Runoff from other open water was assumed to be approximatly equal to evaporation for P8 and for CN calcs.

Appendix C

Watershed Model Results (P8)

Table C.1: Gem Lake 306.34 acres

Year	Annual Runoff (in)	Annual Runoff Volume (ac-ft)	Annual TP Load (lbs)	Average Annual Concentration (ug/L)	Areal Export Rate (lbs/acre/yr)
2000	2.1	54	67	339	0.218
2001	3.4	87	90	311	0.294
2002	4.9	125	117	310	0.383
2003	2.1	54	66	328	0.217
2004	4.4	112	89	247	0.291
2005	4.3	110	103	285	0.336
2007	2.9	74	79	319	0.256
2008	2.3	59	68	325	0.221
2009	2.2	56	71	349	0.231
Average	3.2	81	83	312	0.272
			Stdev	31	
			Average - Stdev=	282	

Note (Table C.1): For the Gem Lake Canfield Bachmann modeling, the low end of the Stdev range for the average annual concentration was used to calibrate the model (282 ug/L). This concentration equates to a load of 62.1 lbs/yr or 0.203 lbs/acre/yr.

Table C.2: East Goose Lake 577.55 acres

Year	Annual Runoff (in)	Annual Runoff Volume (ac-ft)	Annual TP Load (lbs)	Average Annual Concentration (ug/L)	Areal Export Rate (lbs/acre/yr)
2007	4.4	213	171	295	0.297
2008	3.8	184	148	294	0.255
2009	3.8	184	157	314	0.273
2010*	10.1	489	380	285	0.658
Average	5.5	268	214	297	0.371

* Through 8/31/2010

Table C.3: West Goose Lake 238.78 acres

Year	Annual Runoff (in)	Annual Runoff Volume (ac-ft)	Annual TP Load (lbs)	Average Annual Concentration (ug/L)	Areal Export Rate (lbs/acre/yr)
2007	6.4	127	109	319	0.456
2008	5.5	109	95	220	0.396
2009	5.6	111	100	333	0.417
2010*	10.6	211	163	289	0.683
Average	7.0	140	117	290	0.488

* Through 8/31/2010

Table C.4: Gilfillan Lake 531.35 acres

Year	Annual Runoff (in)	Annual Runoff Volume (ac-ft)	Annual TP Load (lbs)	Average Annual Concentration (ug/L)	Areal Export Rate (lbs/acre/yr)
2006	0.9	40	13	120	0.024
2007	1.1	49	17	129	0.031
2008	0.7	31	10	119	0.018
2009	0.7	31	11	133	0.020
2010	2.37	105	30	111	0.057
Average	1.2	51	16	122	0.030

Table C.5: Wilkinson Lake (2007904) 2972.82 acres

Year	Annual Runoff (in)	Annual Runoff Volume (ac-ft)	Annual TP Load (lbs)	Average Annual Concentration (ug/L)	Areal Export Rate (lbs/acre/yr)
2001	5.7	1423	1231	318	0.41
2002	5.1	1271	1075	311	0.36
2003	1.8	452	457	372	0.15
2004	4.6	1131	688	224	0.23
2005	4.2	1032	761	271	0.26
2007	2.9	729	571	288	0.19
2008	2.3	566	475	309	0.16
2009	2.0	502	492	360	0.17
Average	3.6	888	719	306	0.24

Table C.6: Wilkinson Lake (2007901)

Year	Annual Runoff (in)	Annual Runoff Volume (ac-ft)	Annual TP Load (lbs)	Birch Lake Average Annual Concentration (ug/L)	Areal Export Rate (lbs/acre/yr)
2001	9.9	427	56	48	0.087
2002	11.5	497	41	30	0.063
2003	5.7	246	15	23	0.024
2004	12.3	532	49	34	0.077
2005	11.8	507	28	20	0.043
2007	7.6	330	38	42	0.059
2008	6.7	289	26	33	0.041
2009	6.3	273	22	30	0.035
Average	9.0	388	34	33	0.053

Note (Table C.6): P8 modeling for the Birch Lake sub-watershed (517.89 acres excluding open water) was performed to determine annual runoff rates. Runoff volumes were applied to the measured in lake concentrations for lake response modeling to determine the annual TP load to Wilkinson Lake in lbs. This calculated annual load is presented in the table above. The areal export rate reported was calculated using the entire sub-watershed area of 640.83 acres.

Table C.7: Wilkinson Lake (2007903)

Year	Annual Runoff (in)	Annual Runoff Volume (ac-ft)	Annual TP Load (lbs)	Amelia Lake Average Annual Concentration (ug/L)	Areal Export Rate (lbs/acre/yr)
2001	3.7	165	13	29	0.019
2002	5.1	225	21	34	0.030
2003	1.6	70	5	24	0.007
2004	5.1	226	14	23	0.020
2005	4.5	200	10	18	0.014
2007	2.6	115	30	95	0.043
2008	2.1	92	7	26	0.009
2009	2.0	88	15	61	0.021
Average	3.3	148	16	39	0.022

Note (Table C.7): P8 modeling for the Amelia Lake sub-watershed (533.47 acres excluding open water) was performed to determine annual runoff rates. Runoff volumes were applied to the measured in lake concentrations for lake response modeling to determine the annual TP load to Wilkinson Lake in lbs. This calculated annual load is presented in the table above. The areal export rate reported was calculated using the entire sub-watershed area of 691.33 acres.

Notes (Tables C.1-C.7):

P8 model inputs for each modeled lake shed excluded all areas with an open water land use designation. The P8 model outputs for annual runoff volume and TP concentration were applied to the lake shed area excluding only the actual lake area for lake response modeling. Due to the slight difference in these lake shed areas, aerial export rates shown in Tables C.1-C.7 may vary slightly from those reported in Table B.11 (which were calculated from the lake response modeling results).

Appendix D

Subwatershed Air Photos, Landuse, and MS4 Maps for Each Impaired Water Body

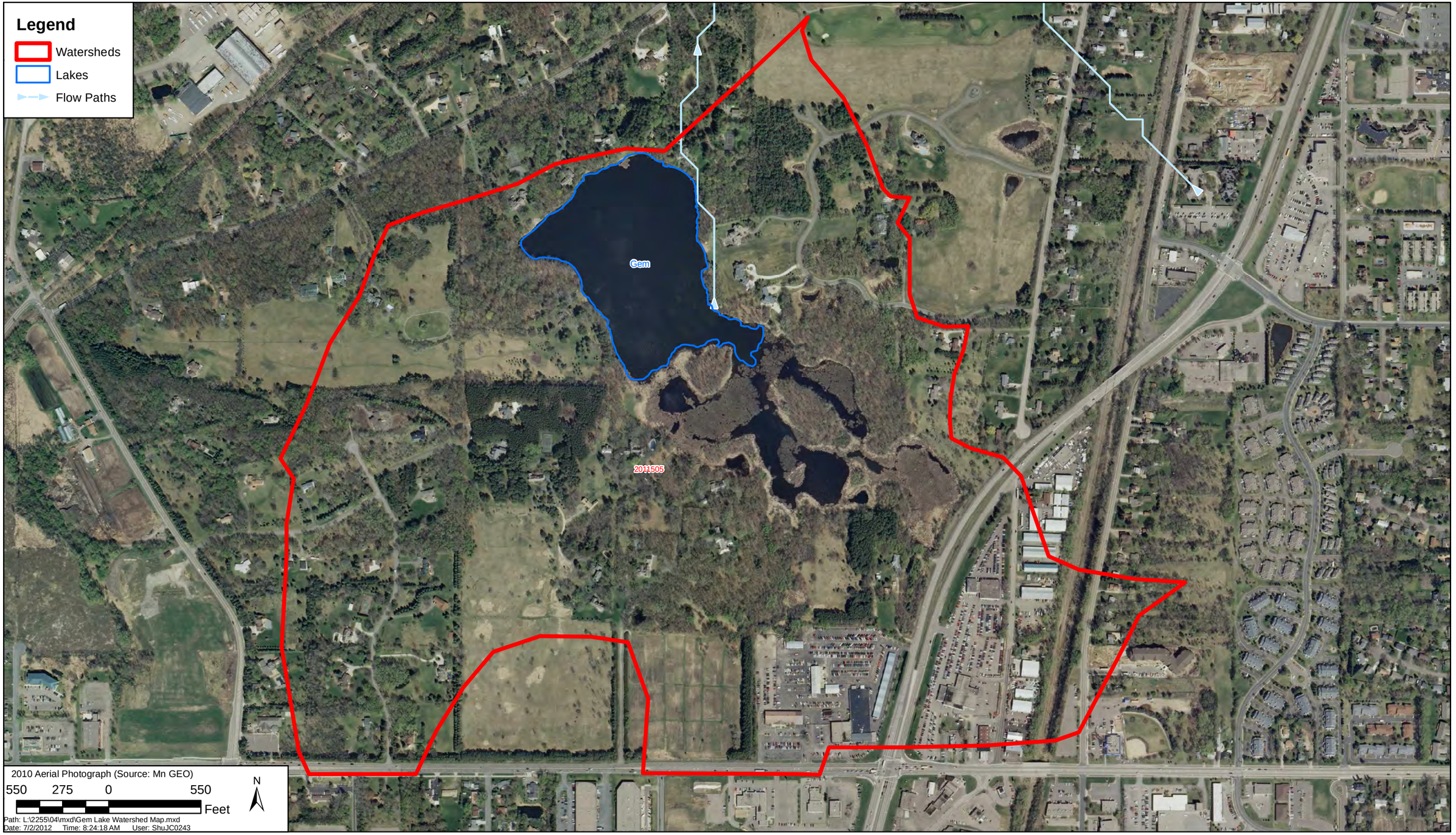


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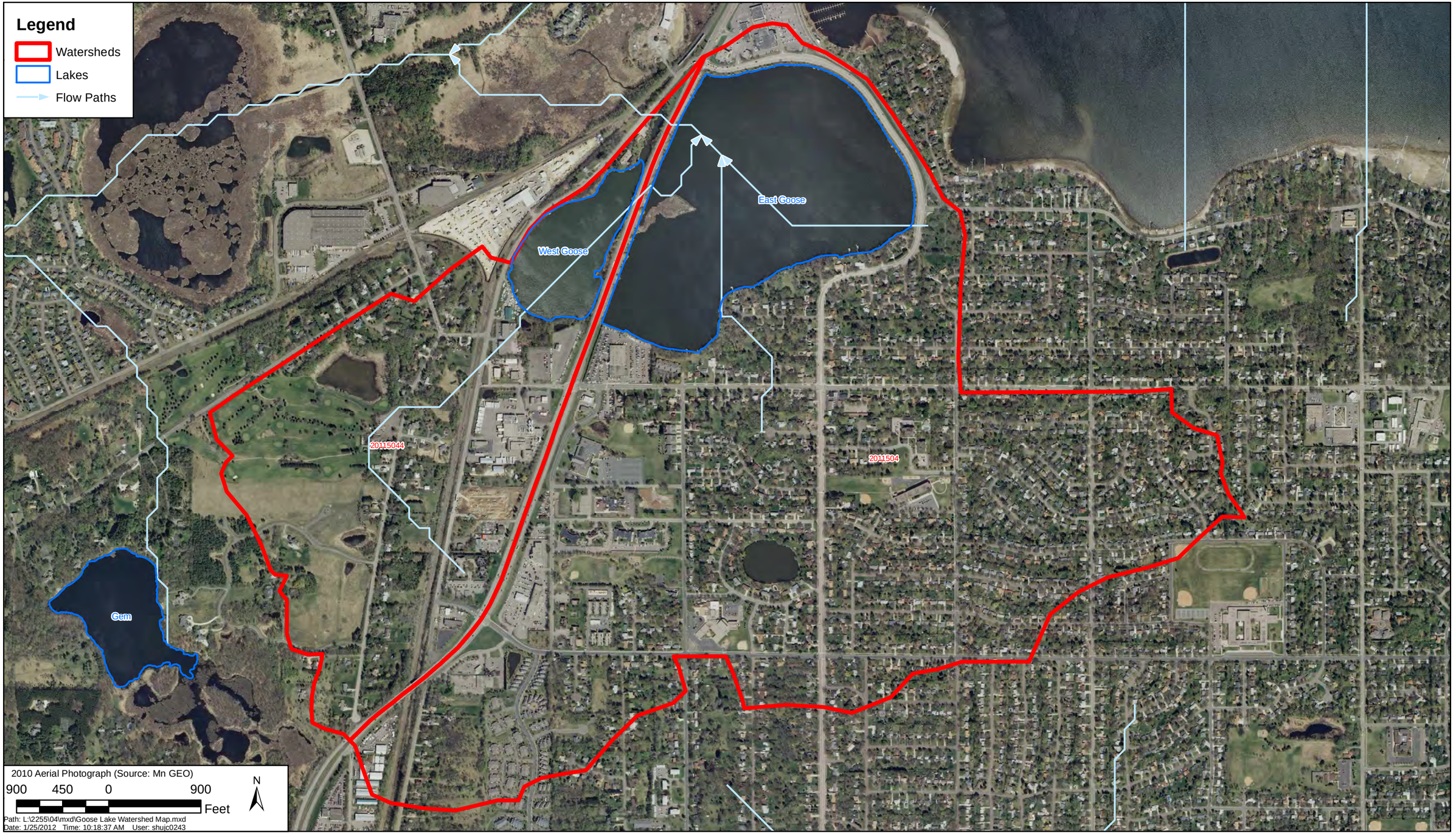
Figure 1



