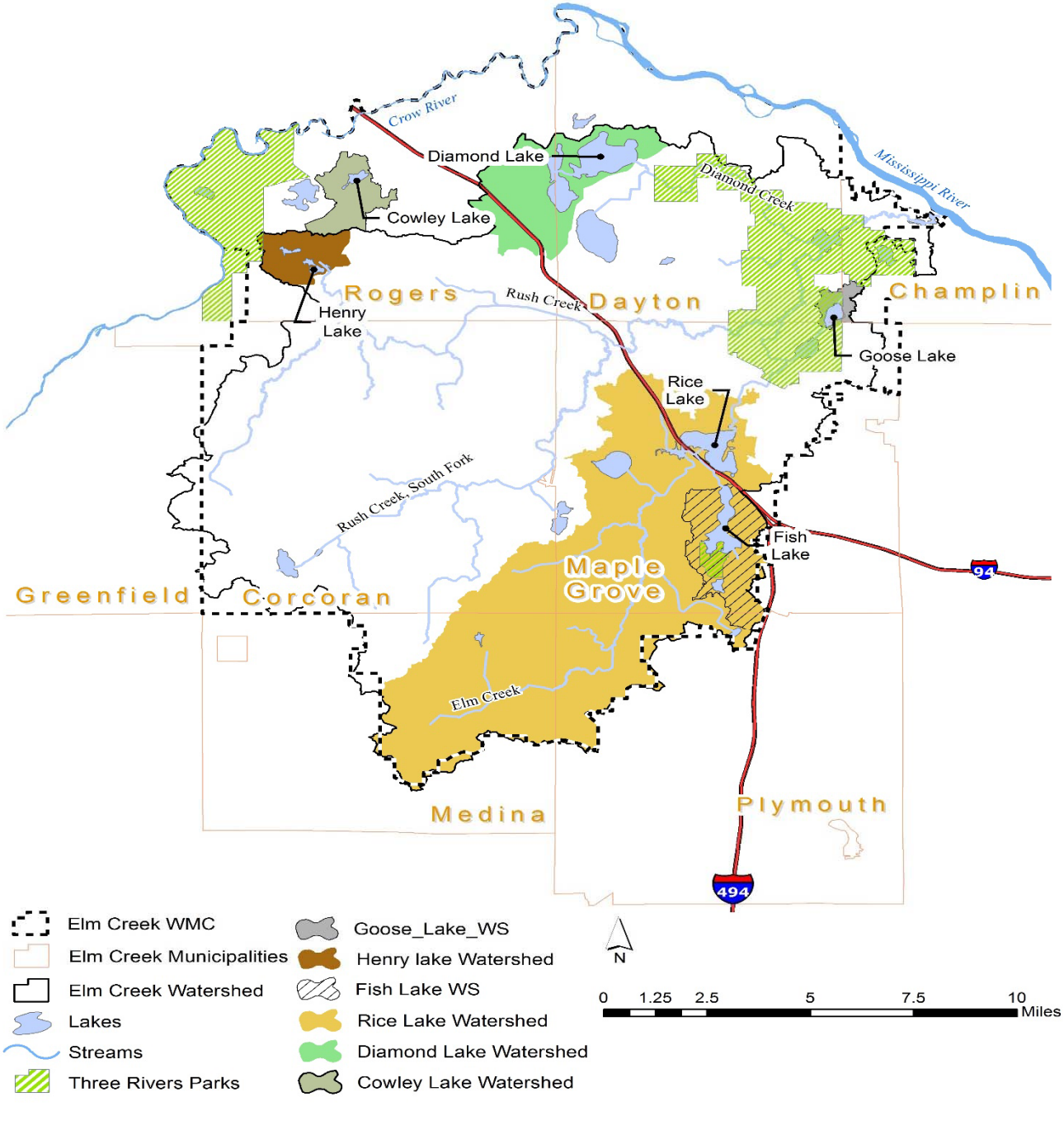
Elm Creek Watershed Restoration and Protection Plan (WRAPP)

Elm Creek Watershed Lakes – Part II

Elm Creek Watershed Management Commission Technical Advisory Committee Meeting
September 10, 2014


Crow River
Diamond Lake
Diamond Creek
Mississippi River
Cowley Lake
Rogers
Rush Creek
Dayton
Champlin
Henry Lake
Goose Lake
Rice Lake
Rush Creek, South Fork
Fish Lake
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Maple Grove
Greenfield
Corcoran
Elm Creek
Medina
Plymouth
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Elm Creek WMC
Elm Creek Municipalities
Elm Creek Watershed
Lakes
Streams
Three Rivers Parks
Goose_Lake_WS
Henry lake Watershed
Fish Lake WS
Rice Lake Watershed
Diamond Lake Watershed
Cowley Lake Watershed
N
0
1.25
2.5
5
7.5
10
Miles

Outline of Presentation

- Focus on Diamond Lake, Henry Lake, Cowley Lake (all listed as impaired), and Goose Lake (likely impaired, not listed)
- Current conditions, watershed/lake characteristics
- Modeling approach, results for all 4 lakes
- Preliminary loading capacities and allocations for all 4 lakes
- Next Steps

What is a Total Maximum Daily Load (TMDL)?

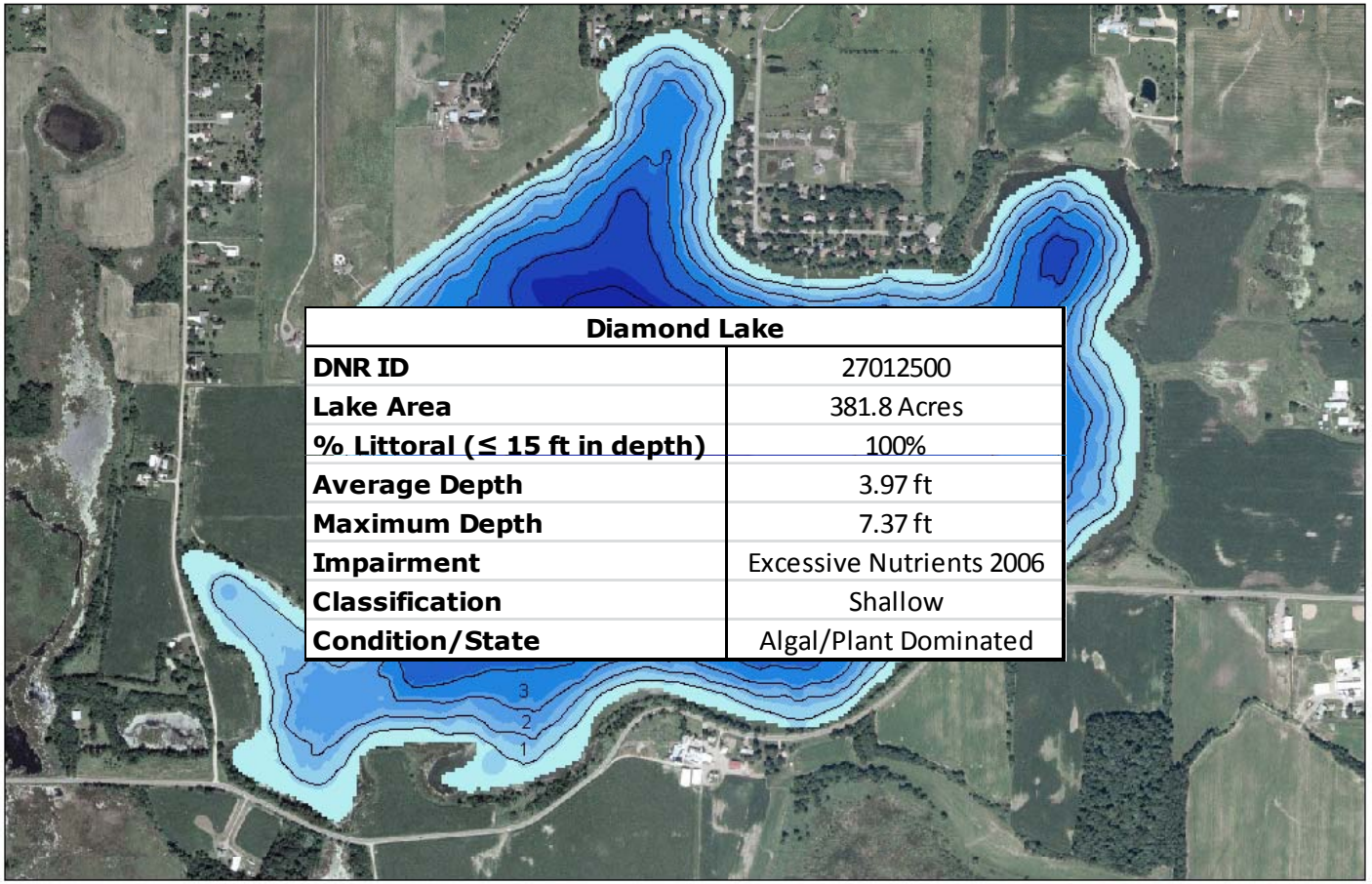
$$TMDL \equiv LC = \sum LA + \sum WLA + MOS$$

- The maximum amount of a pollutant that a water body can receive and still meet water quality standards
- For lakes, focus is on the phosphorus budget
  - -External sources
  - -Internal P recycling
  - -Atmospheric deposition

TMDL Modeling Approach

- Estimate the watershed, internal, and atmospheric loading to the lake.
- Input sources of loading to an in-lake response model (i.e. BATHTUB model).
- Calibrate the in-lake response model to observed water quality conditions.
- In-lake response simulations to estimate the load reduction necessary to meet water quality standards.

