US EPA ARCHIVE DOCUMENT

Development of TMDL's for two Eutrophic Lakes in Vermont

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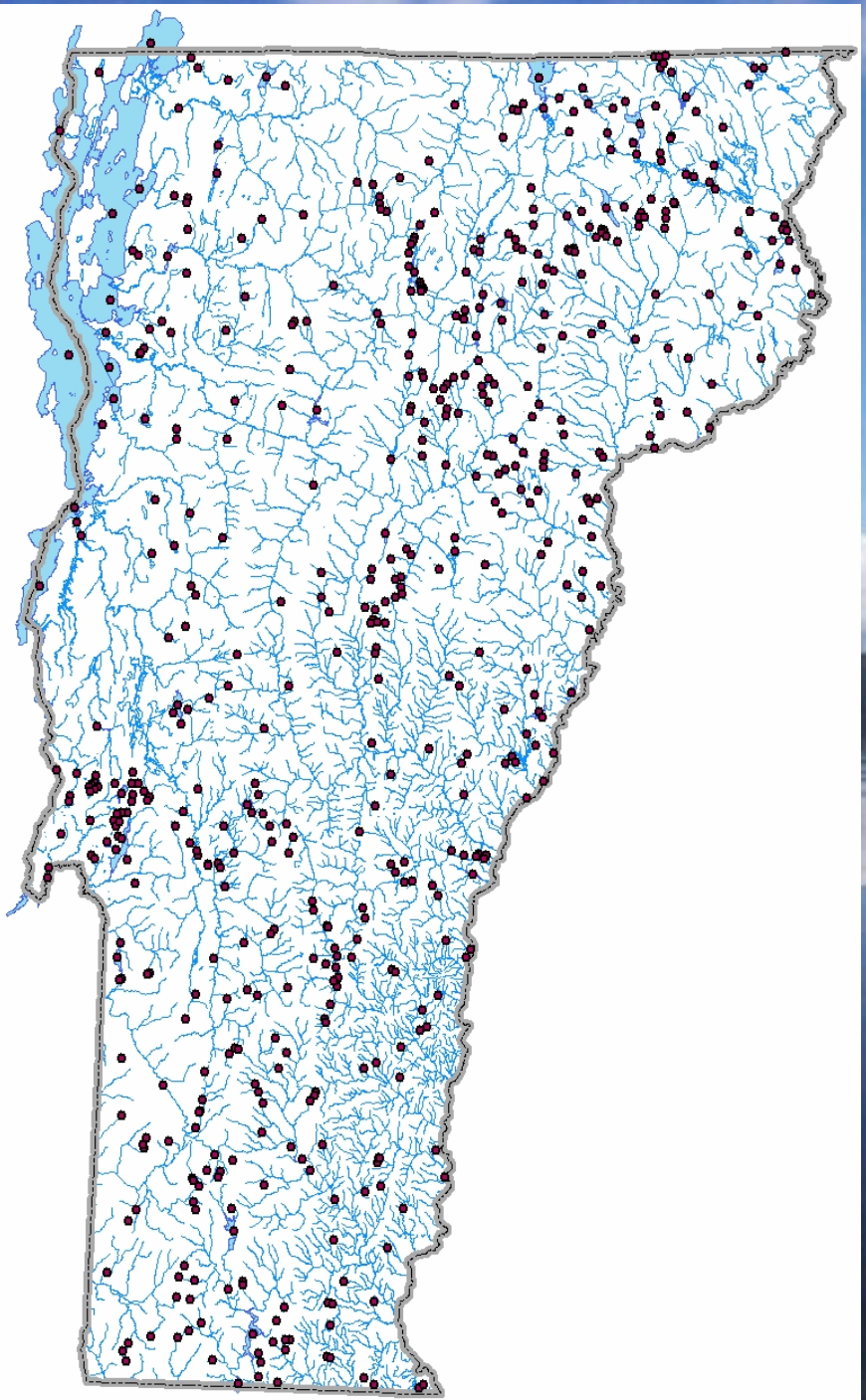
Some acknowledgements

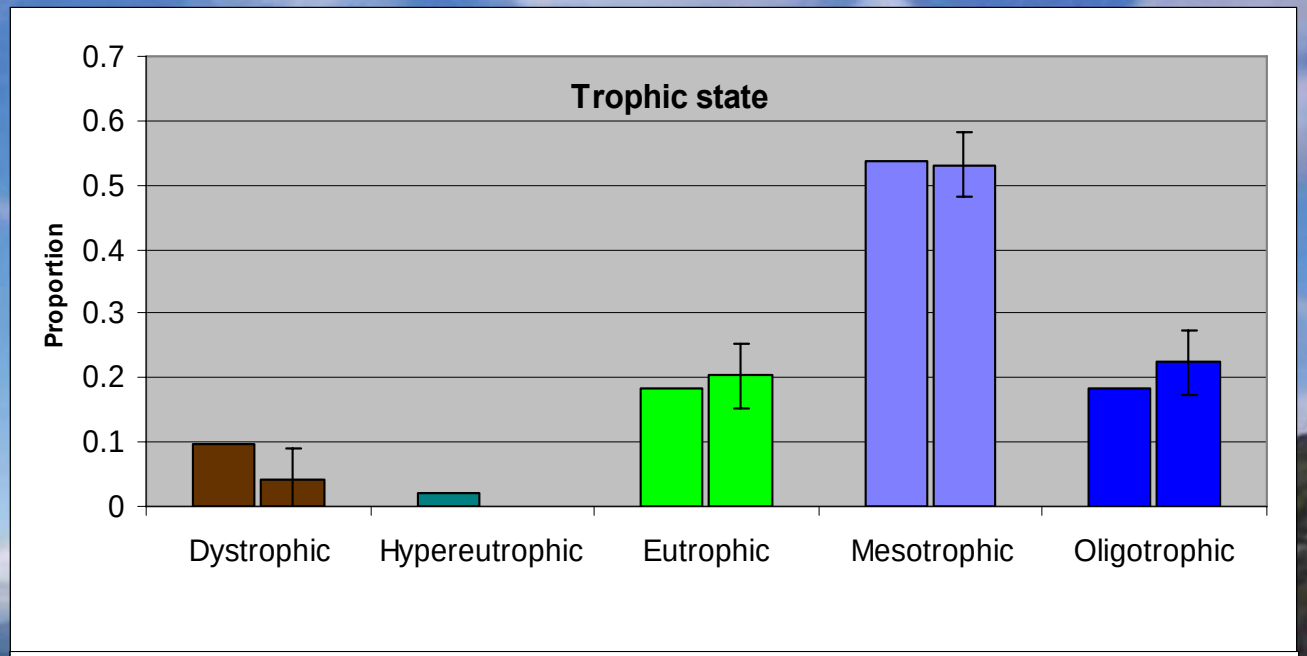
- Individuals
  - Eric Perkins EPA R1
  - Lindsay Harris and Sarah Wheeler, VTANR
  - Brent Frankland, VT Technical College and UVM
  - Ticklenaked Pond Watershed Association
  - Franklin Watersheds Council
- Funding
  - USEPA C.W.A. 104(b)(3) X-97124401
  - VTANR