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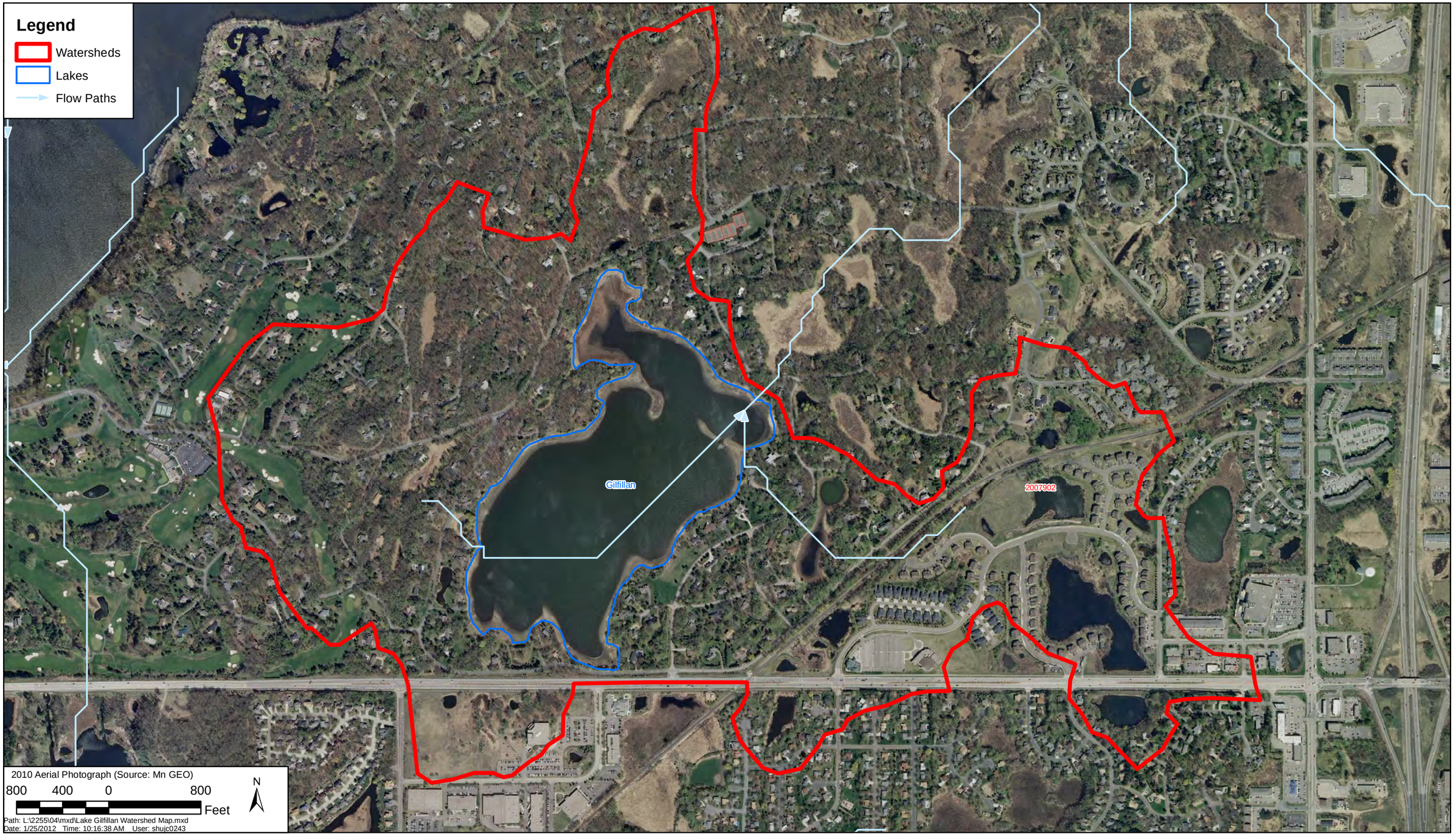

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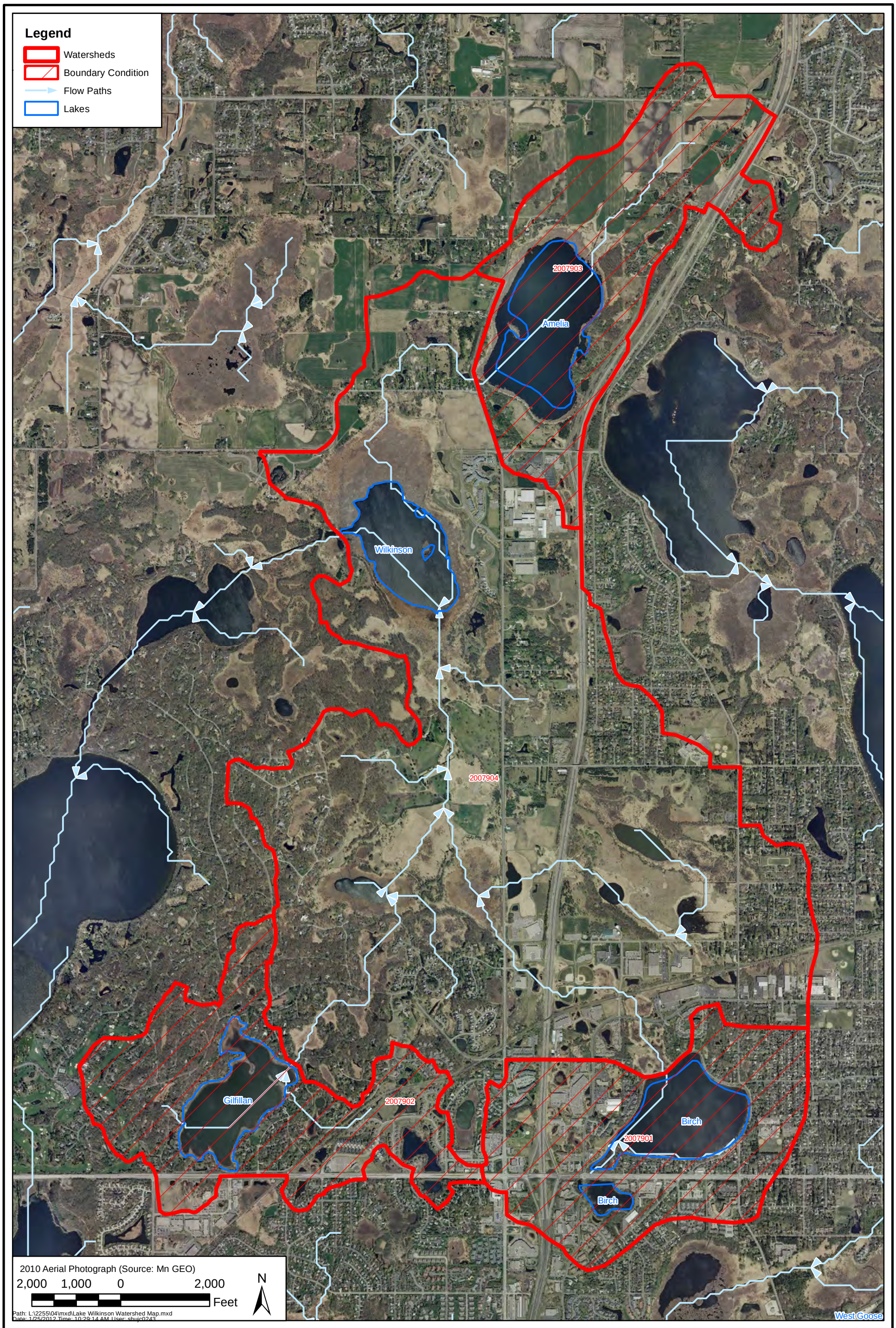

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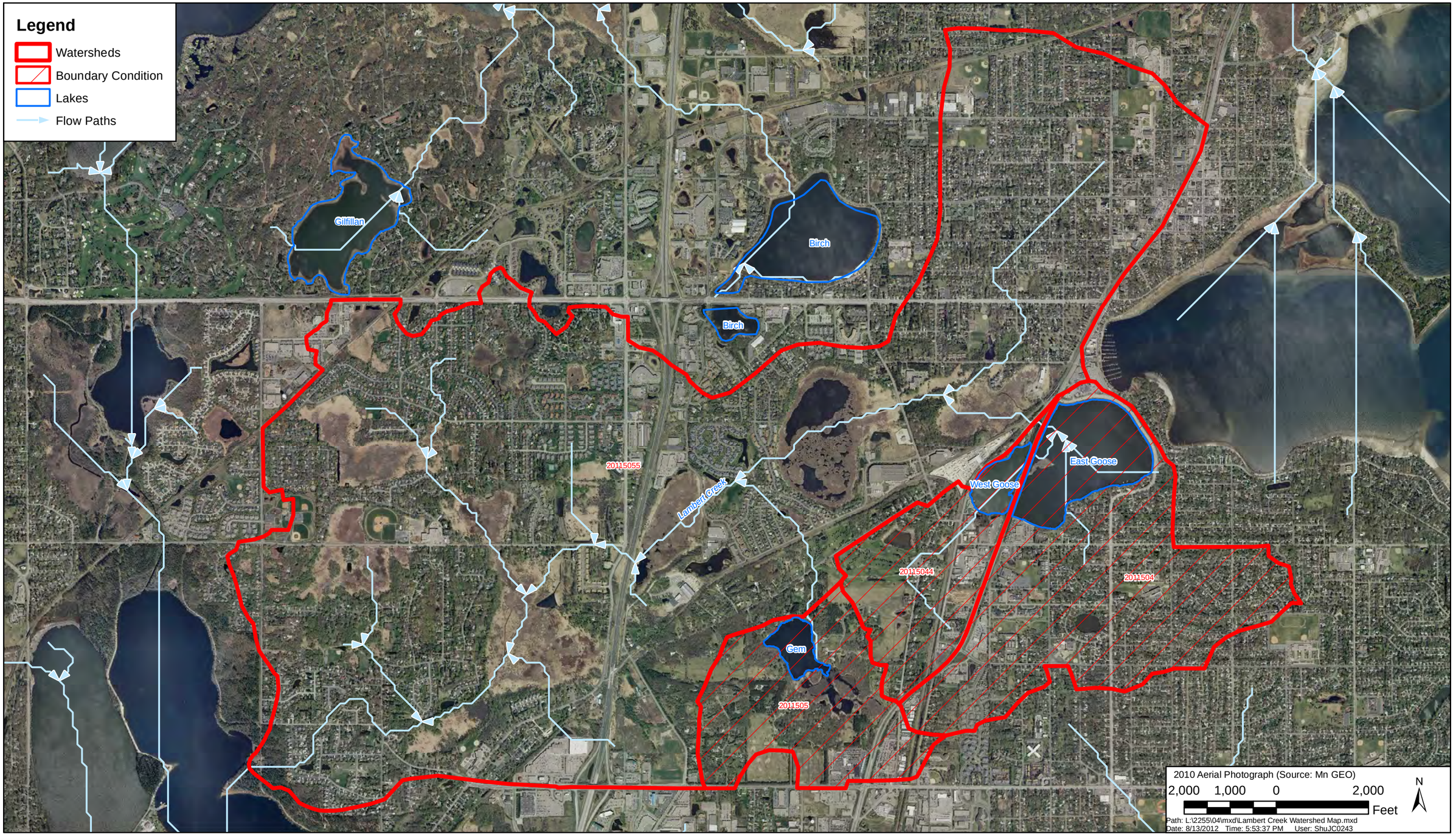