Diamond Lake



Diamond Lake	
DNR ID	27012500
Lake Area	381.8 Acres
% Littoral (≤ 15 ft in depth)	100%
Average Depth	3.97 ft
Maximum Depth	7.37 ft
Impairment	Excessive Nutrients 2006
Classification	Shallow
Condition/State	Algal/Plant Dominated

contours

N

Depth (ft)

0.00 - 0.79	4.09 - 4.90
0.80 - 1.62	4.91 - 5.72
1.63 - 2.44	5.73 - 6.55
2.45 - 3.26	6.56 - 7.37
3.27 - 4.08	

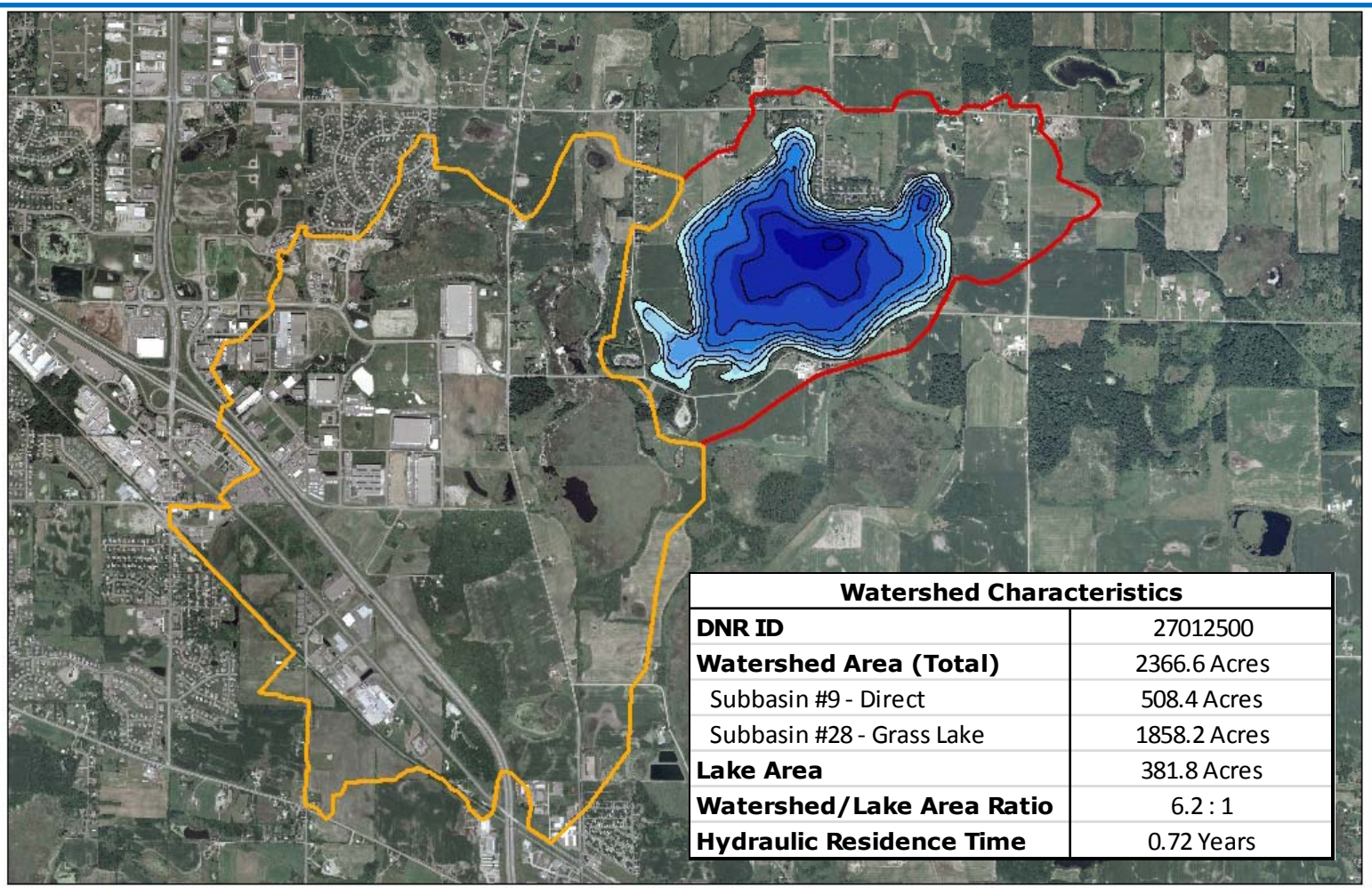
Diamond Lake

Bathymetric Map

Water Resources Department
Created by: Brian Vlach
Map Created: 8/23/2012
Survey Completed: 5/18/2012

ThreeRivers PARK DISTRICT

Diamond Lake Watershed



Watershed Characteristics	
DNR ID	27012500
Watershed Area (Total)	2366.6 Acres
Subbasin #9 - Direct	508.4 Acres
Subbasin #28 - Grass Lake	1858.2 Acres
Lake Area	381.8 Acres
Watershed/Lake Area Ratio	6.2 : 1
Hydraulic Residence Time	0.72 Years

Depth (ft)

0.00 - 0.79
0.80 - 1.62
1.63 - 2.44
2.45 - 3.26
3.27 - 4.08
4.09 - 4.90
4.91 - 5.72
5.73 - 6.55
6.56 - 7.37
contours

Watershed

Subbasin #9 - Direct
Subbasin #28 - Grass Lake

Diamond Lake

Watershed

Water Resources Department
Created by: Brian Vlach
Map Created: 8/23/2012
Survey Completed: 5/18/2012

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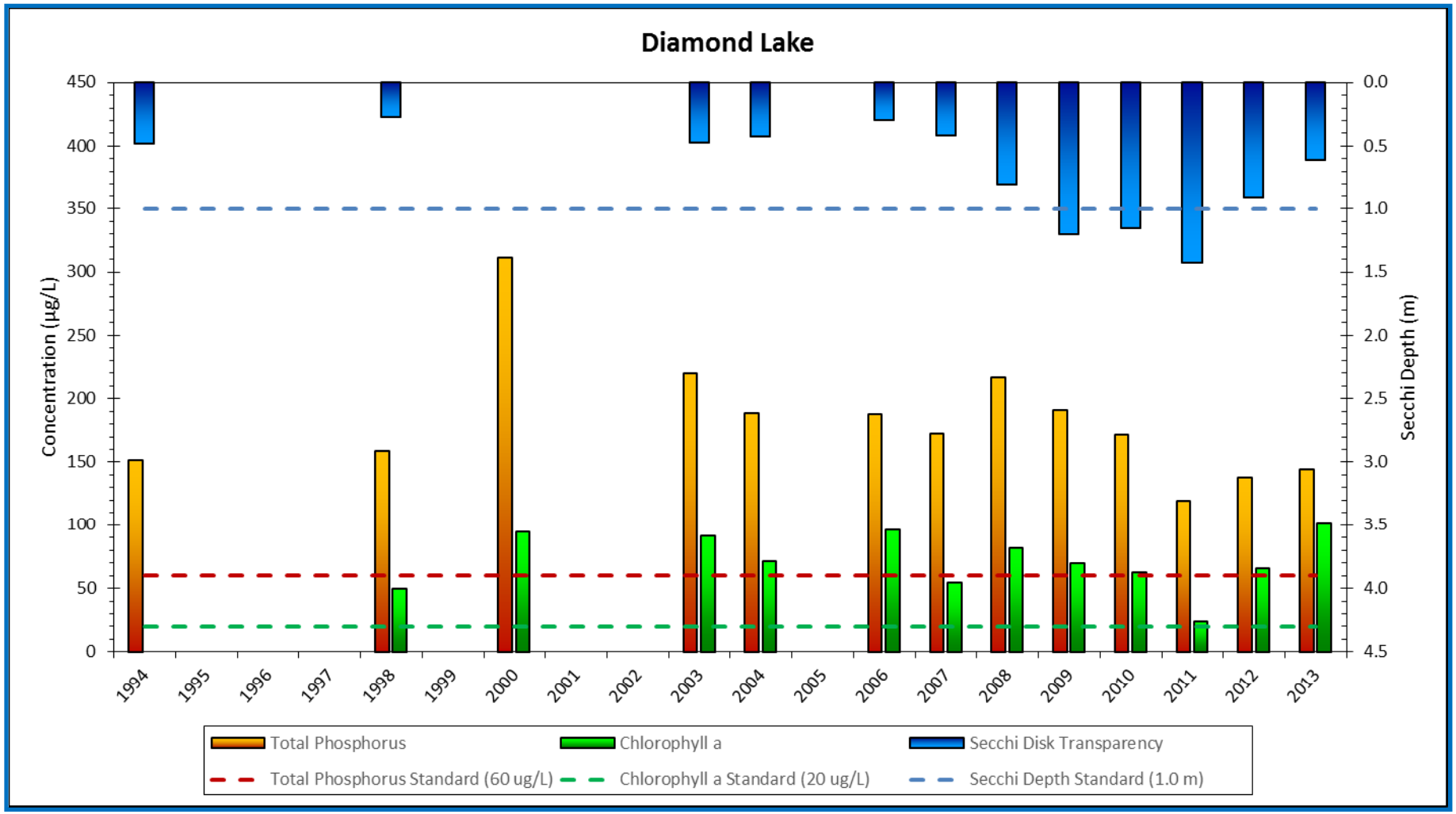
ThreeRivers

Diamond Lake Water Quality



Diamond Lake Modeling Approach

- SWAT model was used to estimate watershed loads for years with average precipitation conditions (Anoka 2010 & 2011).
  - 2010 – 27.0 inches
  - 2011 – 27.3 inches

- The average flow volumes and nutrient concentration (2010 & 2011) from SWAT model was input into the BATHTUB model.