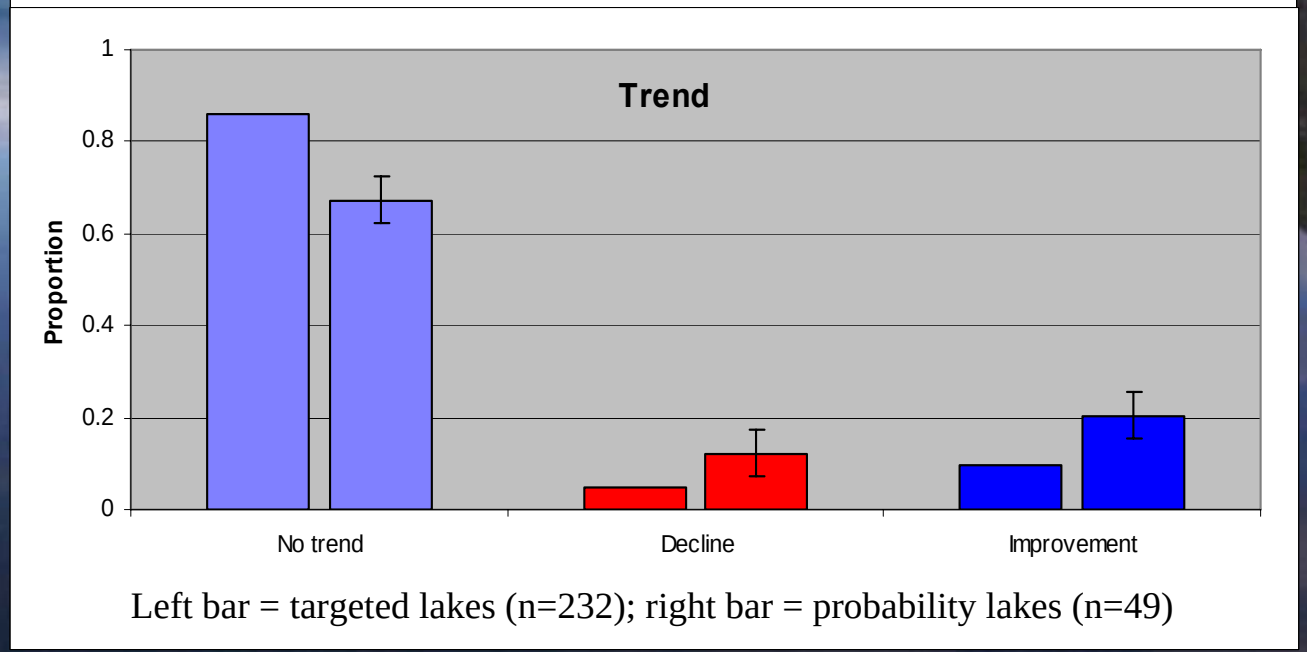


Vermont's lakes

- 560 assessed lakes in 1,436 assessment units
- 229,767 assessed acres
- 174,175 within 11 Lake Champlain segments
- Focus of inland lake program is protection from impairment.
- We are presently working on several lakes that do support uses, but where trends suggest declines in quality

Trophic state and trends in VT lakes

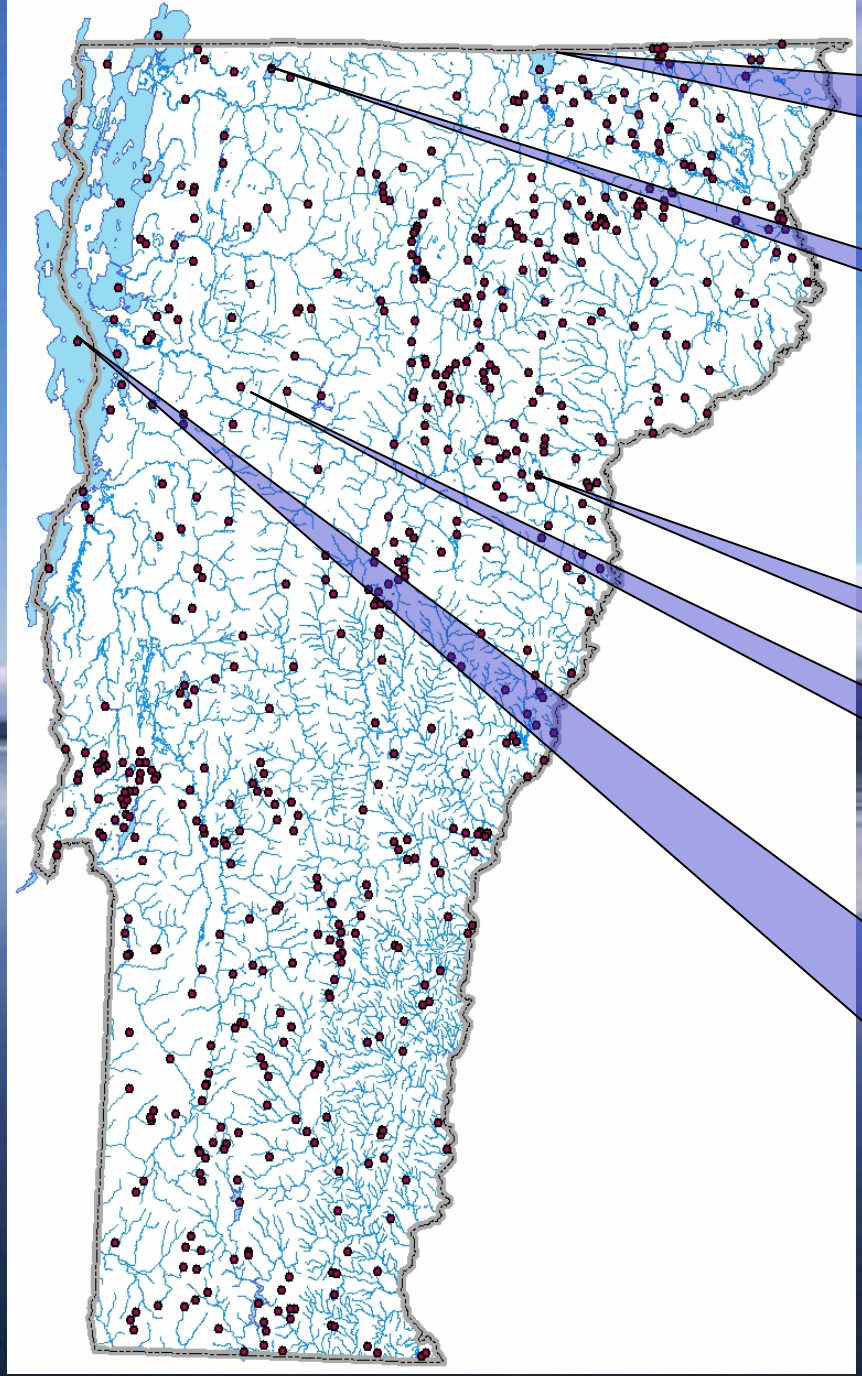




Left bar = targeted lakes (n=232); right bar = probability lakes (n=49)

VT's lake-nutrient TMDL world

Lake	Complexity of TMDL	Jurisdictions involved	TMDL done?
Lake Champlain	Very high, 18 major tribs, dozens of WWTF's	VT, NY, Quebec	Yes, major cleanup plan underway
Lake Memphremagog	Moderate, 4 major tribs, several WWTF	VT, Quebec	Monitoring studies in progress
Shelburne Pond	Low	VT	Possible UAA candidate
Ticklenaked Pond and Lake Carmi			Subject of this presentation



Lake Memphremagog (5,966 ac). Monitoring studies in progress

Lake Carmi (1402 ac), listed and TMDL in development

Ticklenaked Pond (52 ac), listed and TMDL in development

Shelburne Pond (452 ac), listed and we wonder what to do??