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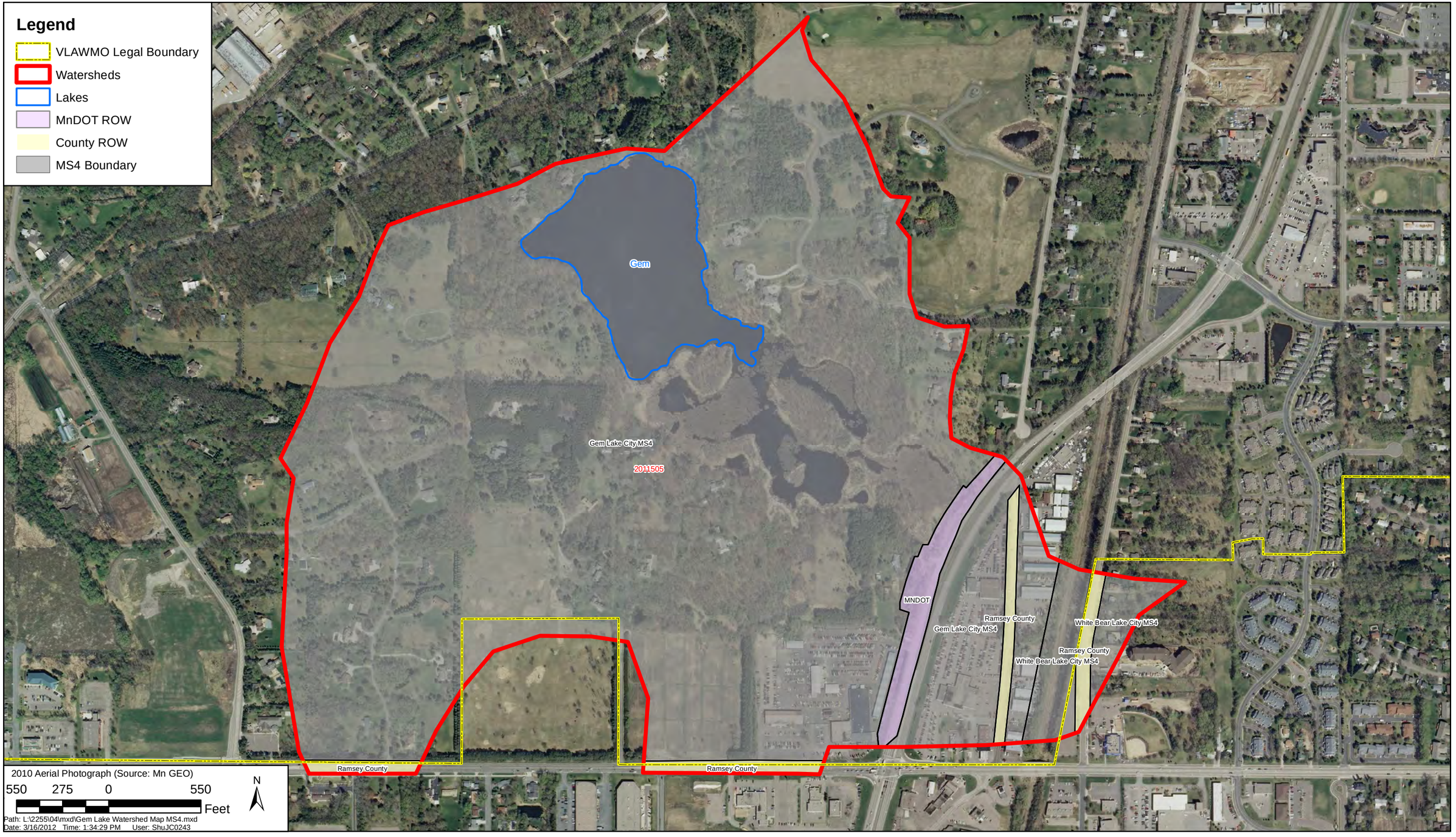

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Gem Lake Watershed and MS4 Boundary Map

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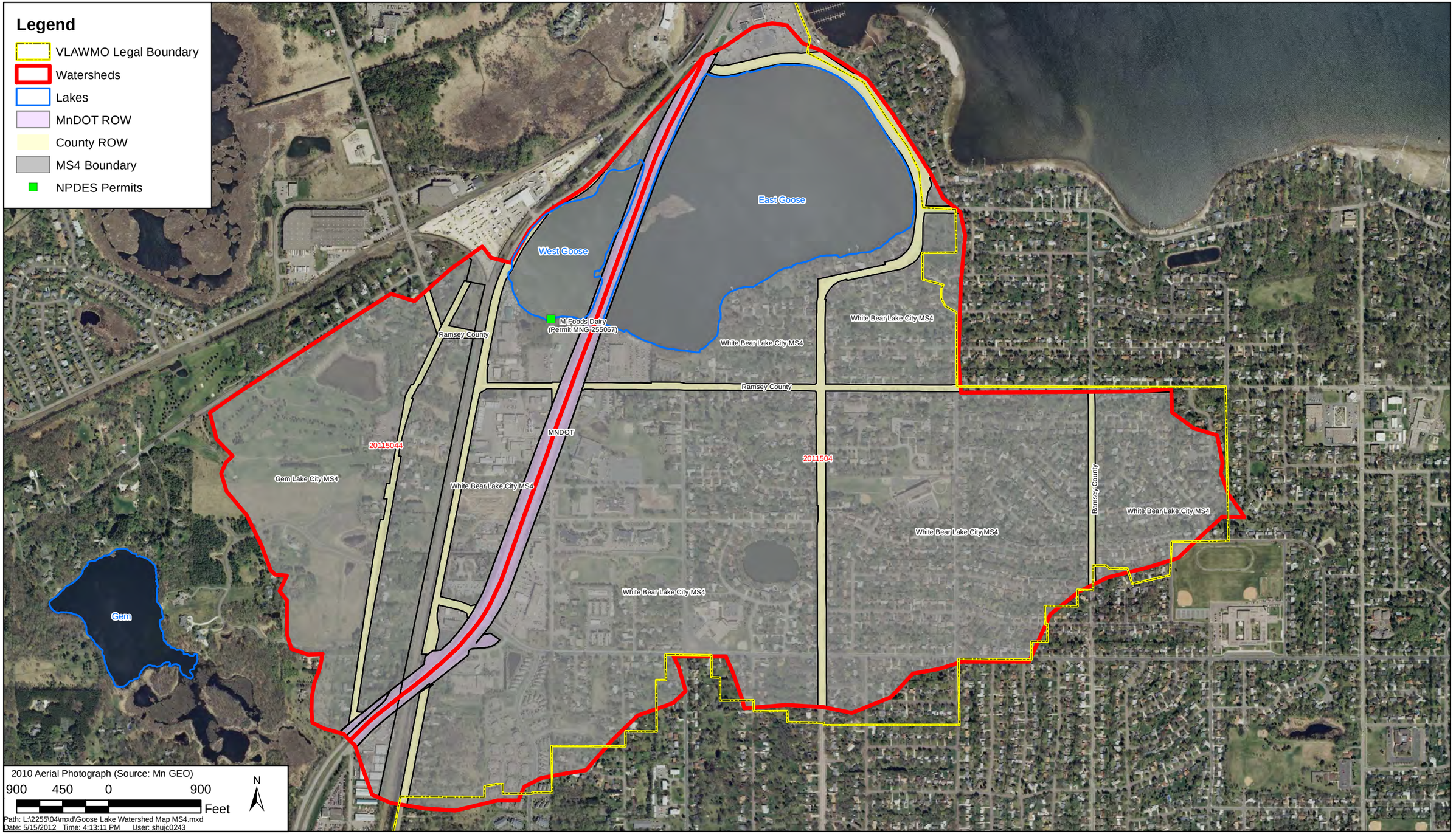

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Goose Lake Watershed and MS4 Boundary Map

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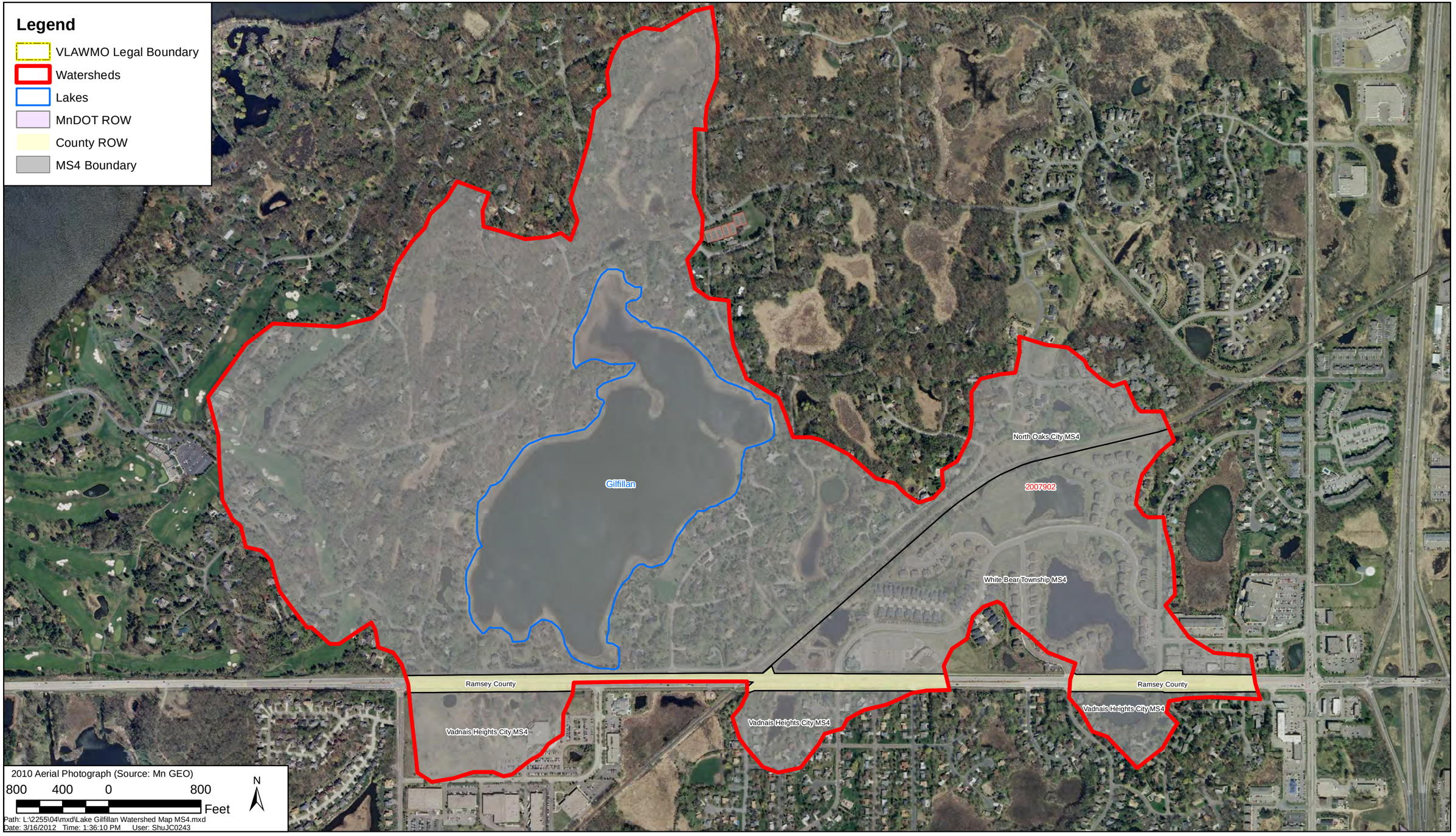

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Lake Gilfillan Watershed and MS4 Boundary Map