Subbasin	Area km2	Flow Volume hm3	Total Phosphorus µg/L
Direct Subbasin #9	2.06	0.204	549.2
Upstream Subbasin #28 (Grass Lake)	7.52	2.422	568.3

- Internal load was input into the BATHTUB model to calibrate to the average in-lake total phosphorus conditions for 2010 & 2011. The BATHTUB model was then calibrated to the chlorophyll-a and secchi depth response variables.

- BATHTUB in-lake load response model used to estimate the load reduction necessary to meet water quality goals.

- Waste Load Allocations assigned to MS4's.

Diamond Lake Internal Load

- Internal Load was estimated using sediment release rates from sediment cores collected in 2012. (Analyzed by William James-STOUT Laboratory). Nürenberg equation (1988) was used to estimate anoxic and oxic internal loading for Diamond Lake.

Conditions	Total Phosphorus	
	Sediment Release Rate (mg/m2/day)	Estimated Internal Load (lbs)
Anoxia	3.2	49.9
Oxic	0.14	48.4
Total		98.3

- Curlyleaf Pondweed internal load was estimated as a range.

Condition	CLP Load lbs/acre	Surface Area Acres	Load lbs
Minimum Load	1.65	381.9	630.1
Maximum Load	3.19	381.9	1218.1

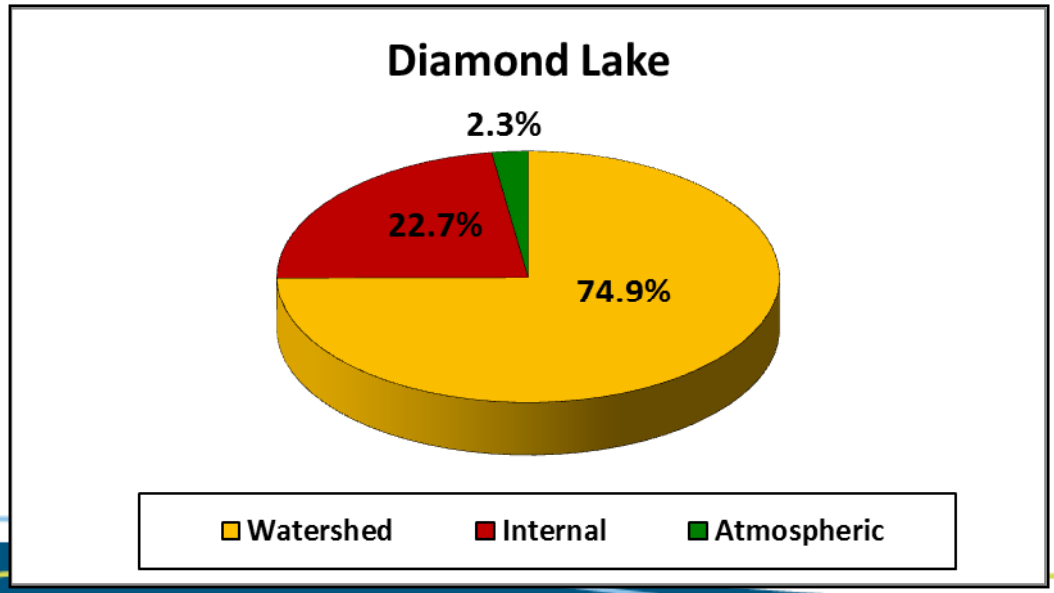
- Total internal Load Estimated = Nürenberg + Curlyleaf Pondweed
  - Total internal Load ≈ 728.4 to 1316.4 pounds/year

- TP internal load input into the BATHTUB model for calibration was 993.1 pounds.

Diamond Lake

Diamond Lake Bathtub Calibration Model Estimates			
Variable	**Predicted**	**Observed**	**Model**
Total Phosphorus (µg/L)	145.3	145.3	Canfield & Bachman, General
Chlorophyll-a (µg/L)	42.7	43	P, Linear
Secchi (m)	1.3	1.3	Chlorophyll-a & Turbidity

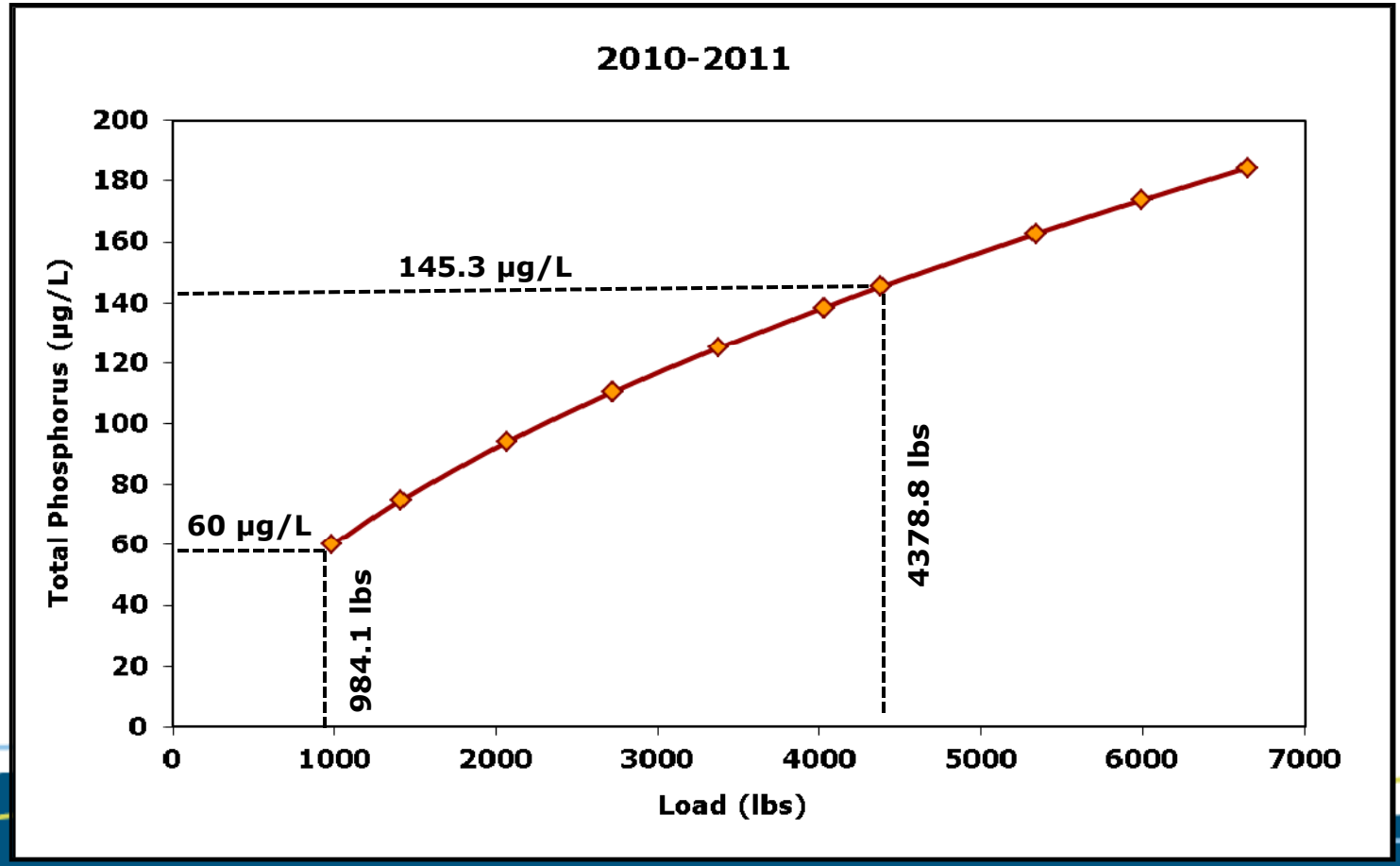
	TP Load		
Load	**kg**	**lbs**	**%**
Watershed	1488.5	3281.6	74.9%
Internal	451.4	995.2	22.7%
Atmospheric	46.3	102.1	2.3%
Total	1986.2	4378.8	100.0



Diamond Lake BATHTUB Model
In-Lake TP Load Response

Reductions Required

3394.7 lb in total load
+
49.2 lbs for Margin of Safety (5%)