Champlain
174,175 (ac) TMDL approved 2002

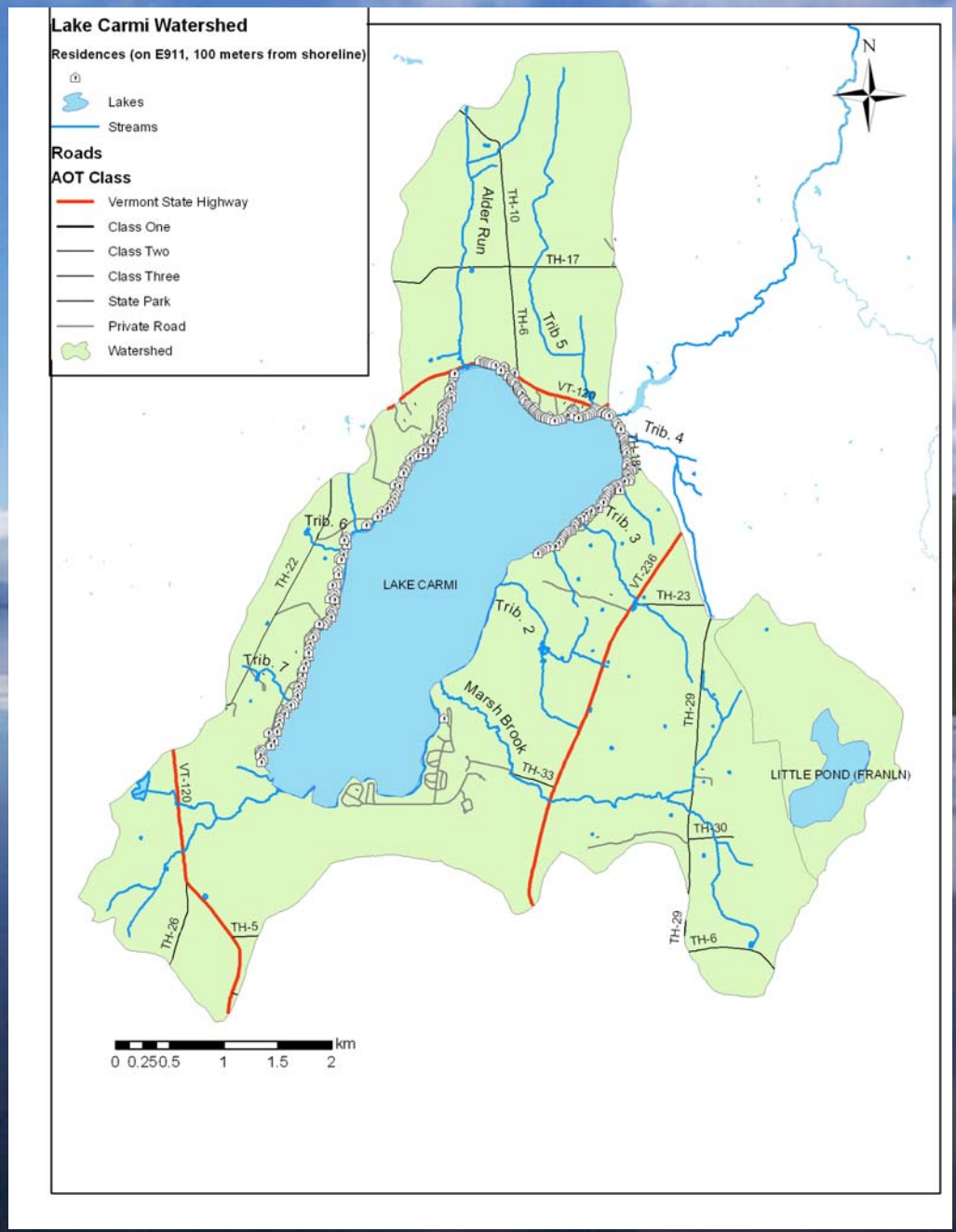
Format of this presentation

- Follow flow of a TMDL
- Articulate commonalities and differences in approaches for these TMDL's
- Highlight the use of some simple tools to facilitate development of lake nutrient TMDL's
- Cast of characters:
  - Lake Carmi, Franklin, VT
  - Ticklenaked Pond, Ryegate, VT

Lake Carmi

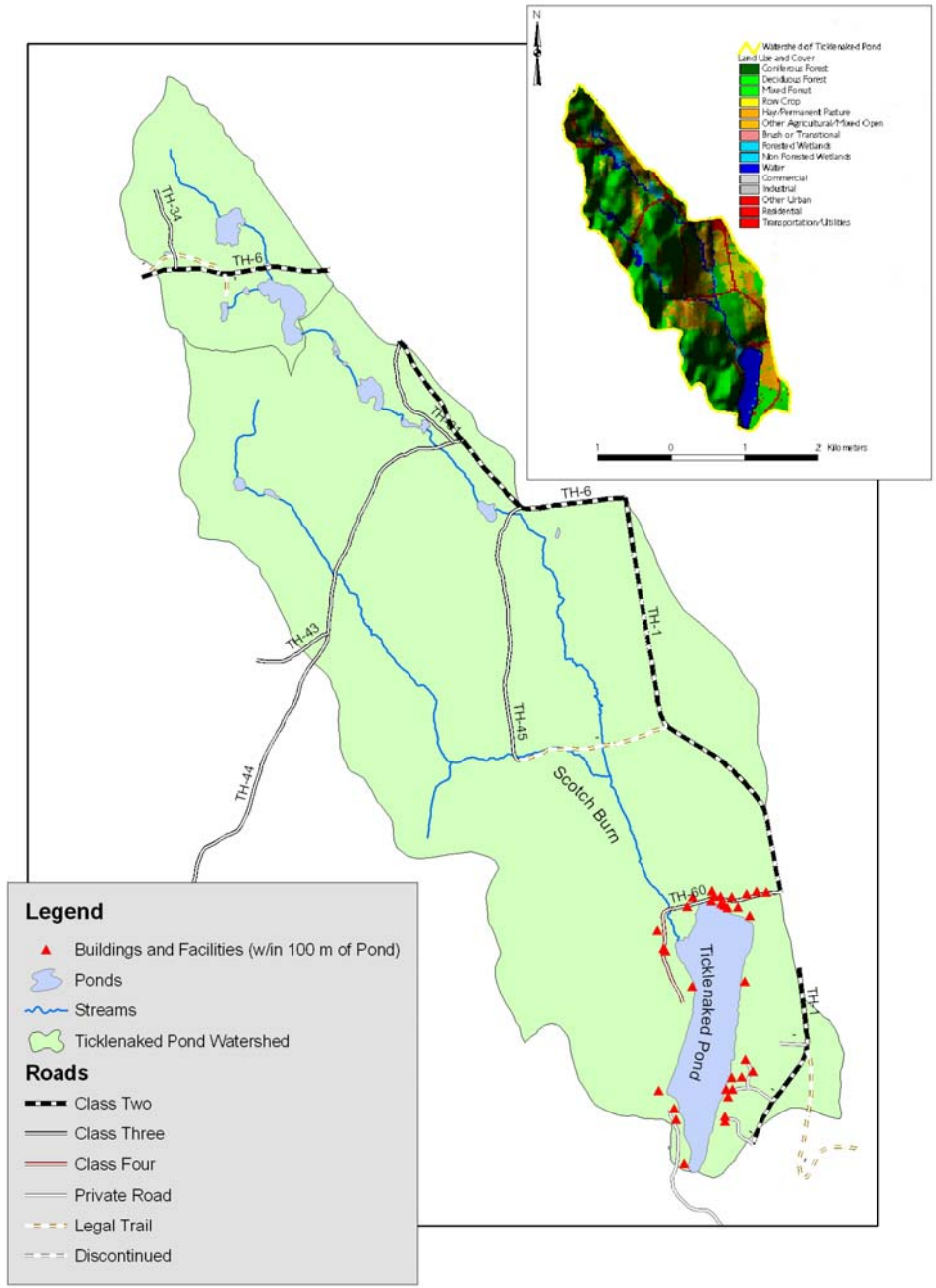
- 1,402 ac lake
- 6,308 ac basin
- Zmax = 33ft
- Vol = 17,554 acft
- TP 28 ppb (spring)
- TP 28-38 ppb (summer)

- One small gaugable tributary, several smaller intermittent tribs
- Outlet is headwater of Pike River
- Land use primarily agricultural
- Several MFO farms active in watershed
- Some (very) recalcitrant landowners


Lake Carmi Watershed
Residences (on E911, 100 meters from shoreline)
Lakes
Streams
Roads
AOT Class
Vermont State Highway
Class One
Class Two
Class Three
State Park
Private Road
Watershed
N
Alder Run
TH-10
TH-17
TH-6
Trib 5
VT-120
Trib. 4
TH-181
Trib. 3
Trib. 6
TH-22
LAKE CARMI
VT-236
TH-23
Trib. 2
Trib. 7
Marsh Brook
TH-29
TH-33
LITTLE POND (FRANLN)
VT-120
TH-30
TH-26
TH-5
TH-29
TH-6
km
0 0.250.5 1 1.5 2

Ticklenaked Pond

- 54 ac lake
- 1,444 ac basin
- Zmax = 46ft
- Vol = 864 acft
- TP 41 ppb (spring)
- TP 45 ppb (summer)
- Outlet to CT River
- One small gauged tributary
- Land use forested with some agriculture
- Two MFO farms active in watershed