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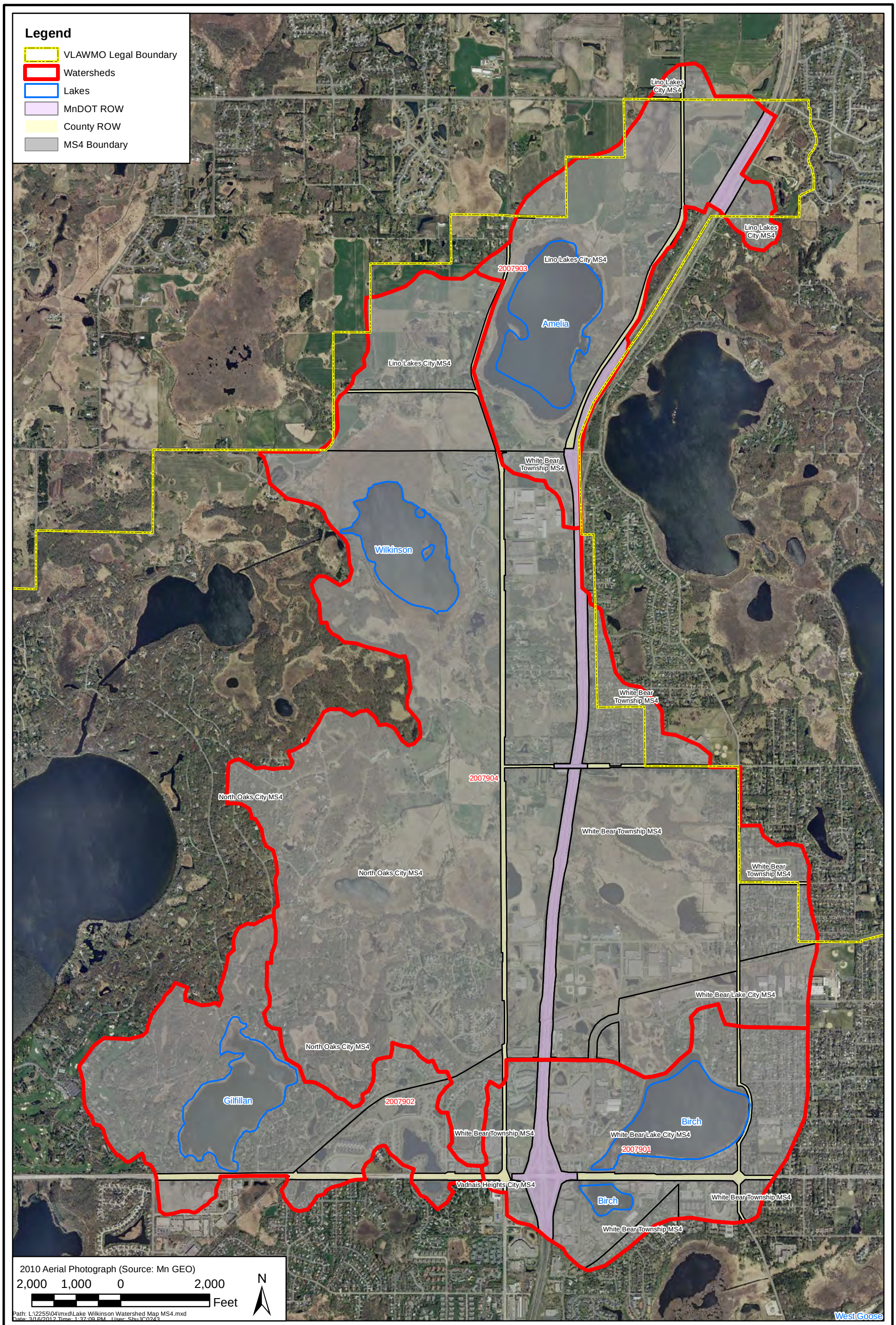

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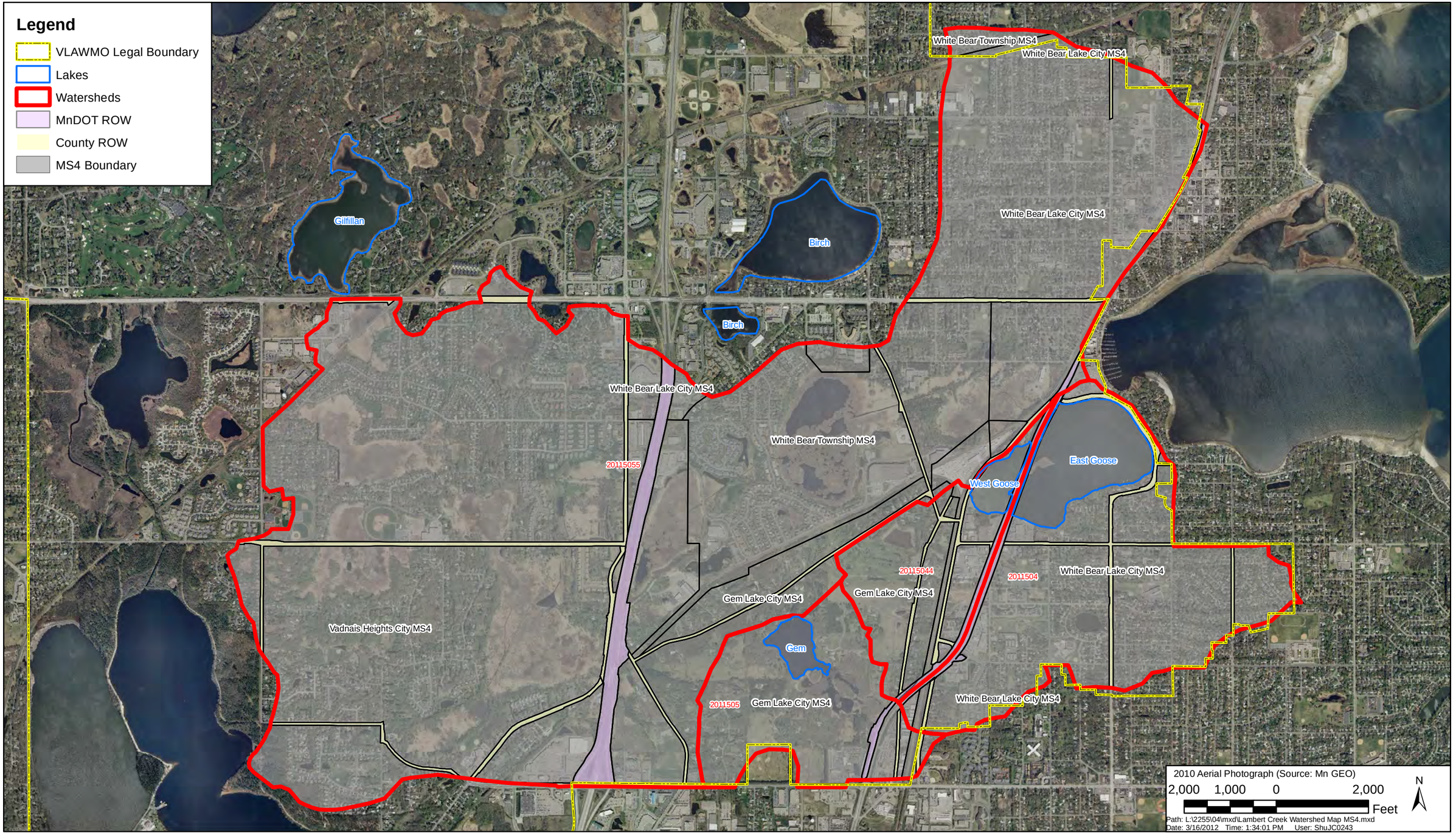

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Lambert Creek Watershed and MS4 Boundary Map

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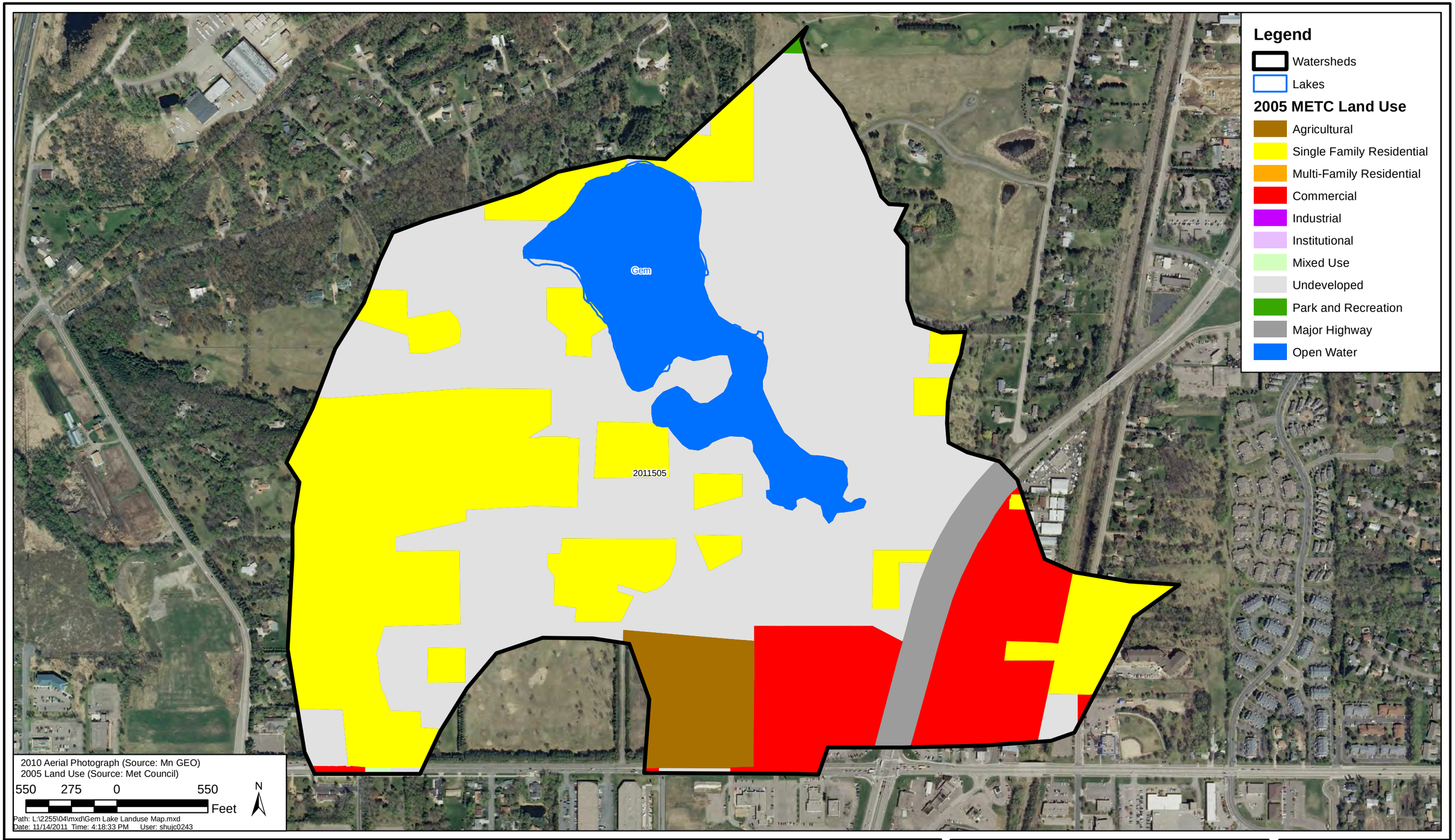

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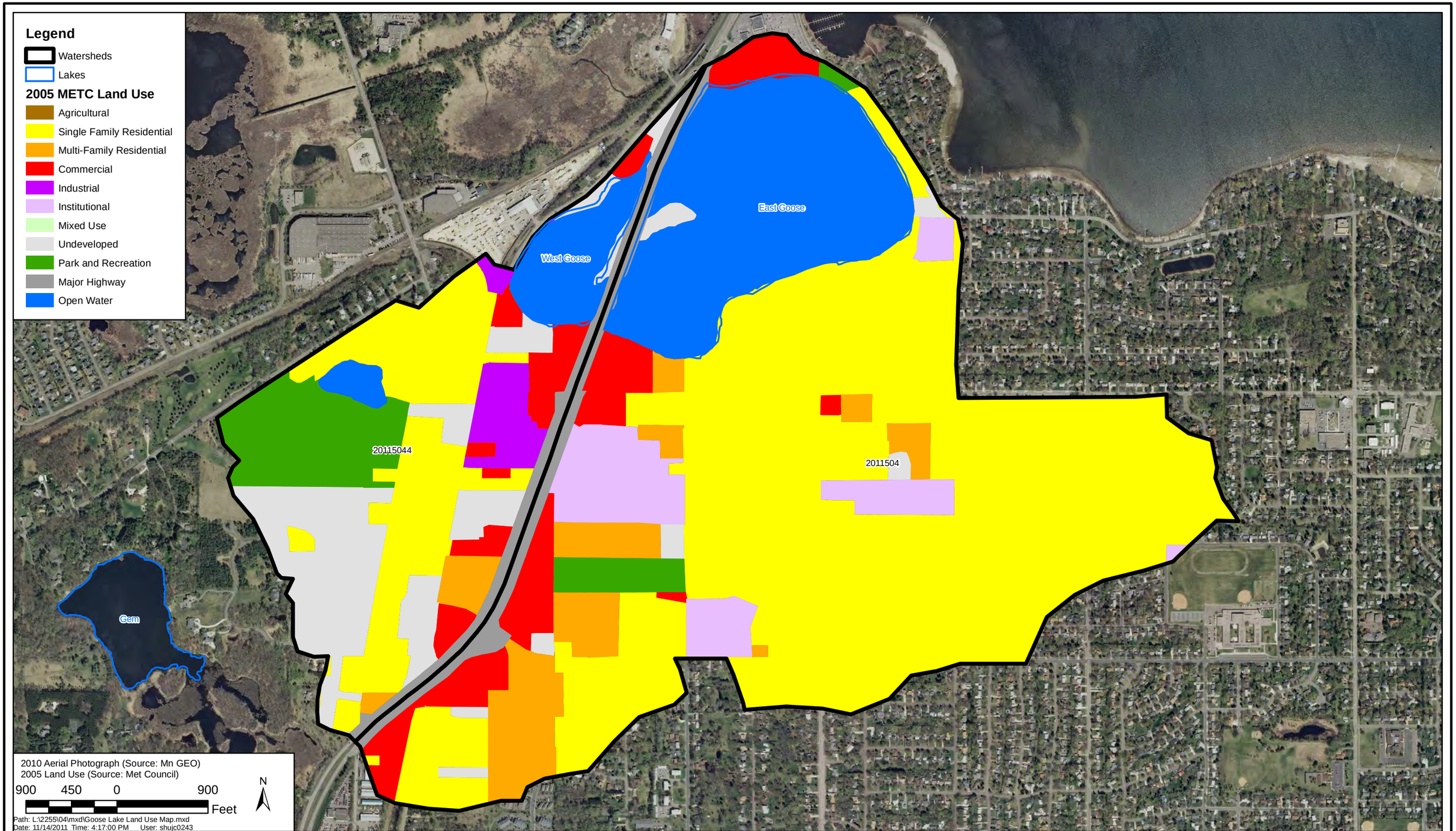
NOV 2011