Reminder of Methodology Used to Set Allocations

- Allocate load (after subtracting MOS) among:
  - Permitted wastewater dischargers
  - Construction and Industrial stormwater
  - Areas to be served by Municipal Separate Storm Sewer Systems (MS4s) before 2030
  - Non-permitted sources (i.e. all areas not expected to drain through a permitted MS4 stormwater conveyance system)

Allocation Methodology (con't)

- Allocations made proportionate to area in contributing watershed (minus wetlands/water/permanent public open space)
- No waste load allocation = not permitted to discharge
- MnDOT and Hennepin County road ROW
  - Assigned as part of WLA if within 2010 urbanized area
  - Assigned as part of LA if outside 2010 urbanized area

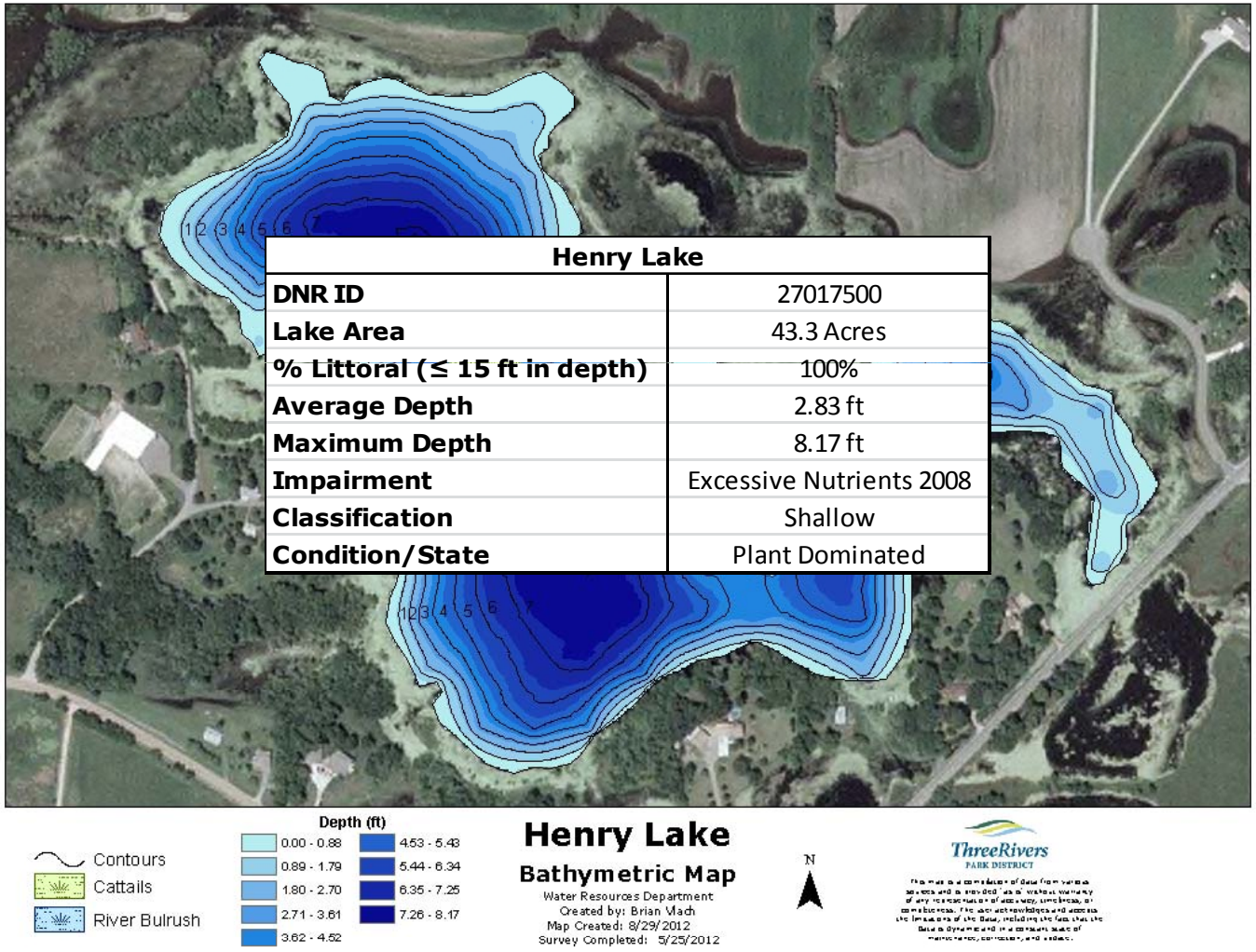
Allocation Methodology (con't)

- For lakes, guidance from MPCA is to reduce loadings from permitted sources first to try to achieve in-lake water quality goals.
- Reductions from non-permitted sources (e.g. internal load) can be called for if achievable watershed load reductions are not sufficient.

Preliminary Allocations For Diamond Lake

Diamond Lake TMDL Summary (AUID 27-0125)		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		lbs./yr.	lbs./day	lbs./yr.	lbs./day	lbs./yr.	%
LOADING CAPACITY/TOTAL LOAD		4378.8	11.997	948	2.597	3430.8	78.4%
5% EXPLICIT MOS		0.0	0.000	47.4	0.130	47.4	0.0%
TOTAL REDUCTION						**3478.2**	**78.4%**
Wasteload Allocations	Permitted Point Source Dischargers	0.0	0.000	0	0.000	0.0	0.0%
	Construction/Industrial SW		0.000	9.0	0.025	0.0	0.0%
	Dayton MS4	368.6	1.010	47.8	0.131	320.8	87.0%
	Rogers MS4	2050.2	5.617	265.9	0.728	1784.3	87.0%
	Hennepin County MS4	31.7	0.087	4.1	0.011	27.6	87.0%
	MnDOT MS4	30.2	0.083	3.9	0.011	26.3	87.0%
Load Allocations	Non-MS4 Runoff	791.7	2.169	102.7	0.281	689.0	87.0%
	Upstream Lakes	0.0	0.000	0.0	0.000	0.0	N/A
	Atmospheric Deposition	102.1	0.280	102.1	0.280	0.0	0.0%
	Internal Load	995.2	2.727	365.1	1.000	630.1	63.3%