N
Watershed of Ticklenaked Pond
Land Use and Cover
Coniferous Forest
Deciduous Forest
Mixed Forest
Row Crop
Hay/Permanent Pasture
Other Agricultural/Mixed Open
Brush or Transitional
Forested Wetlands
Non-Forested Wetlands
Water
Commercial
Industrial
Other Urban
Residential
Transportation/Utilities
1 0 1 2 Kilometers
TH-34
TH-6
TH-1
TH-6
TH-43
TH-44
TH-45
TH-1
Scotch Burn
TH-60
Ticklenaked Pond
TH-1
Legend
Buildings and Facilities (w/in 100 m of Pond)
Ponds
Streams
Ticklenaked Pond Watershed
Roads
Class Two
Class Three
Class Four
Private Road
Legal Trail
Discontinued

TMDL Section: Background

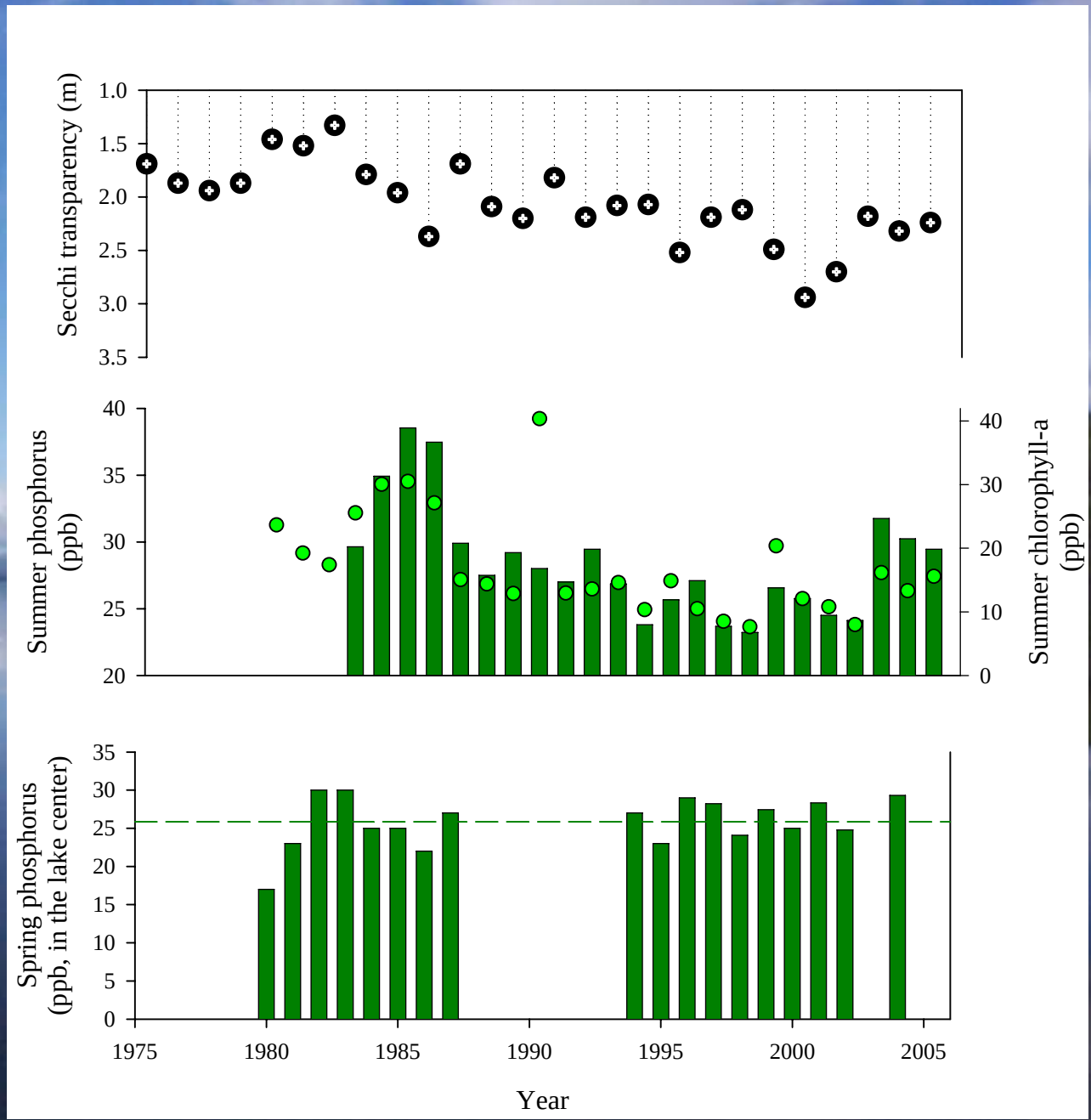
Lake Carmi

- Recurring, severe cyanobacteria blooms
- Long history of impairment
- Long history of farming use in watershed
- Mean chla of 17 ppb is in top 5% of inland VT lakes
- Stratified polymictic, little evidence of internal P loads
- Uses impaired: aesthetics, contact recreation

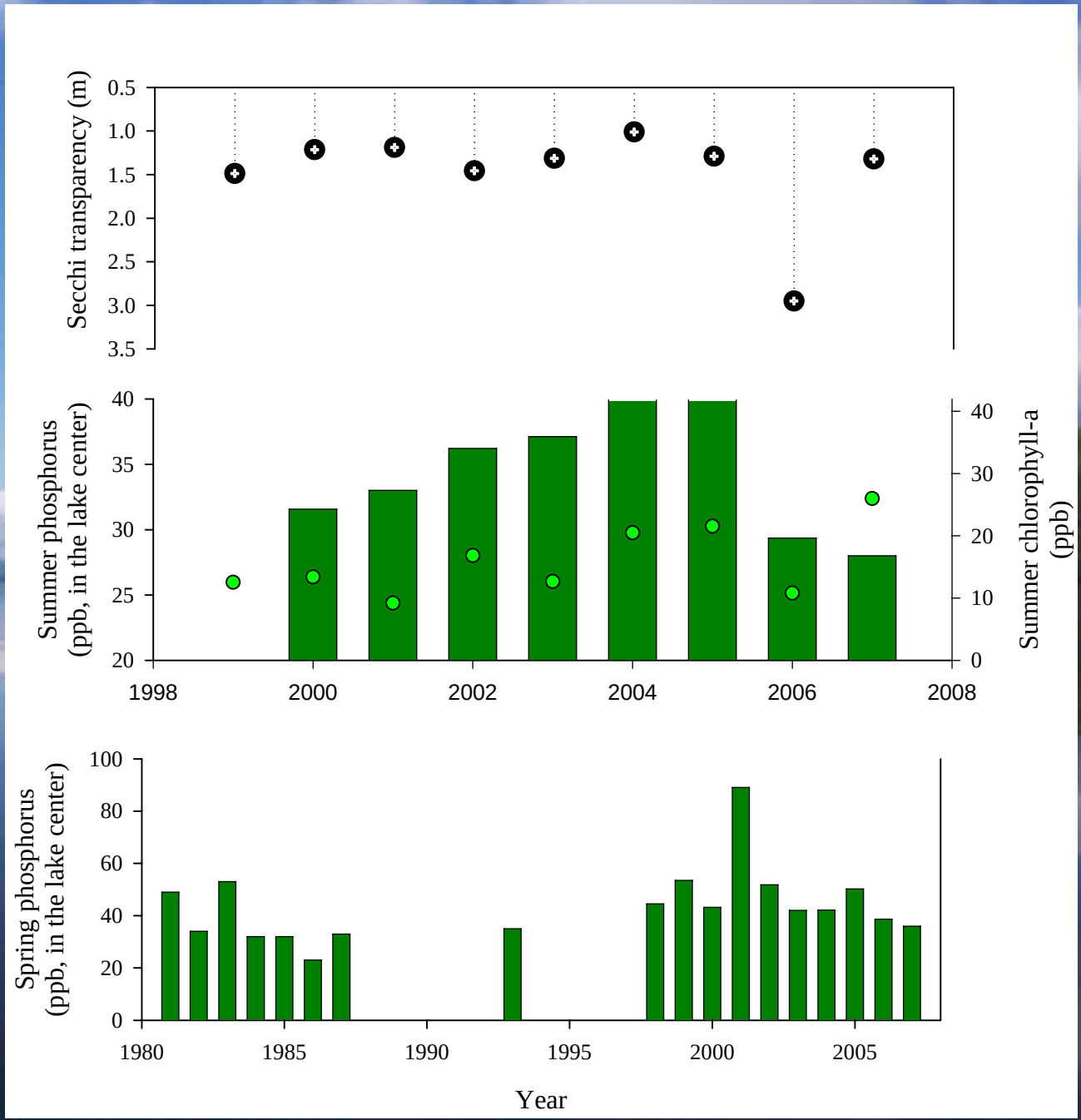
Ticklenaked Pond

- Thin monitoring data until 1999
- Rapidly deteriorating WQ from 1999 to 2004
- Moderate cyano blooms beginning 1999
- TP and chla (15 ppb) in top 5% of inland VT lakes
- Stratified dimictic, evidence of internal P loads
- Uses impaired: aesthetics, contact recreation, AQL

Lake Carmi WQ Trends



Ticklenaked Pond WQ Trends



TMDL Category: Applicable WQS

10 V.S.A. Chapter 47,
All waters - general policy
In all waters, total phosphorous loadings shall be limited so that they will not contribute to the acceleration of eutrophication or the stimulation of the growth of aquatic biota in a manner that prevents the full support of uses. (…)

- In Class B waters, this means:
  - Consistently good aesthetic value
  - Supports swimming
  - No change from reference conditions that would have an undue adverse effect on the composition of the aquatic biota, the physical or chemical nature of the substrate or the species composition or propagation of fishes.