Figure 1



VADNAIS LAKE AREA WMO

Goose Lake Watershed Land Use Map

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Business Professionals
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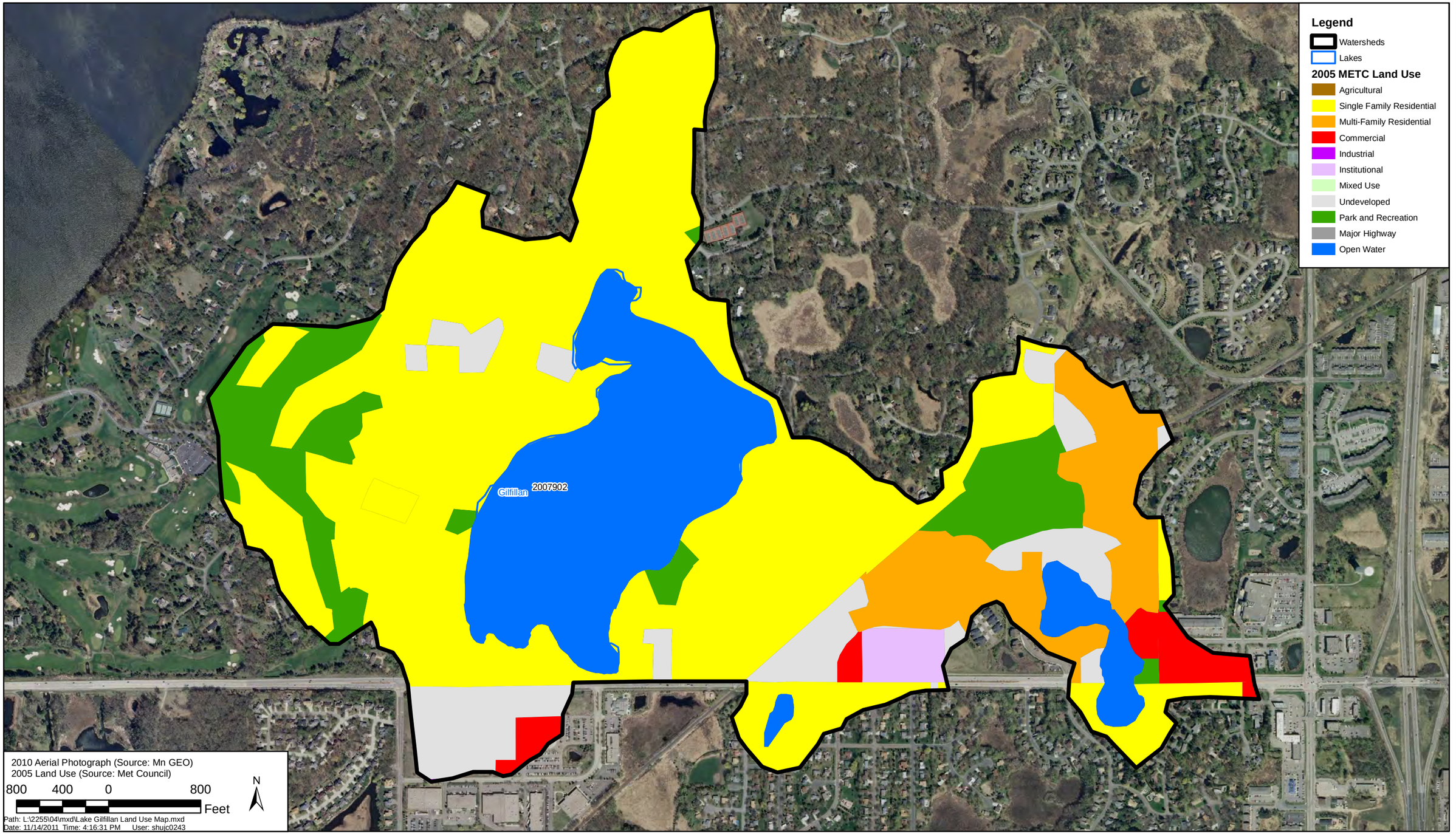
NOV 2011

Figure 1



VADNAIS LAKE AREA WMO

Lake Gilfillan Watershed Land Use Map

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Figure 1

Legend

Watersheds

Lakes

2005 METC Land Use

- Agricultural
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Institutional
- Mixed Use
- Undeveloped
- Park and Recreation
- Major Highway
- Open Water

2007903

Wilkinson

2007904

Gilfillan

2007901

East Goose

2010 Aerial Photograph (Source: Mn GEO)
2005 Land Use (Source: Met Council)

2,000 1,000 0 2,000 Feet

N

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VADNAIS LAKE AREA WMO

Lake Wilkinson Watershed Land Use Map

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Figure 1

Legend

- Watersheds
- Lakes

2005 METC Land Use

- Agricultural
- Single Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Institutional
- Mixed Use
- Undeveloped
- Park and Recreation
- Major Highway
- Open Water

Gilfillan
20115055
East Goose
West Goose
20115044
2011504
Gem
2011505

2010 Aerial Photograph (Source: Mn GEO)
2005 Land Use (Source: Met Council)

2,000 1,000 0 2,000 Feet

N

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VADNAIS LAKE AREA WMO

Lambert Creek Watershed Land Use Map

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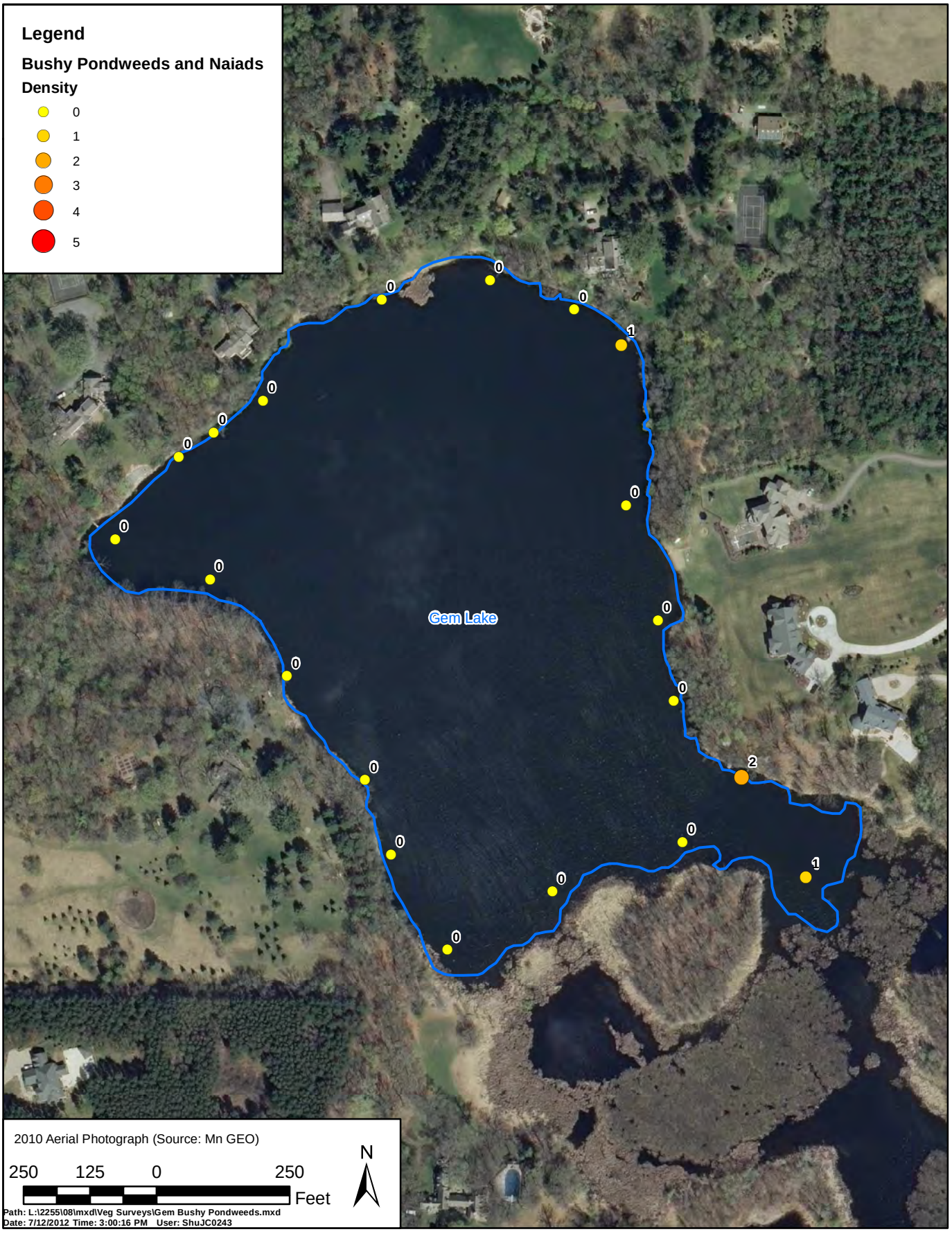
Figure 1