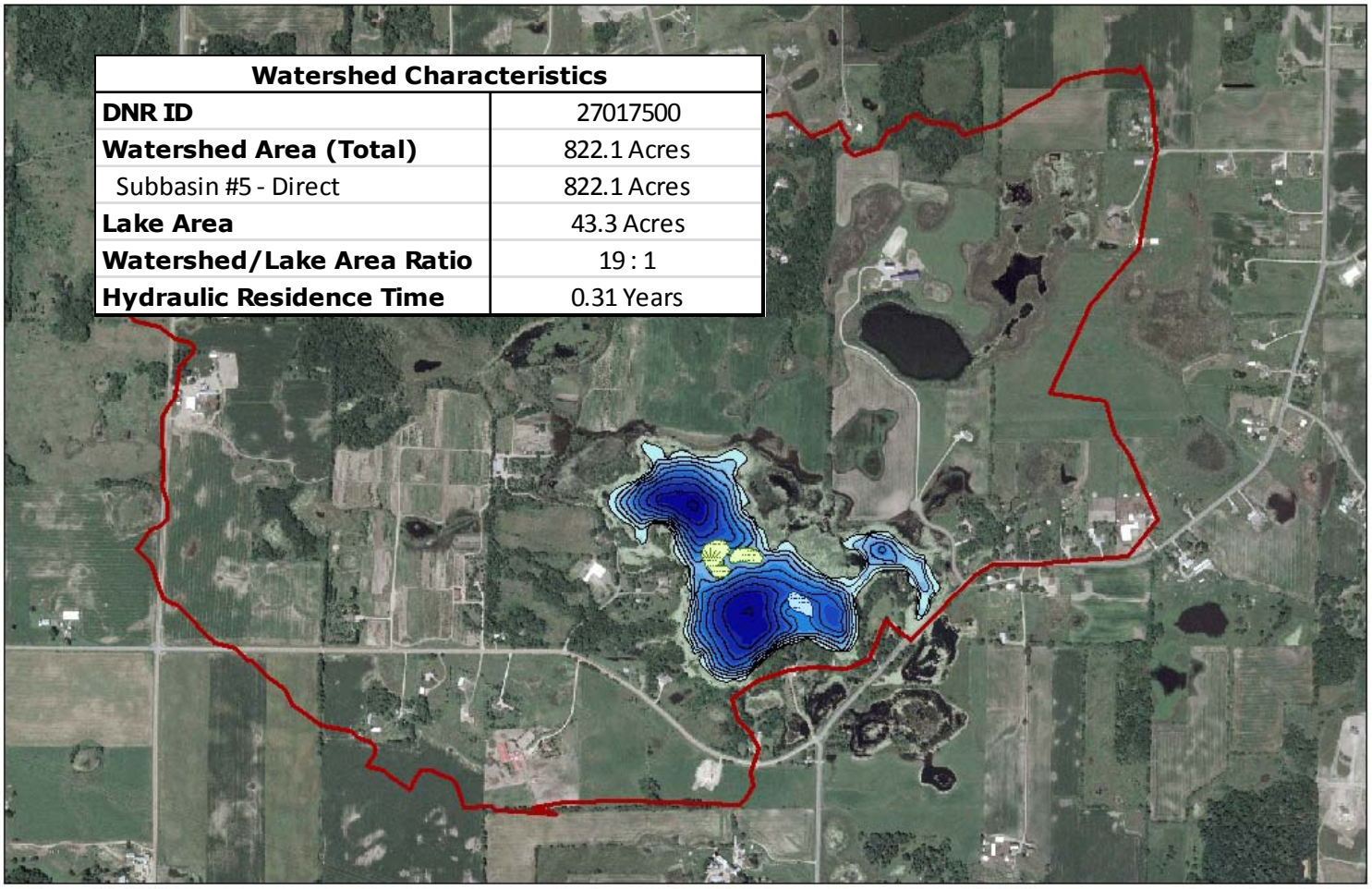
Henry Lake



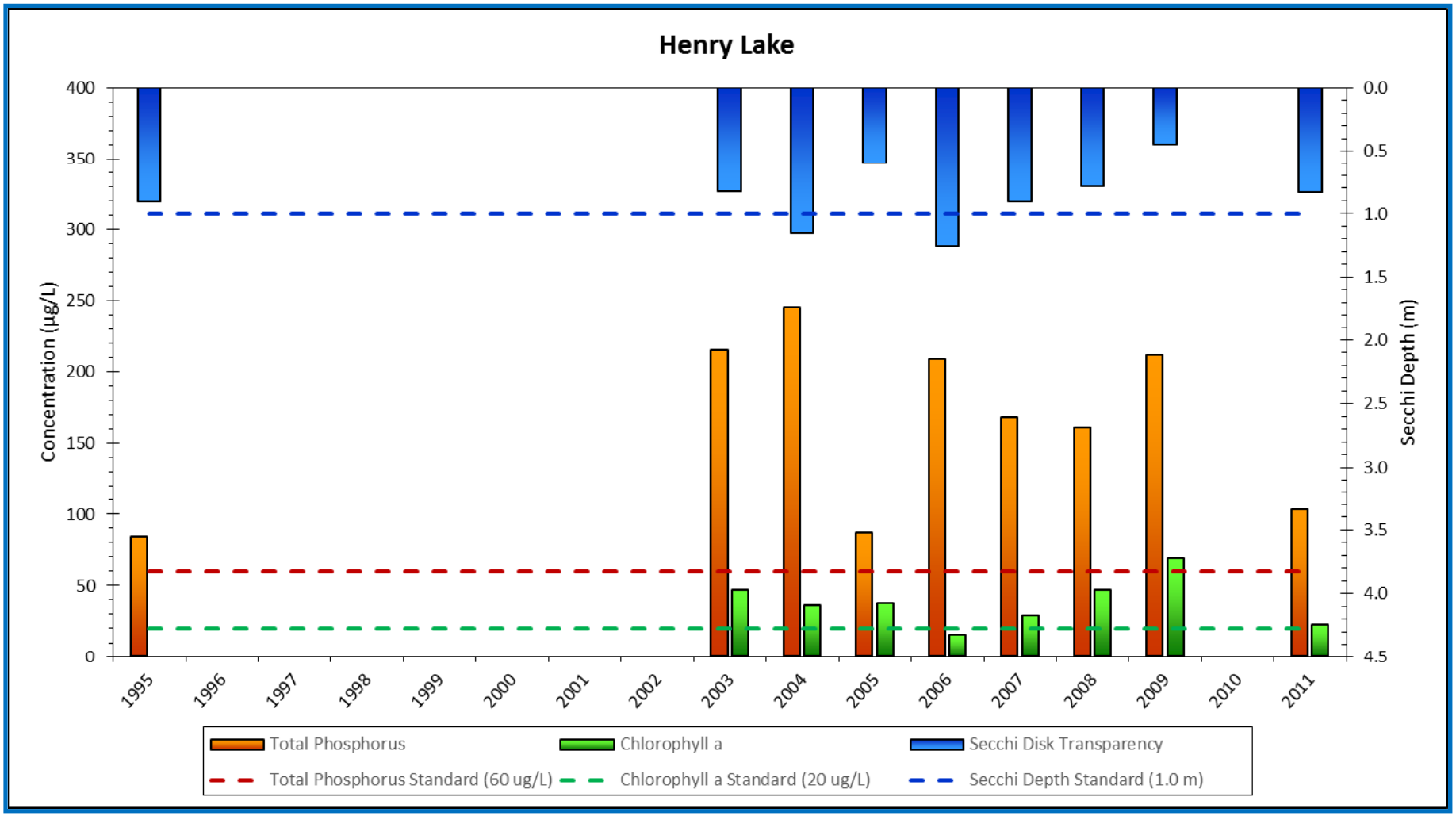
Henry Lake	
DNR ID	27017500
Lake Area	43.3 Acres
% Littoral (≤ 15 ft in depth)	100%
Average Depth	2.83 ft
Maximum Depth	8.17 ft
Impairment	Excessive Nutrients 2008
Classification	Shallow
Condition/State	Plant Dominated

Henry Lake

Watershed Characteristics	
DNR ID	27017500
Watershed Area (Total)	822.1 Acres
Subbasin #5 - Direct	822.1 Acres
Lake Area	43.3 Acres
Watershed/Lake Area Ratio	19 : 1
Hydraulic Residence Time	0.31 Years



Henry Lake Water Quality



Henry Lake Modeling Approach

- SWAT model was used to estimate watershed loads for years with average precipitation conditions (Rockford 2009 & 2011).
  2009 – 28.2 inches & 2011 – 27.9 inches

- The average flow volumes and nutrient concentration (2009 & 2011) from SWAT model was input into the BATHTUB model.

Subbasin	Area km2	Flow Volume hm3	Total Phosphorus µg/L
Direct Subbasin #5	3.33	0.486	743.6

- Internal TP load (101.4 lbs) was input into the BATHTUB model to calibrate to the average in-lake total phosphorus conditions. This internal load was compared to a minimum and maximum range using the Nürenberg equation and sediment release rates from similar plant dominated shallow lakes (Bischoff and James 2012) . The BATHTUB model was then calibrated to the chlorophyll-a and secchi depth response variables.

Internal Load Source	TP Load (lbs)	
	Minimum	Maximum
Sediment Release	15.4	54.2
Curlyleaf Pondweed	35.7	69.0
Total	51.1	123.2

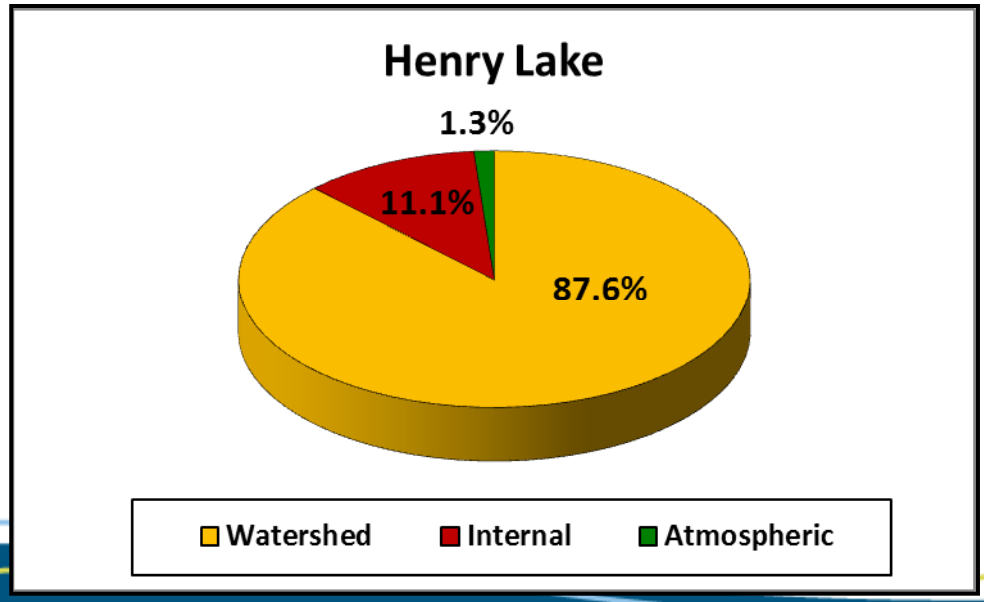
- BATHTUB in-lake load response model was used to estimate the load reduction necessary to meet water quality goals.

- Waste Load Allocations assigned to MS4's.