TMDL Target Concentration

Lake Carmi

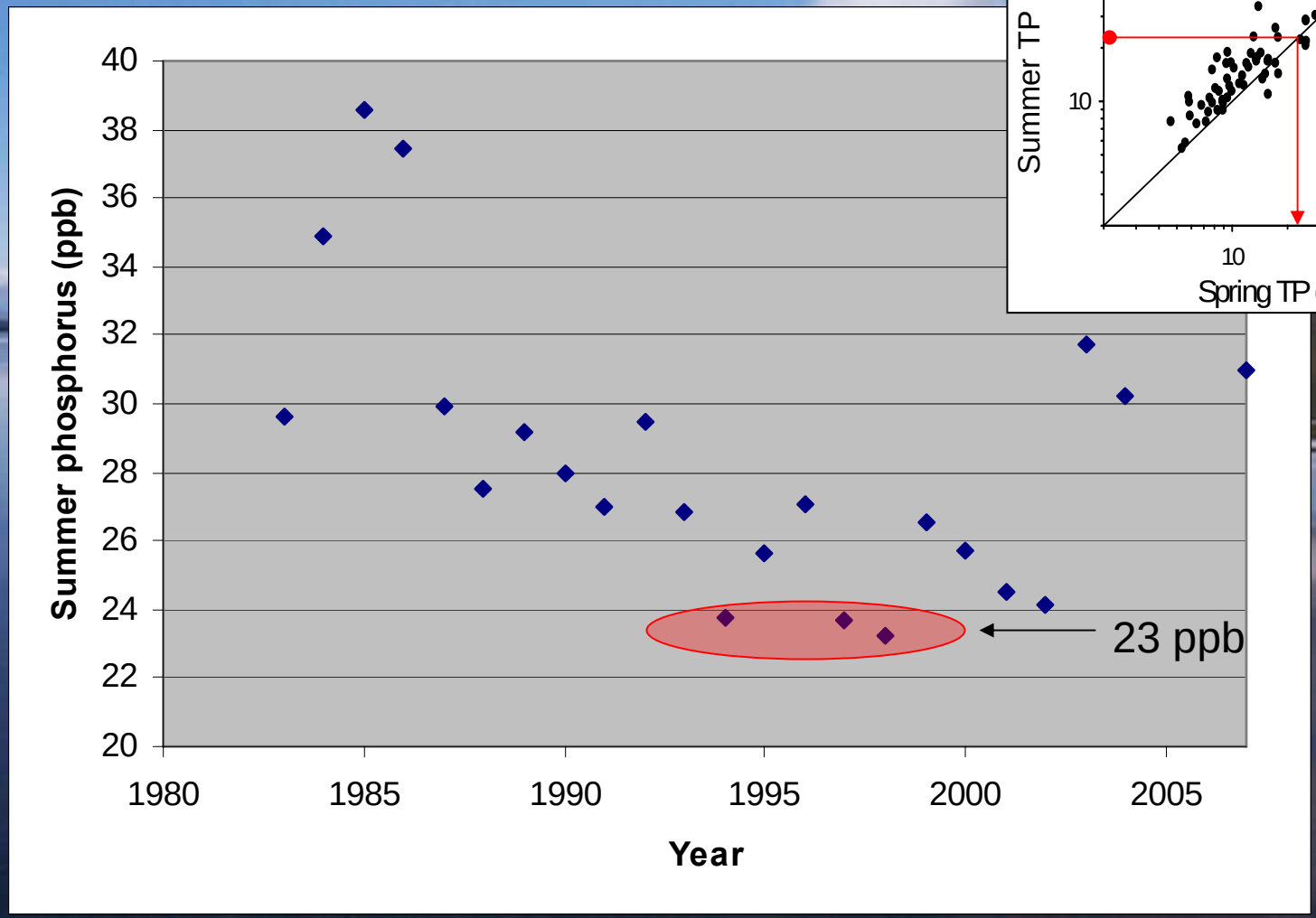
- Lake has experienced good WQ in occasional years
- Identify measured concentration for the best (lowest P) three years
- Yields target of 23 ppb

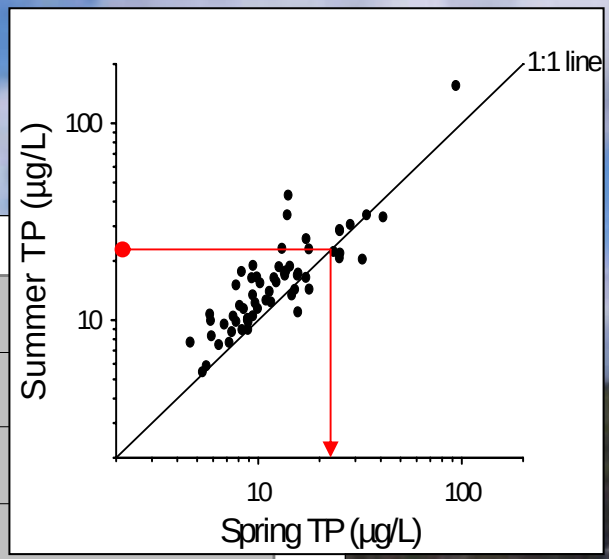
Ticklenaked Pond

- Leverage analyses from nutrient criteria project to guide selection of criterion
- Perceived nuisance→summer chla → summer TP → spring TP
- Yields target of 22 ppb