Appendix E

VLAWMO Informal Plant Surveys for Impaired Lakes Map Results



VADNAIS LAKE AREA WMO

Gem Lake- Bushy Pondweeds and Naiads

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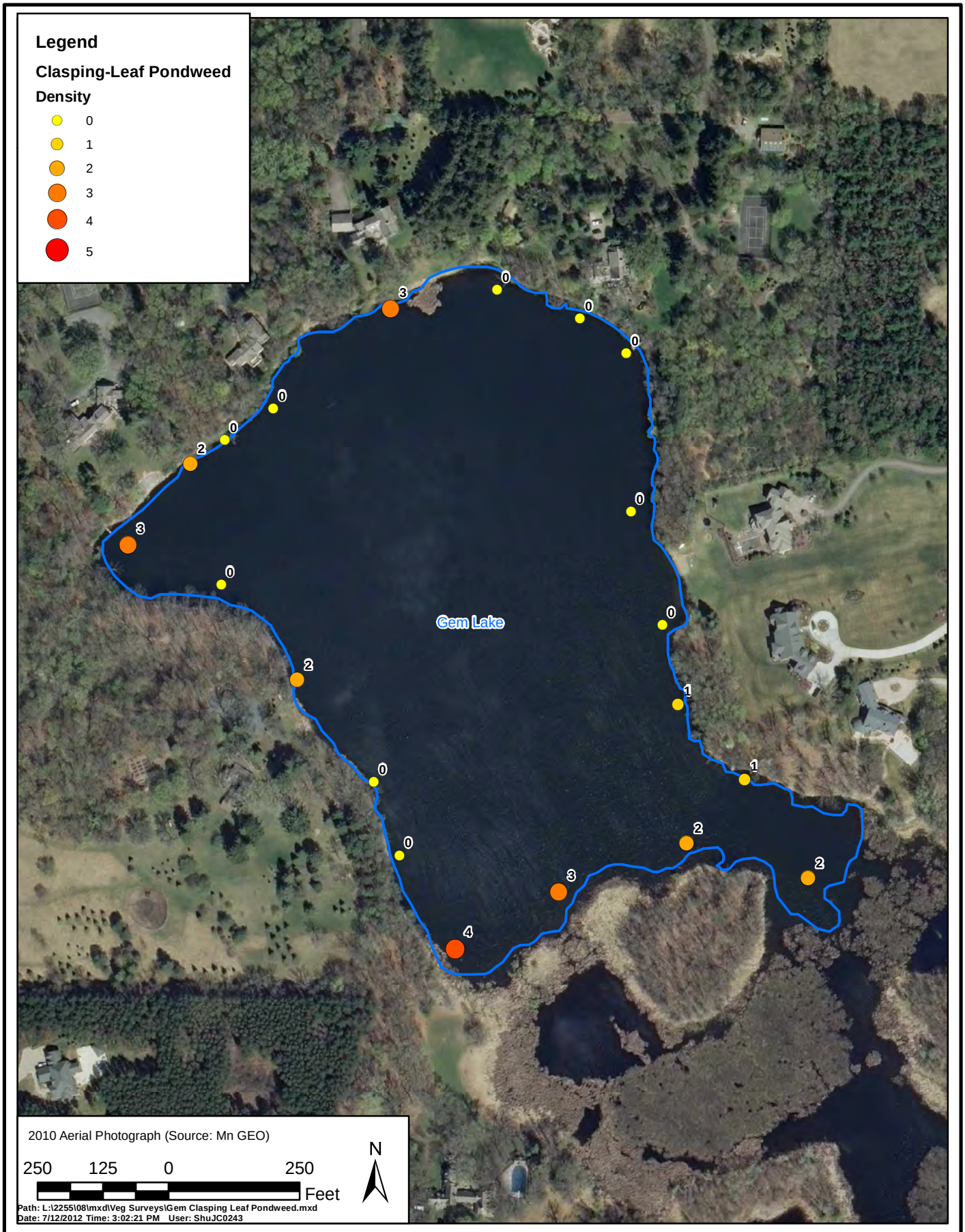

VADNAIS LAKE AREA WMO

Gem Lake- Clasping Leaf Pondweed

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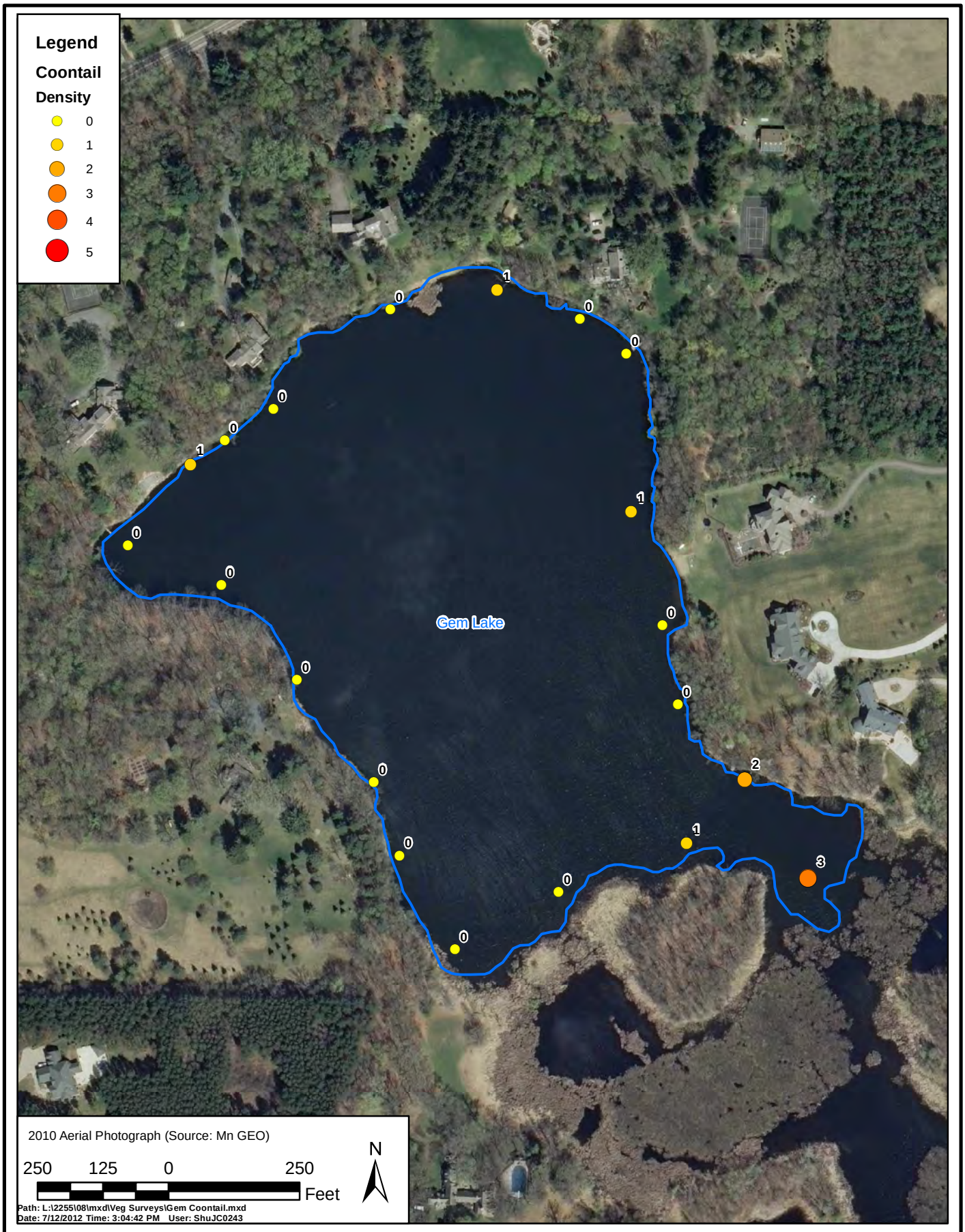

VADNAIS LAKE AREA WMO

Gem Lake- Coontail

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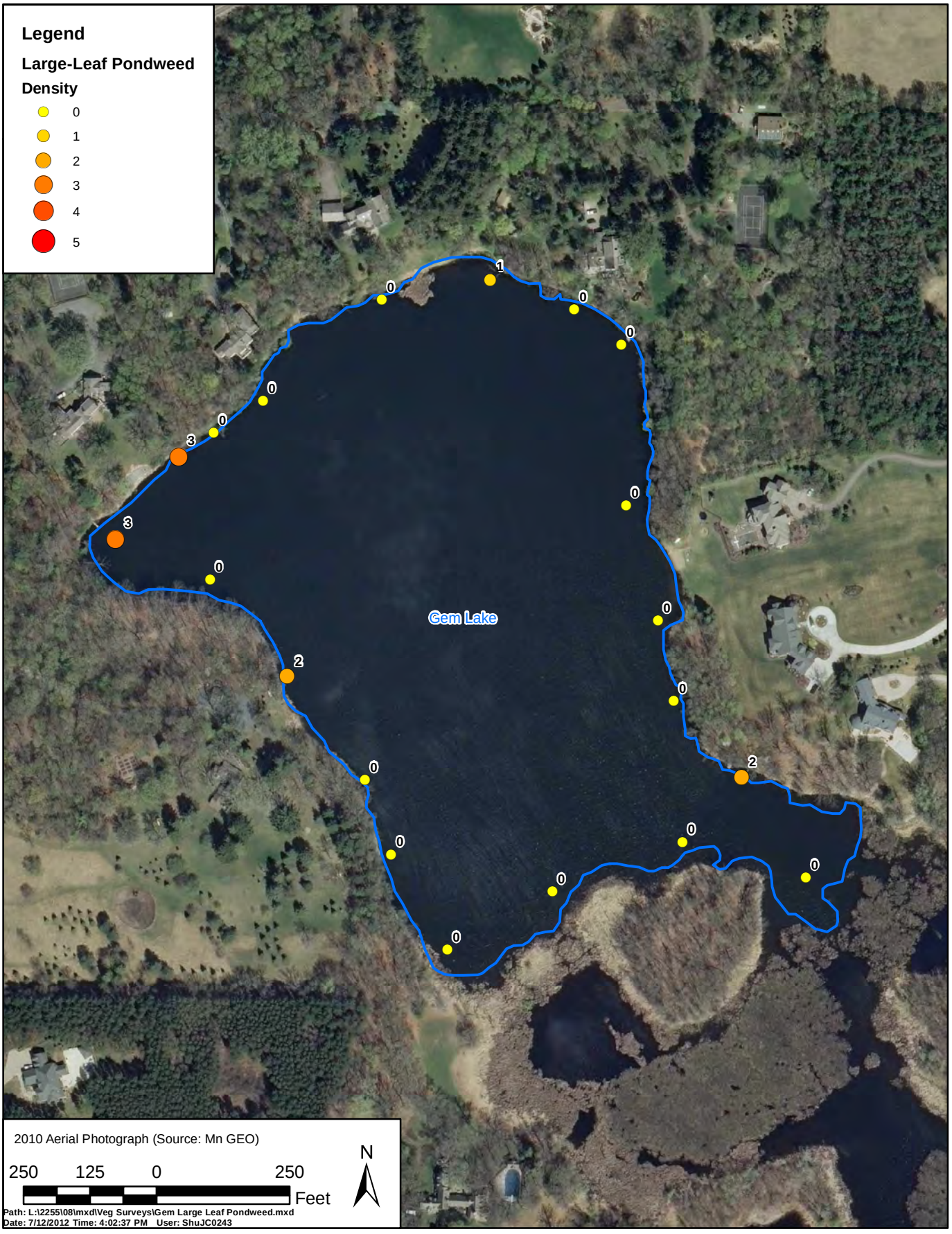

VADNAIS LAKE AREA WMO

Gem Lake- Large Leaf Pondweed

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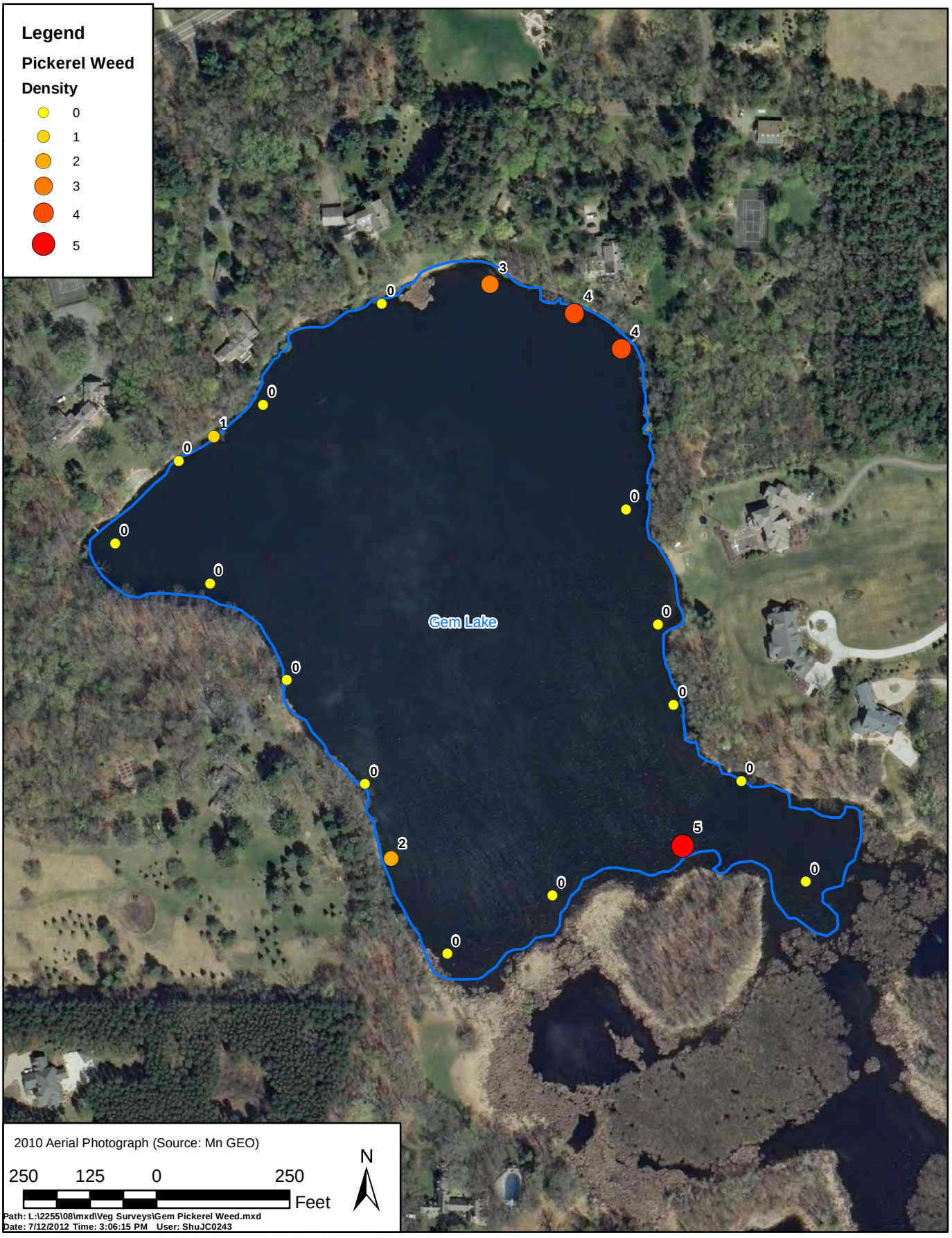