Henry Lake

Henry Lake Bathtub Calibration Model Estimates			
Variable	**Predicted**	**Observed**	**Model**
Total Phosphorus (µg/L)	149.3	149.3	2nd Order, Fixed
Chlorophyll-a (µg/L)	38.2	38.4	P, Linear
Secchi (m)	0.7	0.7	Chlorophyll-a & Turbidity

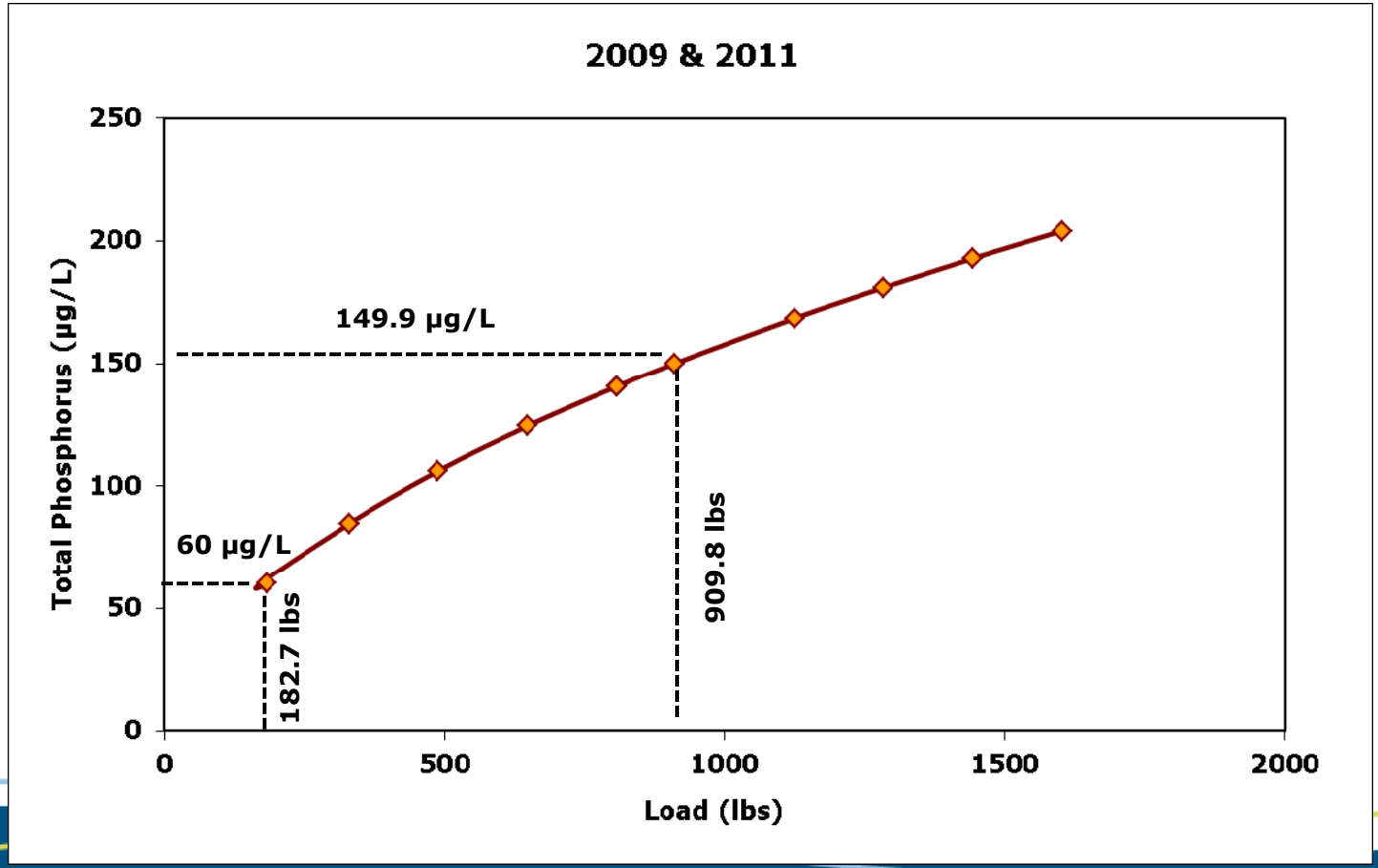
	TP Load		
Load	**kg**	**lbs**	**%**
Watershed	361.4	796.7	87.6%
Internal	46	101.4	11.1%
Atmospheric	5.3	11.7	1.3%
Total	412.7	909.8	100.0



Henry Lake BATHTUB Model
In-Lake TP Load Response

Reductions Required

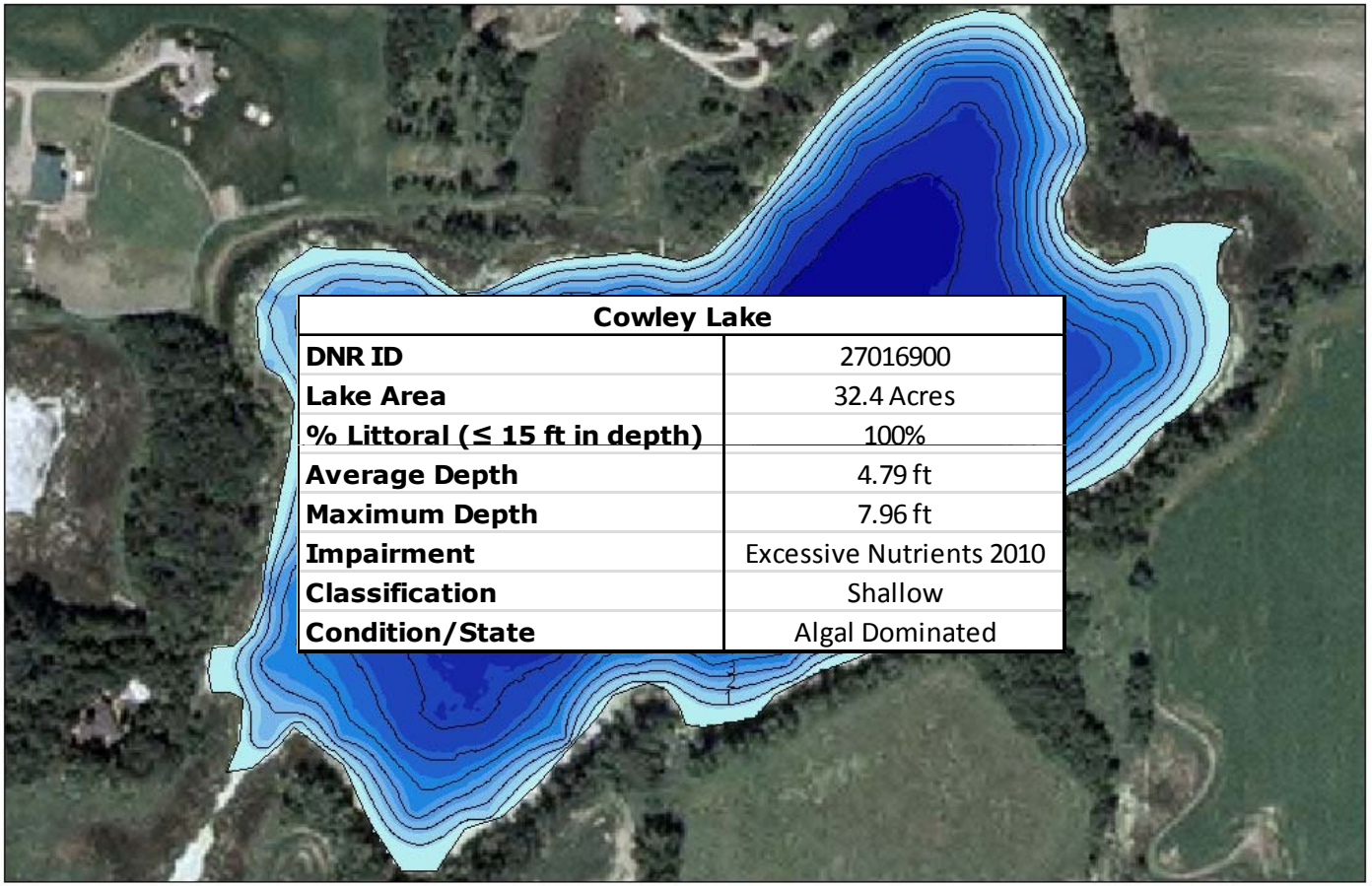
727.1 lb in total load
+
9.1 lbs for Margin of Safety (5%)