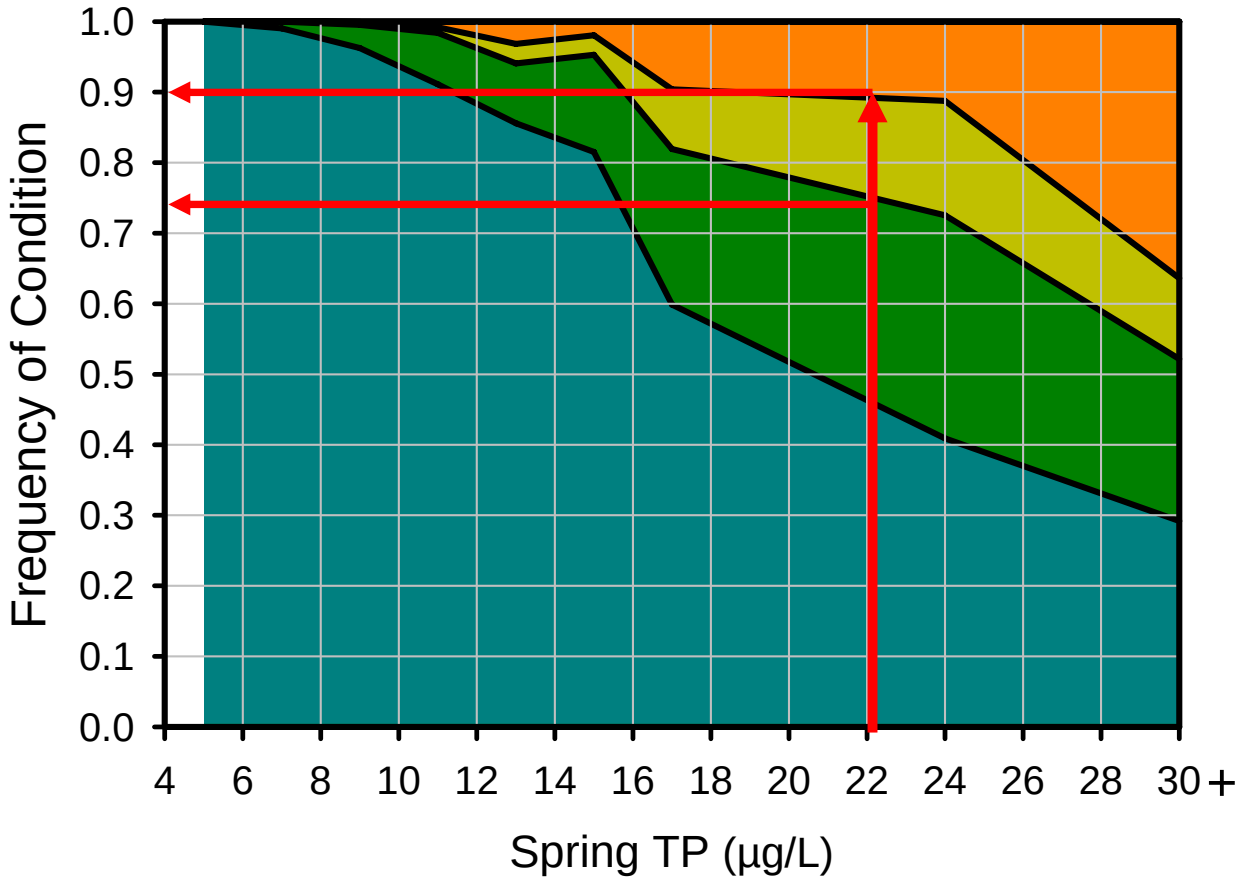
For consistency, both TMDL's were calculated using a target criterion of 22 ppb

TMDL Target Concentration (Carmi)





TMDL Target Concentration (Tick-N)



Less than good: Chl-a >24 µg/L
Good: Chl-a >16 µg/L and ≤24 µg/L
Very Good: Chl-a >9 µg/L and ≤16 µg/L
Excellent: Chl-a ≤9 µg/L

Estimating Total Loads

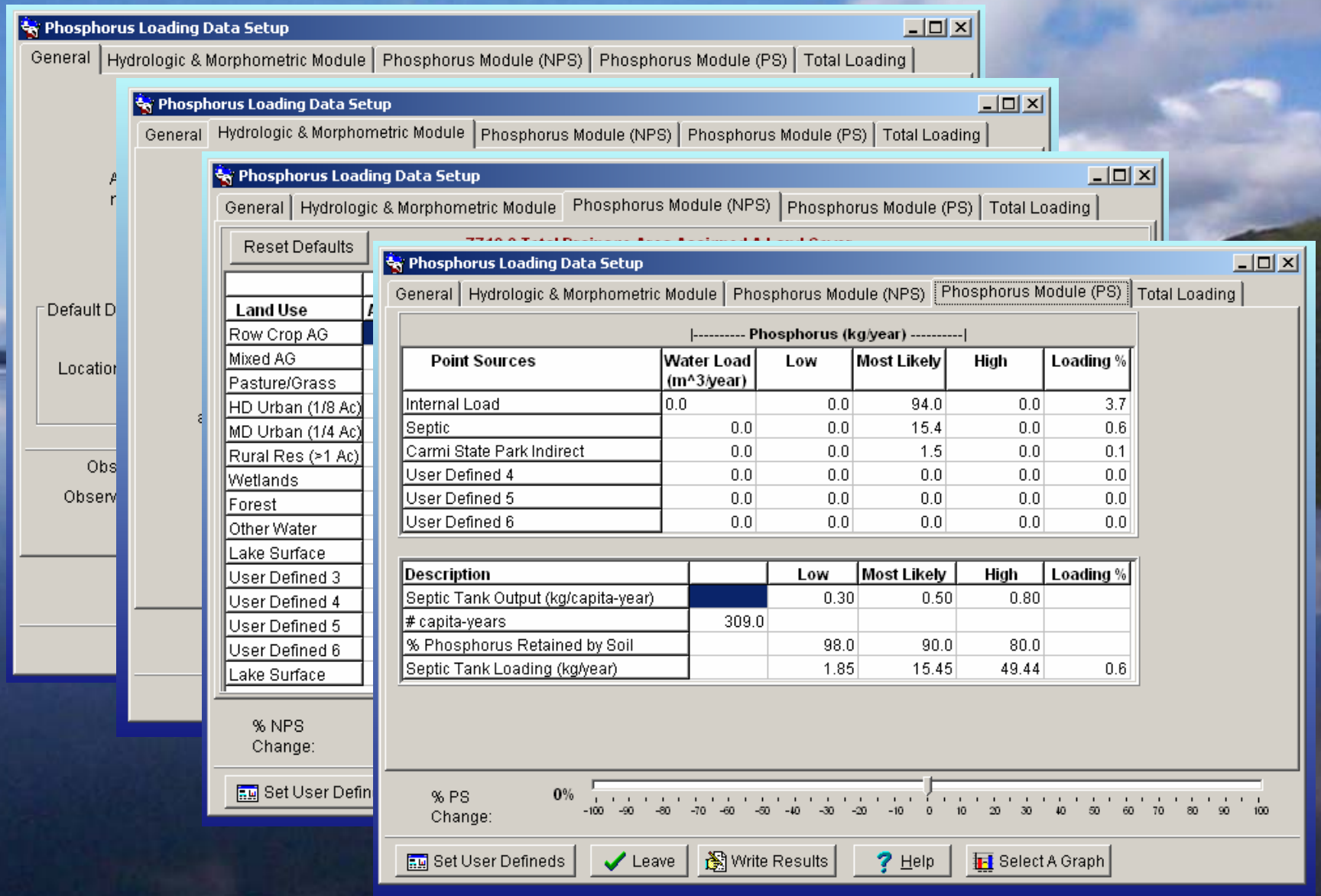
Lake Carmi

- Modeled nutrient export from land use to estimate TP loads to lake
- Export coeff's from Troy et al., 2007
- Use WILMS model to bound export estimates against measurements and estimate internal load
- Use WILMS to predict load reductions needed

Ticklenaked Pond

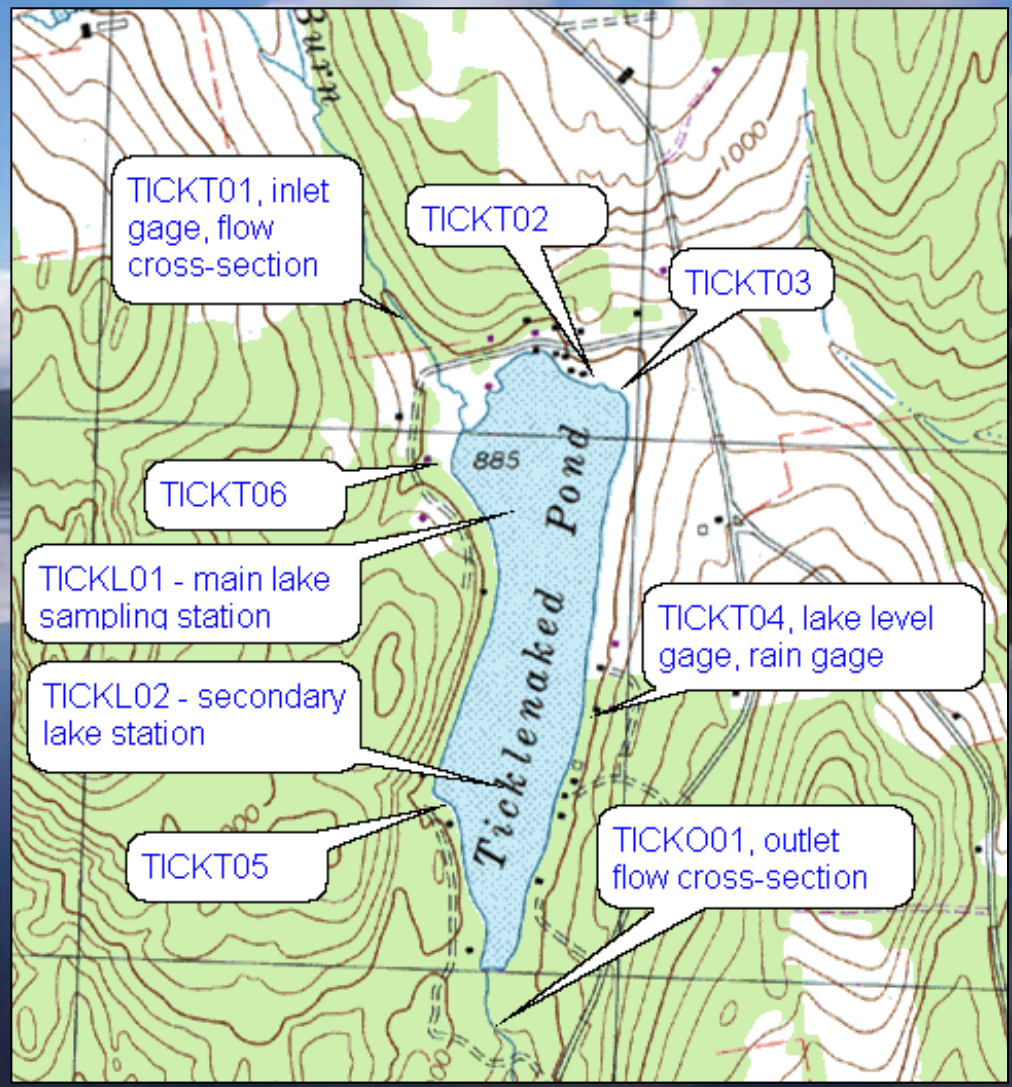
- Conducted mass P balance study during 2005-2006
- Calculated mass P balance for WY2006
- Adjusted annual P load to long-term mean WY
- Use WILMS to predict load reductions needed at mean WY