VADNAIS LAKE AREA WMO

Gem Lake- Pickerel Weed

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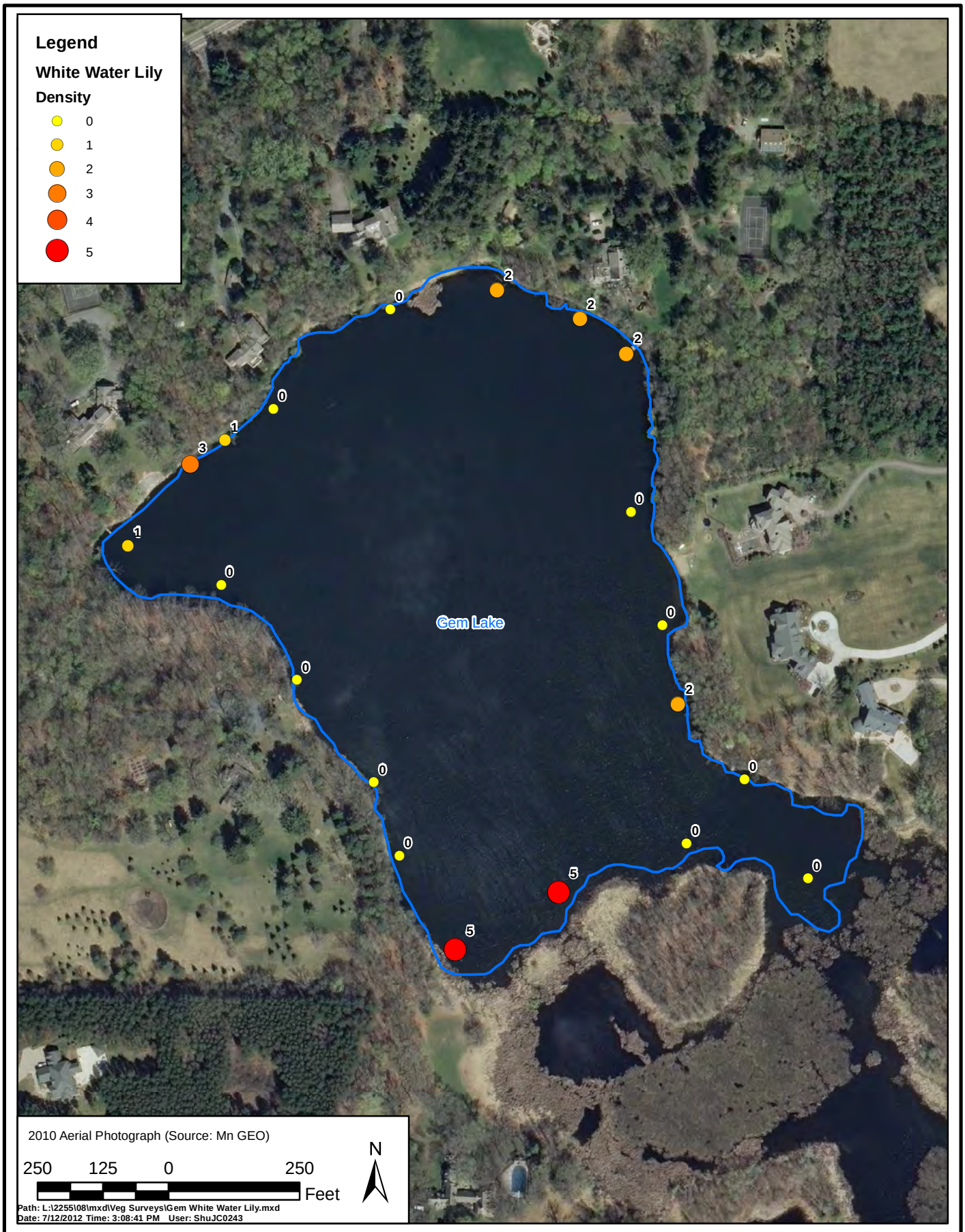

VADNAIS LAKE AREA WMO

Gem Lake- White Water Lily

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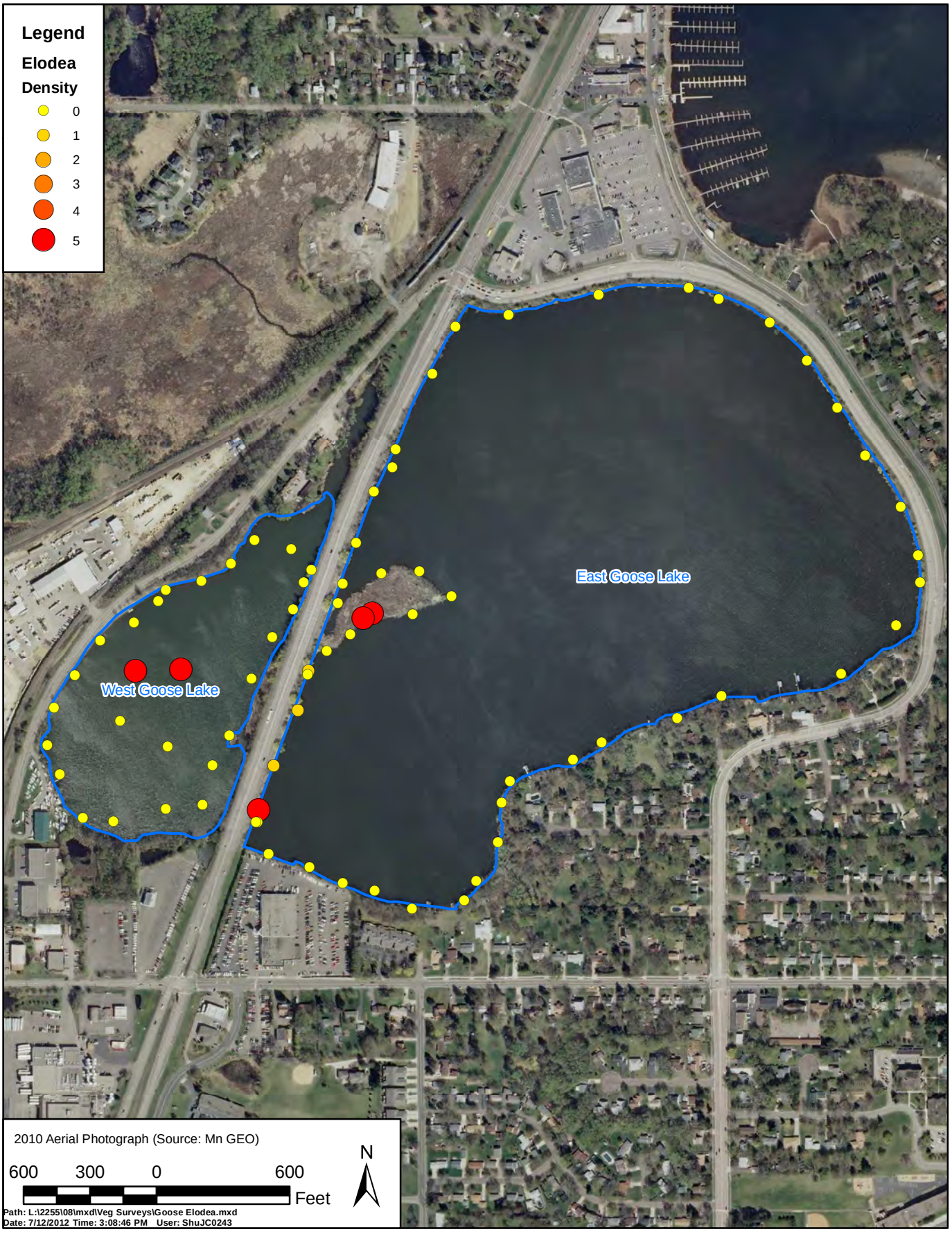

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Goose Lake- Elodea

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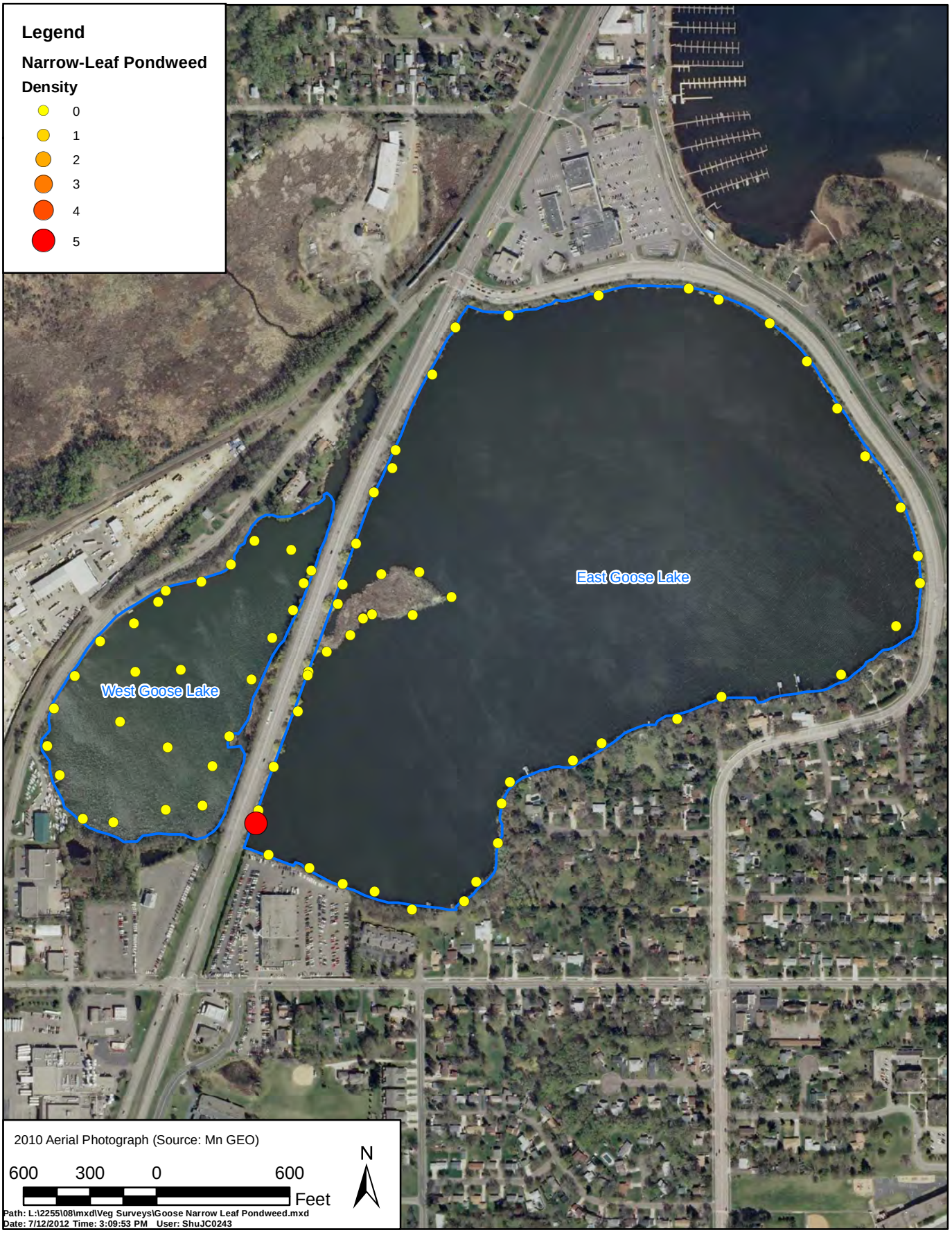