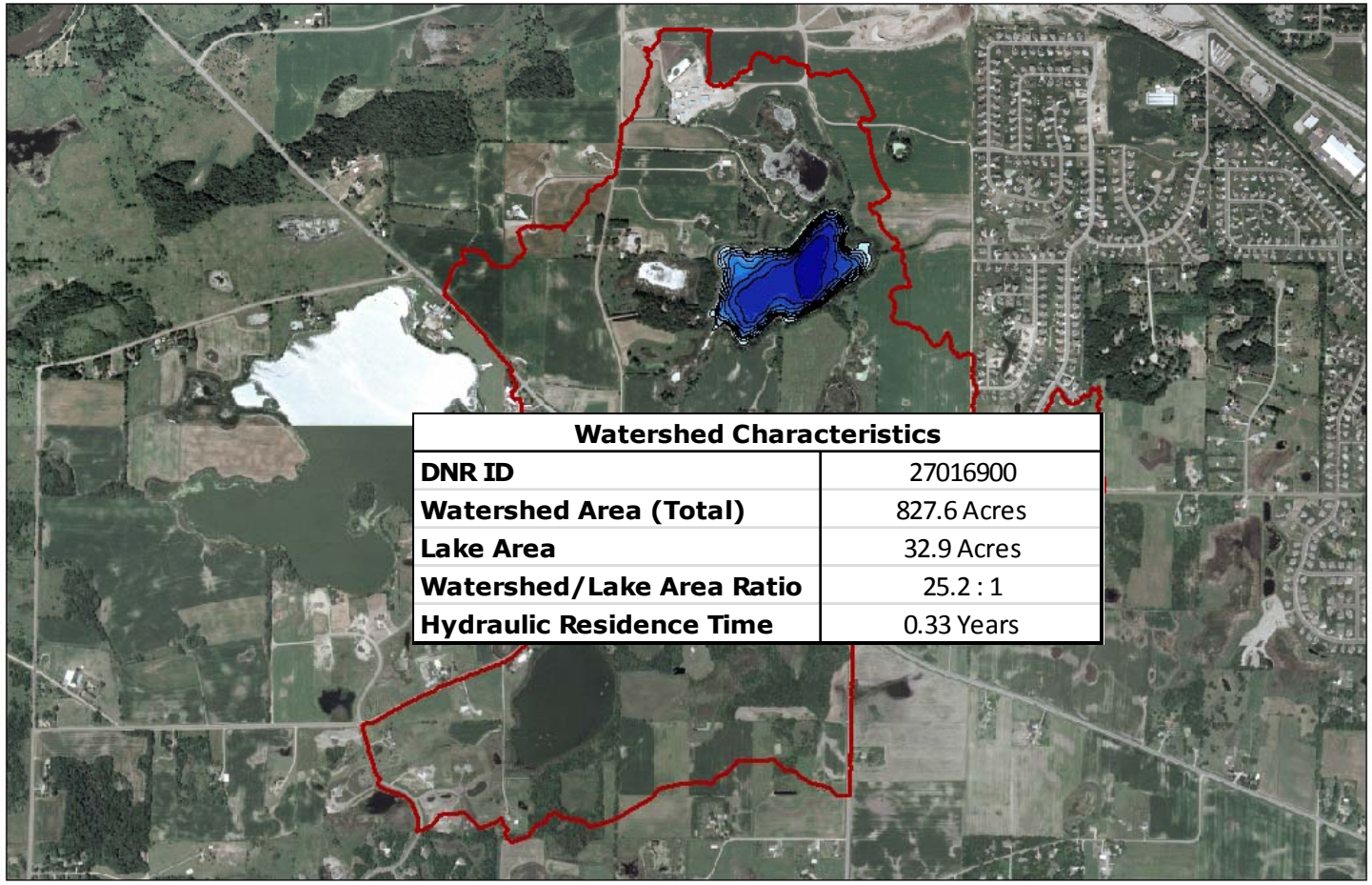
Henry Lake Preliminary Allocations

Henry Lake TMDL Summary (AUID 27-0175)		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		lbs./yr.	lbs./day	lbs./yr.	lbs./day	lbs./yr.	%
LOADING CAPACITY/TOTAL LOAD		909.8	2.493	182.7	0.501	727.1	79.9%
5% EXPLICIT MOS		0.0	0.000	9.135	0.025	9.1	1.0%
TOTAL REDUCTION						**736.2**	**80.9%**
Wasteload Allocations	Permitted Point Source Dischargers	0.0	0.000	0	0.000	0.0	0.0%
	Construction/Industrial SW		0.000	1.7	0.005	0.0	0.0%
Load Allocations	Non-MS4 Runoff	795.0	2.178	111.0	0.304	683.9	86.0%
	Upstream Lakes	0.0	0.000	0.0	0.000	0.0	N/A
	Atmospheric Deposition	11.7	0.032	11.7	0.032	0.0	0.0%
	Internal Load	101.4	0.278	49.1	0.135	52.3	51.6%

Cowley Lake


Cowley Lake
DNR ID 27016900
Lake Area 32.4 Acres
% Littoral (≤ 15 ft in depth) 100%
Average Depth 4.79 ft
Maximum Depth 7.96 ft
Impairment Excessive Nutrients 2010
Classification Shallow
Condition/State Algal Dominated
Contours
N
Depth (ft)
0.00 - 0.76
0.77 - 1.66
1.67 - 2.56
2.57 - 3.46
3.47 - 4.36
4.37 - 5.26
5.27 - 6.16
6.17 - 7.06
7.07 - 7.96
Cowley Lake
Bathymetric Map
Water Resources Department
Created by: Brian Mach
Map Created: 8/1/2012
Survey Completed: 6/5/2012
ThreeRivers
PARK DISTRICT

Cowley Lake



Watershed Characteristics	
DNR ID	27016900
Watershed Area (Total)	827.6 Acres
Lake Area	32.9 Acres
Watershed/Lake Area Ratio	25.2 : 1
Hydraulic Residence Time	0.33 Years

Depth (ft)

0.00 - 0.76
0.77 - 1.66
1.67 - 2.56
2.57 - 3.46
3.47 - 4.36
4.37 - 5.26
5.27 - 6.16
6.17 - 7.06
7.07 - 7.96

Contours

Cowley Watershed

Cowley Lake

Watershed

Water Resources Department
Created by: Brian Vlach
Map Created: 8/1/2012
Survey Completed: 6/5/2012

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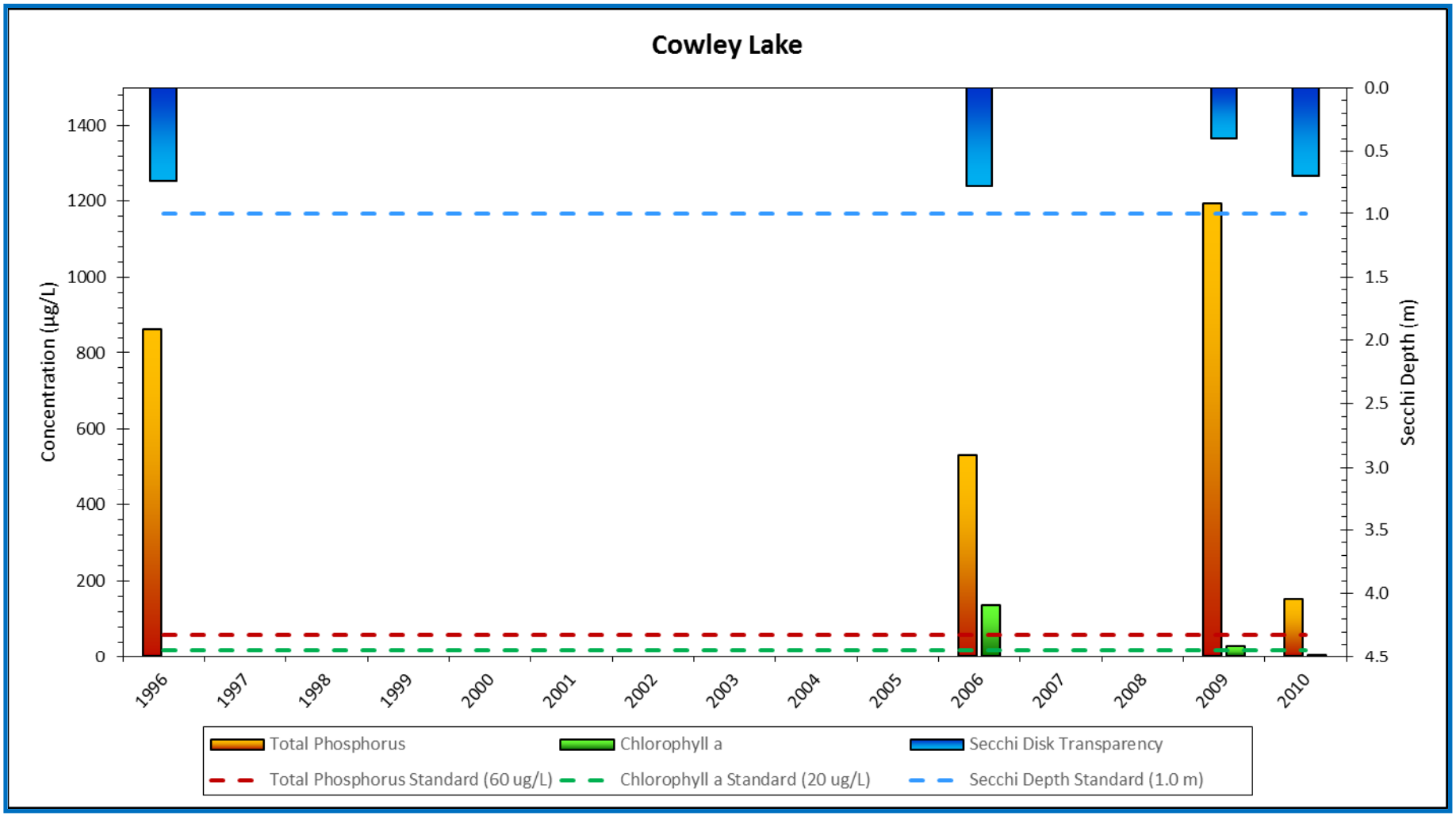
ThreeRivers PARK DISTRICT

This map is a compilation of data from various sources and is provided "as is" without warranty of any representation of accuracy, timeliness, or completeness. The user acknowledges and accepts the limitations of the Data, including the fact that the Data is dynamic and in a constant state of maintenance, correction, and update.