Wisconsin Inland Lakes Modeling Suite (WILMS)

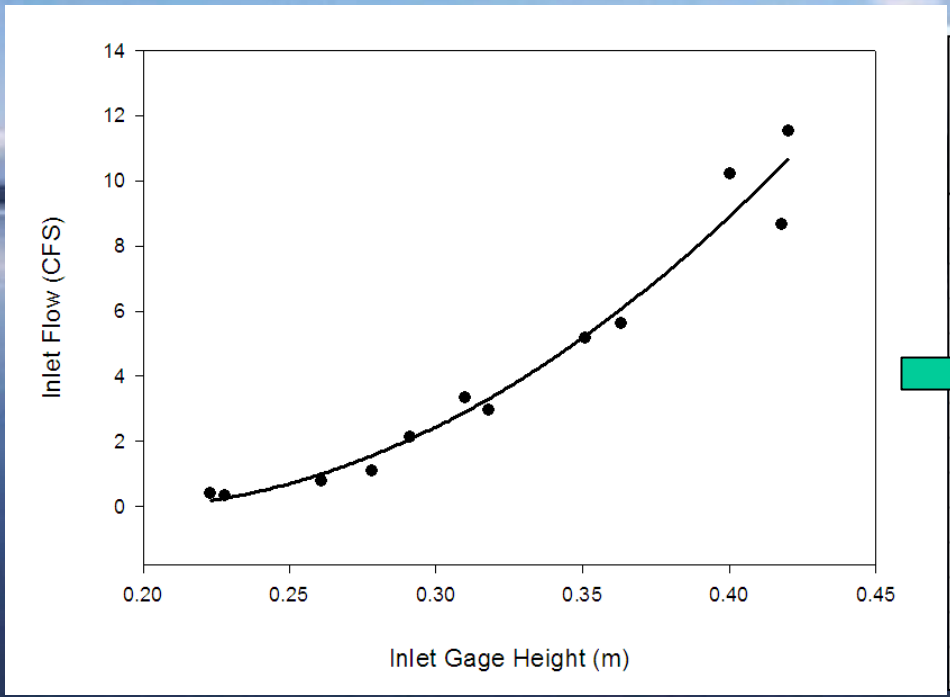


Ticklenaked Pond Mass P Balance -Field study

- Five inlet tributaries
- One inlet gauge
- One lake-level gauge
- One rain gauge
- One ISCO autosampler

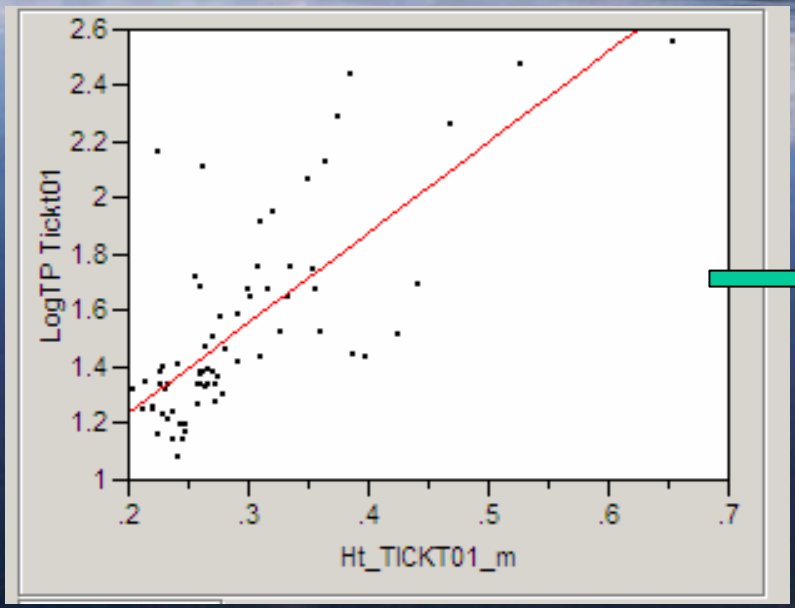


- ***Stage-discharge relationship:***
- Measure water heights and water flows, use this to construct flow history, for inlet and outlet



Date	Hour	Q_Tickt01_L/H (daily for infilled data)	Q_TickO01_L/H (daily for infilled data)	HourlyPLoad_g (daily for infilled data)
22-Jul-05	13	155742	127954	3.25
22-Jul-05	14	124806	124782	2.34
22-Jul-05	15	145235	138670	2.93
22-Jul-05	16	202719	161876	4.92
22-Jul-05	[illegible]	237268	162440	6.38
[illegible]	[illegible]	223493	164136	5.77
22-Jul-05	19	216704	164702	5.48
22-Jul-05	20	207551	165836	5.11
22-Jul-05	21	199118	165836	4.77
22-Jul-05	22	189610	165836	4.41
22-Jul-05	23	185493	164136	4.26
23-Jul-05	0	182569	166404	4.16
23-Jul-05	1	176761	164702	3.95
23-Jul-05	2	172154	163570	3.79

- ***Stage-concentration relationship***
- Relate water heights to total nutrient concentrations
- Use this to construct nutrient accumulation history for gauging record
- Calculated hourly to account for flashiness of stream
- Calculated loads from minor tribs, then sediments, by mass balance