VADNAIS LAKE AREA WMO

Goose Lake- Narrow Leaf Pondweed

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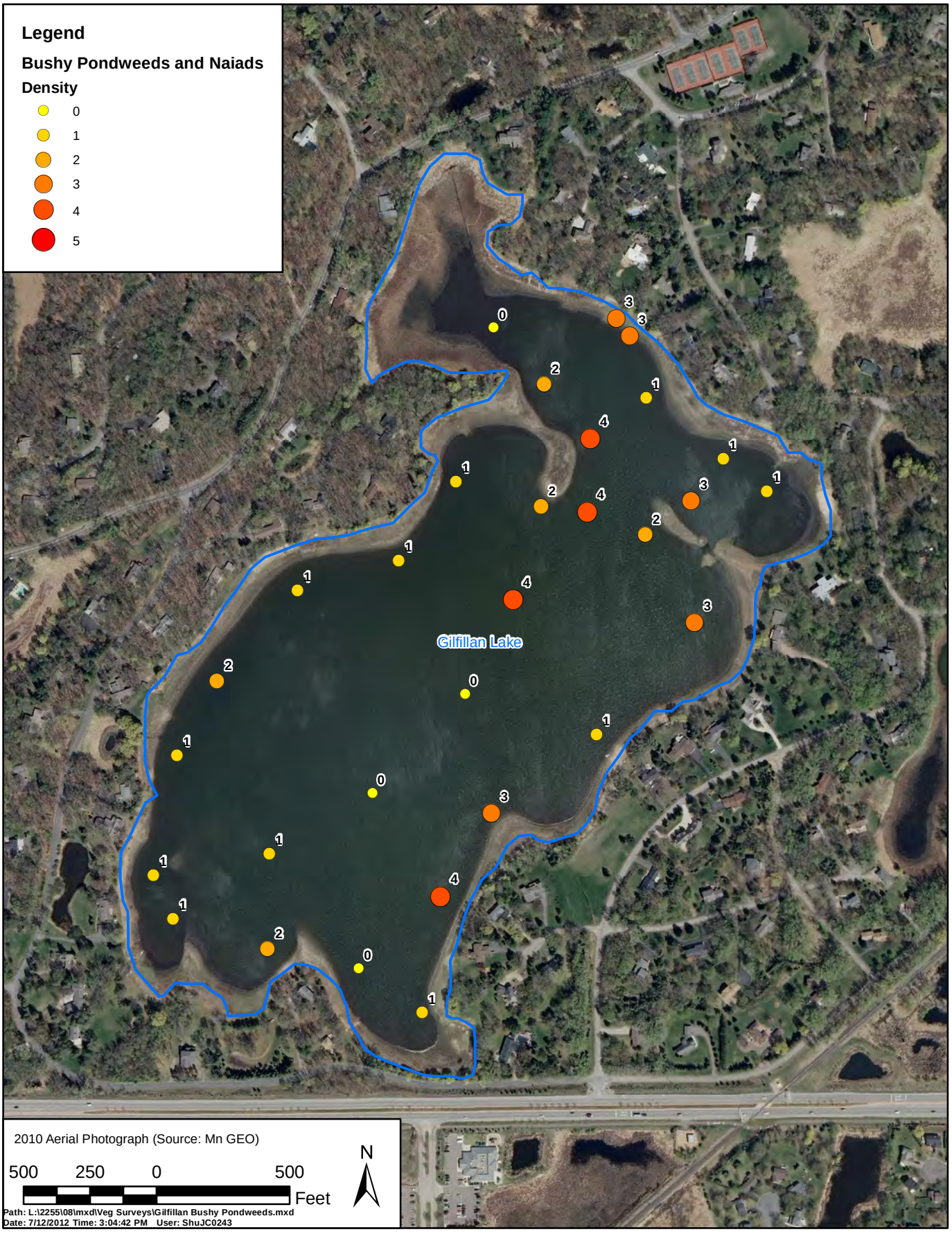

VADNAIS LAKE AREA WMO

Gilfillan Lake- Bushy Pondweeds and Naiads

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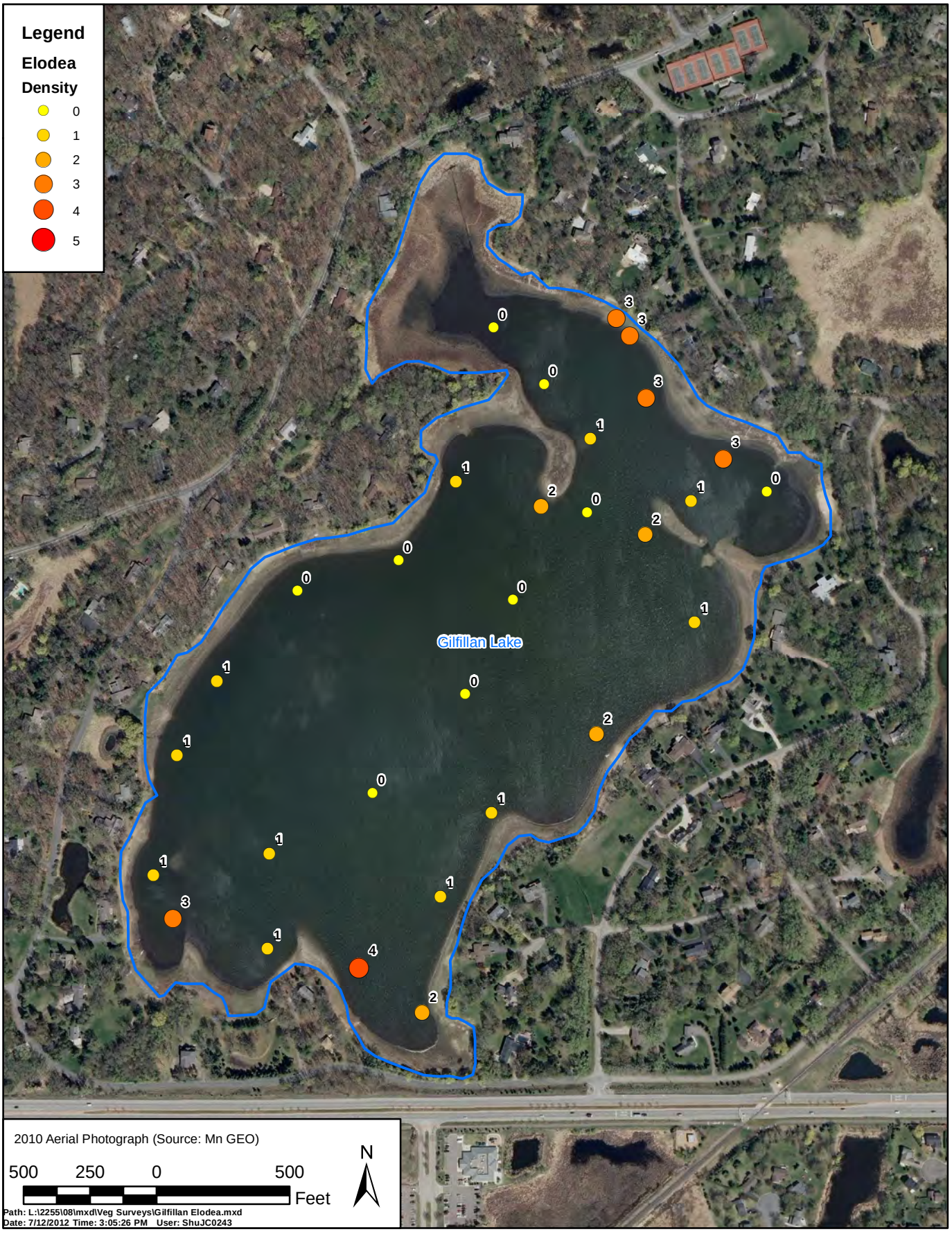

VADNAIS LAKE AREA WMO

Gilfillan Lake- Elodea

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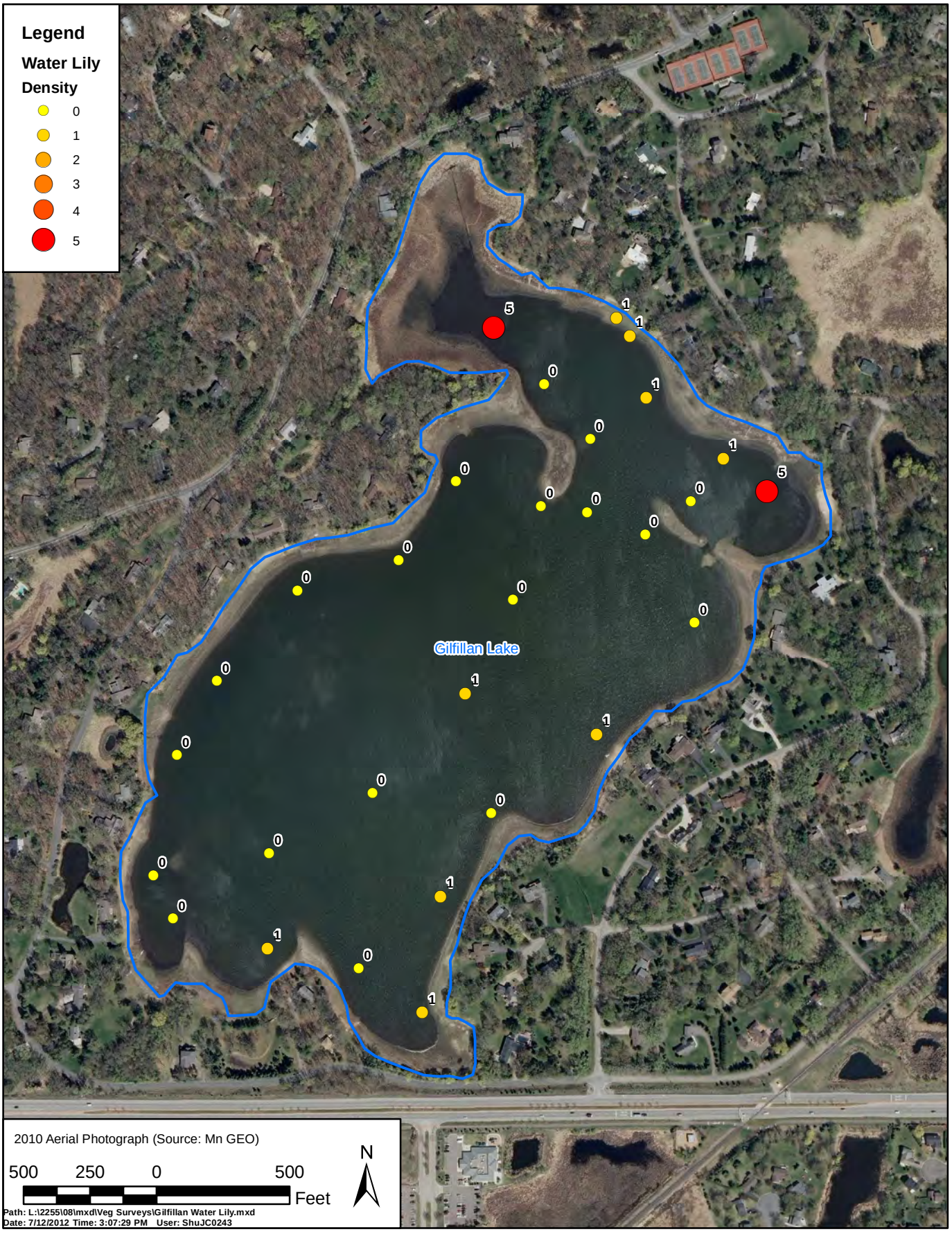

VADNAIS LAKE AREA WMO

Gilfillan Lake- Water Lily

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Appendix F

May 3, 2012 TMDL Open House & Workshop Summary of Public Comment

Results of electronic, end-of-workshop assessment and stakeholder input.

Participants responded to a series of 11 multiple choice questions using the instantaneous Turning Point electronic assessment system. Some summary statements are below:

- 42% of the participants indicated the TMDL has large implications to their city or organization. 21% said a little. 11% no impacts. 26% did not know yet.
- 61% of the participants only slightly better understood the bacteria reductions needed. 22% indicated they understood them much better.
- 33% of the participants indicated that their city or organization could do a lot to implement new practices and policies to achieve the reductions. 39% indicated they thought their city or organization could do a little. No one said they could not do anything, however, 11% did not know yet what they could do.
- 76% indicated a good to very good understanding of the sources of the pollutants to the five lakes and Lambert Creek.
- Participants highly varied in their understanding of how the recommended reductions were determined and assigned. 42% said good/very good understanding, 37% said average/fair, 21% said poor, 0% said very poor
- 50% agreed strongly with the target reductions, 22% somewhat agreed, 11% strongly disagreed, and 17% indicated they did not know their level of agreement quite yet.