Cowley Lake Water Quality



Cowley Lake Modeling Approach

- Unit Area Loads for each land use type were developed using the SWAT model for Henry and Diamond Lake in 2006. These unit area loads were used for each land use type and aggregated to estimate the total watershed load to Cowley Lake. The total watershed load were representative of Rockford 2006 precipitation conditions (25.7 inches).

- Flow volume and nutrient concentrations estimated from the aggregated unit area loads for 2006 were input into the BATHTUB model.

Subbasin	Area km2	Flow Volume hm3	Total Phosphorus µg/L
Direct Watershed	3.35	0.578	352.8

- Internal TP load (376.5 lbs) was input into the BATHTUB model to calibrate for average in-lake total phosphorus conditions. This internal load was compared to a minimum and maximum range using the Nürenberg equation and sediment release rates from similar algal dominated shallow lakes (Bischoff and James 2012) . The BATHTUB model was then calibrated to the chlorophyll-a and secchi depth response variables.

Internal Load Source	TP Load (lbs)	
	Minimum	Maximum
Sediment Release	177.6	300.0
Curlyleaf Pondweed	53.5	103.4
Total	231.1	403.4

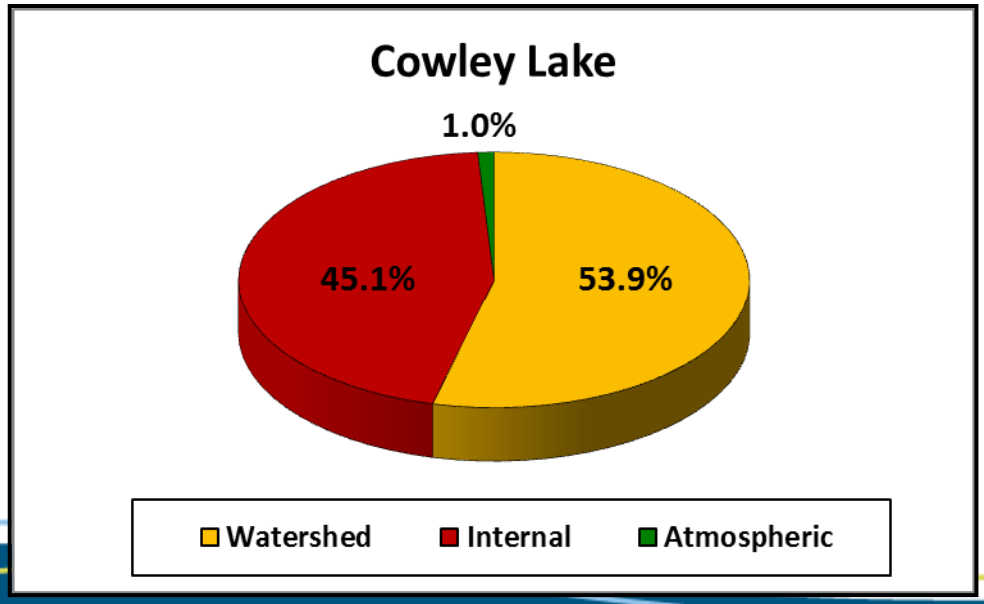
- BATHTUB in-lake load response model was used to estimate the load reduction necessary to meet water quality goals.

- Waste Load Allocations assigned to MS4's.

Cowley Lake

Cowley Lake Bathtub Calibration Model Estimates			
Variable	**Predicted**	**Observed**	**Model**
Total Phosphorus (µg/L)	533.0	533.6	Settling Velocity
Chlorophyll-a (µg/L)	135.8	135.6	P, Linear
Secchi (m)	0.8	0.8	Chlorophyll-a vs Turbidity

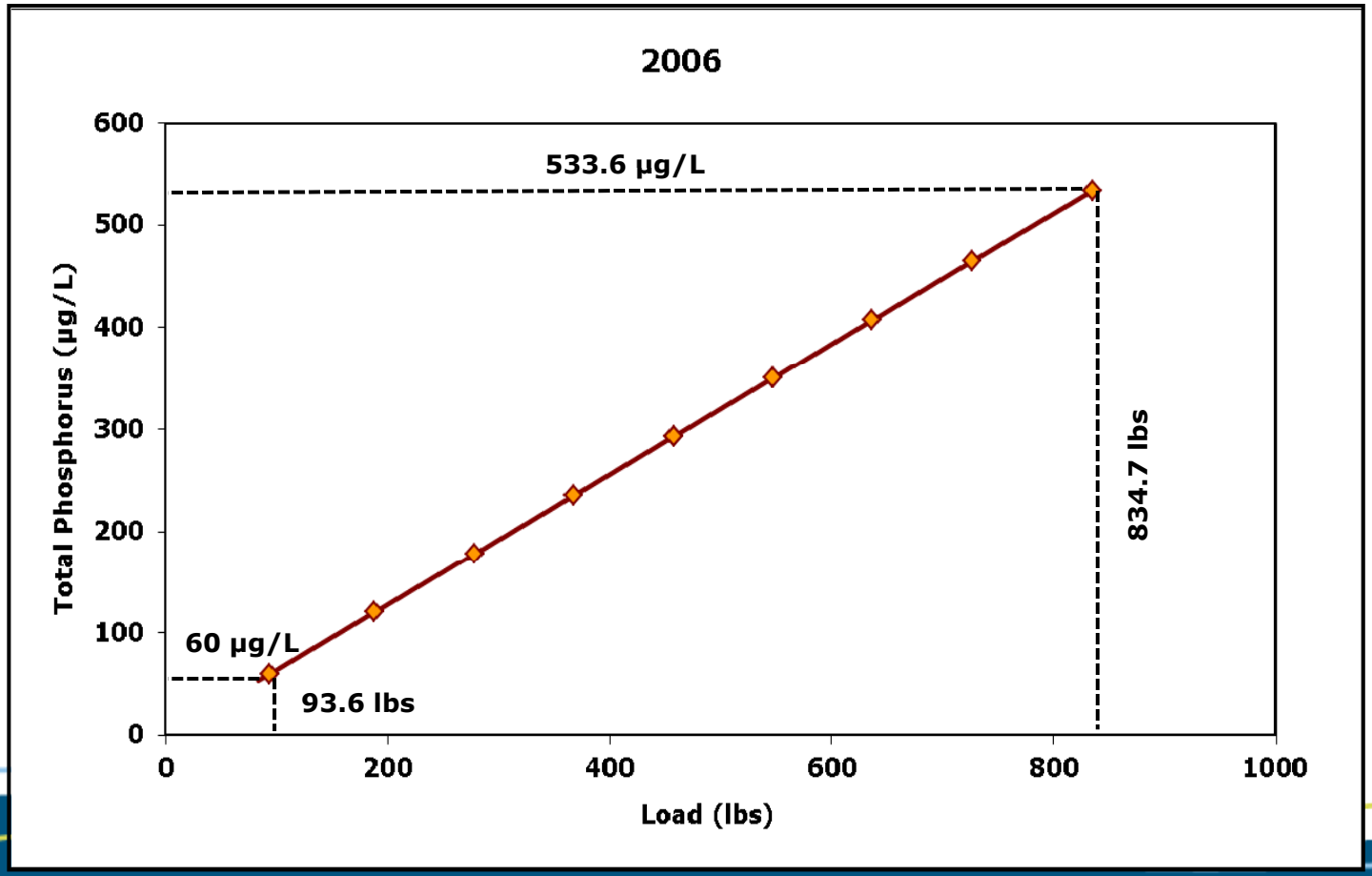
	TP Load		
Load	**kg**	**lbs**	**%**
Watershed	203.9	449.5	53.9%
Internal	170.8	376.5	45.1%
Atmospheric	3.9	8.6	1.0%
Total	378.6	834.7	100.0



Cowley Lake BATHTUB Model
In-Lake TP Load Response

Reductions Required

741.1 lb in total load
+
4.7 lbs for Margin of Safety (5%)



Cowley Lake Preliminary Allocations

Cowley Lake TMDL Summary (AUID 27-0169)		Existing TP Load		Allowable TP Load		Estimated Load Reduction	
		lbs./yr.	lbs./day	lbs./yr.	lbs./day	lbs./yr.	%
LOADING CAPACITY/TOTAL LOAD		834.7	2.287	85	0.233	749.7	89.8%
5% EXPLICIT MOS		0.0	0.000	4.25	0.012	4.3	0.0%
TOTAL REDUCTION						**754.0**	**89.8%**
Wasteload Allocations	Permitted Point Source Dischargers	0.0	0.000	0	0.000	0.0	0.0%
	Construction/Industrial SW		0.000	0.8	0.002	0.0	0.0%
	Rogers MS4	304.2	0.833	48.4	0.132	255.9	84.1%
	Hennepin County MS4	1.3	0.003	0.2	0.001	1.1	84.1%
Load Allocations	Non-MS4 Runoff	143.3	0.393	22.8	0.062	120.5	84.1%
	Upstream Lakes	0.0	0.000	0.0	0.000	0.0	N/A
	Atmospheric Deposition	8.6	0.024	8.6	0.024	0.0	0.0%
	Internal Load	376.5	1.032	0	0.000	376.5	100.0%

Next Steps