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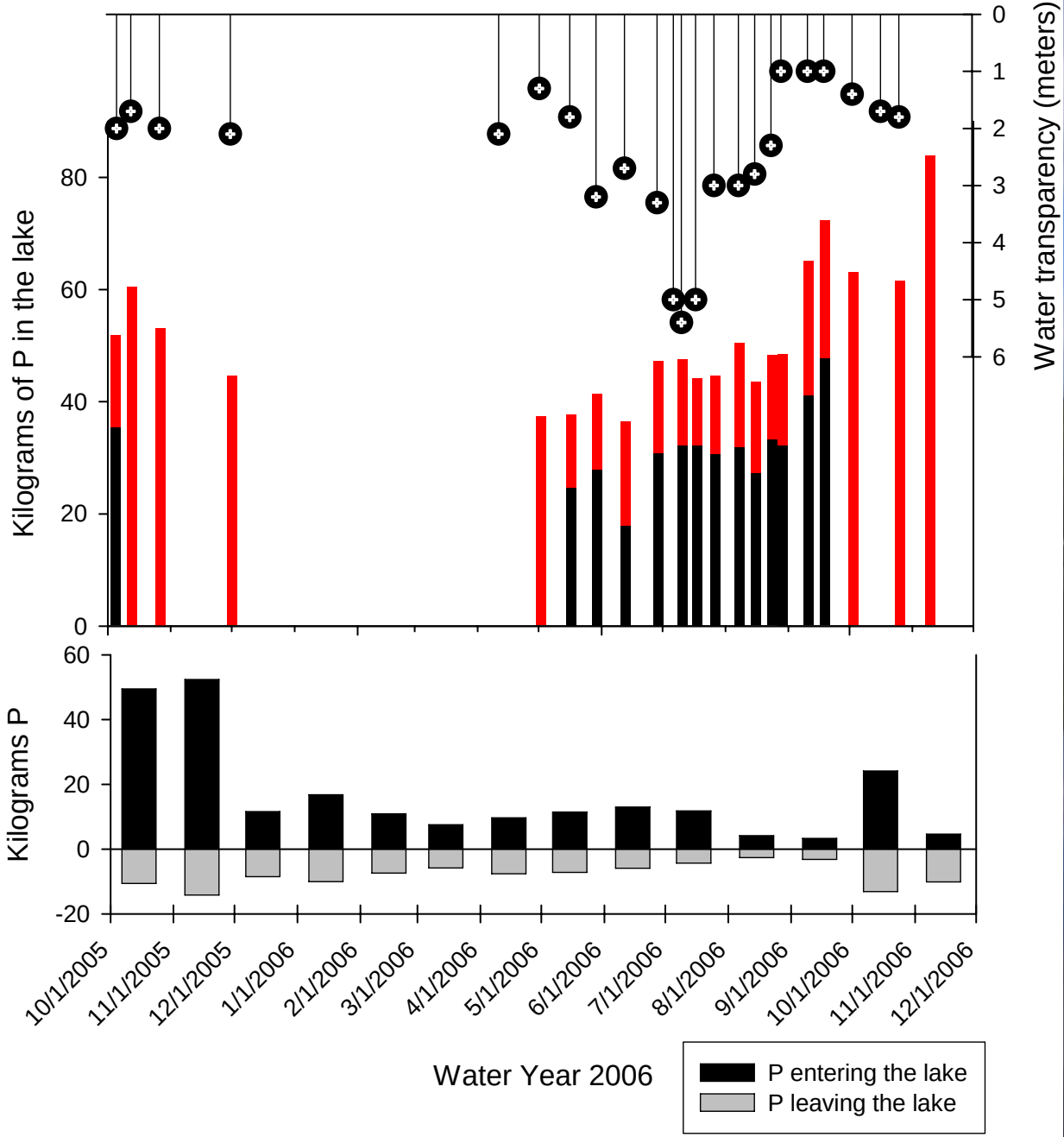
Phosphorus in and out of the lake



Loading summary for both ponds

Ticklenaked Pond

Source of phosphorus load	Measured load in kg (± range), water year 2006	Estimated load, mean water year[3]	Value used to calculate TMDL (kg)
Watershed tributaries[1]	206 (141-264)[2]	116	116
Septic loads	2.5 (<1 – 8)	2.5	3
Internal load	42	86	86
Total annual load	251 (184 – 314)	205	205

Lake Carmi

Source of phosphorus load	Annual range (kg)	Value used to calculate TMDL
Watershed tributaries[1]	510 – 2,227	1,731
Septic loads	16 - 50	33
Internal loads	-154 - 245	94
Load fr m Lake Carmi State Park WWTF[4]	1.5	2
Total annual load		1,860

1) Includes direct P to lake; 2) expressed as std. err; 3) 57% of 2006 flows

Using WILMS to estimate TLC

Phosphorus Predictions & Uncertainty Analysis

Observed spring overturn total phosphorus (SPO): 40.0 mg/m^3

Observed growing season mean phosphorus (GSM): 45.0 mg/m^3

Back calculation for SPO total phosphorus: 22 mg/m^3

Back calculation GSM phosphorus: 22 mg/m^3

Nurnberg Model Input - Est. Gross Int. Loading: 0 kg

% Confidence Range: 70

Lake Phosphorus Model	Low Total P (mg/m^3)	Most Likely Total P (mg/m^3)	High Total P (mg/m^3)	Predicted -Observed (mg/m^3)	% Dif.	Confidence Lower Bound	Confidence Upper Bound	Parameter Fit?	Back Calculation (kg/year)	Model Type
Walker, 1987 Reservoir	16	35	52	-10	-22	20	51	FIT	156	GSM
Canfield-Bachmann, 1981 Natural Lake	23	44	61	-1	-2	14	127	FIT	107	GSM
Canfield-Bachmann, 1981 Artificial Lake	21	37	50	-8	-18	11	107	FIT	118	GSM
Rechow, 1979 General	17	36	54	-9	-20	20	55	FIT	151	GSM
Rechow, 1977 Anoxic	27	58	87	13	29	34	84	FIT	94	GSM
Rechow, 1977 water load<50m/year	20	42	63	-3	-7	24	63	FIT	130	GSM
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	22	47	70	7	18	23	78	FIT	117	SPO
Vollenweider, 1982 Combined OECD	19	35	48	-8	-19	17	60	FIT	142	ANN
Dillon-Rigler-Kirchner	16	35	52	-5	-13	20	51	P	157	SPO
Vollenweider, 1982 Shallow Lake/Res.	15	29	41	-14	-33	14	49	FIT	185	ANN
Larsen-Mercier, 1976	21	45	67	5	13	27	64	P Pin	122	SPO
Nurnberg, 1984 Oxic	18	39	58	-6	-13	20	62	FIT	140	ANN

Finished | Write Results | Display Parameter Values | Help

TMDL: Total Loading Capacity (initial)

Lake Phosphorus Model - Lake Carmi	Predicted current TP	LCL - UCL	Model Fit	Total Loading capacity (kg) for TP = 22 ppb
Rechow, 1979 General	24	11-34	FIT	1825
Nurnberg, 1984 Oxic	38	16-58	FIT	1168
Vollenweider, 1982	39	16-64	FIT	1056
Rechow, 1977	46	21-65	FIT	960
Average of four models				1252
Ticklenaked Pond				
Rechow, 1977 Anoxic	49	24 - 66	FIT	94
Walker, 1977 General	39	16 - 62	FIT	117
Canfield-Bachmann, 1981	37	11 - 107	FIT	107
Rechow, 1977	35	16 - 49	FIT	130
Average of four models				112

TMDL Element: Margin of Safety

- A-priori added 5% margin of safety to both lakes to ensure attainment after watershed implementation

- Lake Carmi
  - 63 kg
- Ticklenaked Pond
  - 7 kg

TMDL: Load and wasteload allocation

- All documented sources in these watersheds presently fall within the Load Allocation
- New point sources…part of the Wasteload Allocation?
- For the purposes of these TMDL's, we are not articulating a defined WLA. However we acknowledge that stormwater permitted discharge falls within WLA.
- New development will have to undergo permitting through stormwater construction general permit, which contains provisions for TMDL watersheds.
- Other NPDES permitting would require reopening TMDL

TMDL Summary

TMDL = LA + WLA = MOS

TMDL Category	Lake Carmi	Ticklenaked Pond
Existing Load	1,860	205
Wasteload Allocation	-	-
Load Allocation	1,189	105
Margin of Safety	63	7
Total Loading Capacity	1,252	112
Load Reduction Required	608	93
%	33%	45%

TMDL

- Expressed as an annual load, with allowable daily and seasonal variation
- Permissible per NRDC v. Muszynski, 286 F 3d.91 (2nd Cir. 2001)

Reasonable Assurance

- Where WLA is predicated on anticipated non-point controls, reasonable assurances on NPS implementation are necessary
- No WLA, so not relevant.

Implementation Plans

Lake Carmi

- 18-point plan
- Tasks articulated within in-lake, lakeshore, and watershed categories
- Plan written as a menu of items from which to choose, with priorities

Ticklenaked Pond

- 3-phase plan, 18 items

1. Watershed + lake- shore project planning
2. Watershed+ lakeshore implementation, plan for in-lake treatment
3. In-lake treatment

- Plan written as a sequence of events designed to facilitate in-lake treatment by controlling watershed sources

Both plans envision multiple-stakeholder involvement!!

Questions?

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