Phosphate Treated Drinking Water: Exploring influence on stormwater

Bruce Wilson (MPCA)| Nick Olson (MDOT)

p-gen3-14h

http://frugal.families.com/blog/how-to-repair-a-garden-hose

PO4 Treated Drinking Water
Potential Influences on Stormwater Runoff

- Losses to streets & curbs from irrigation, fire hydrant flushing, cleaning, car washing, infiltration into stormwater conveyance etc.
  - For this analysis – assumed all ortho P
  - Summer water use ~2.5 times greater than winter
    - Growing season
- Implications?
  - Lakes: near shore impacts (green filamentous, loss clarity)
  - Increased turf & soil P content
    - Linked to winter turf soluble P release?
  - Storm pulses from accumulated street PO4

Drinking Water PO4 Treatment: Summary

Factors affecting corrosion rate:

- Alkalinity, pH, total dissolved solids, temperature
  - » Can't do much about changing these characteristics
- Dissimilar of Metals (causing lead release)
  - » zinc > cast iron > lead > brass > copper

Factors causing copper corrosion problems in MN:

- High dissolved oxygen - gravity iron removal systems
- High Ammonia and TOC in groundwater sources
- Ammonia + high D.O. = Nitrification (iron filters and/or water distribution systems)

From Lih-in Rezania, MDH

Phosphate-based Corrosion Inhibitors

- Used by nearly 400 Community Public Water Systems
- Historical use of polyphosphate - keep water clear and from turning red/black
- Easy to implement/switch from polyphosphate to blended-phosphates or orthophosphate
- Result shown within weeks of implementation
- MDH requires chlorination with treatment

From Lih-in Rezania, MDH

Phosphate Treatments Work

Orthophosphates

- Used by most Iron removal plants
- Most effective
- Optimal feed rate: 1 - 2 ppm as total-PO4

Blended Phosphates

- By some iron removal plants
- Use products that contains at least 50% of orthophosphate
- Optimal feed rate 1.5 - 3 ppm as total-PO4

Polyphosphates

- Work well for lime-softening systems with high pH
- Maximum allowable: dose 10 mg/L; average dose: around 5 mg/L
- Some success at low dosage; copper level goes up at high dosage

From Lih-in Rezania, MDH

Polyphosphate Data

- Given as concentration of phosphate in water supply

- Data collected from 2009-2010

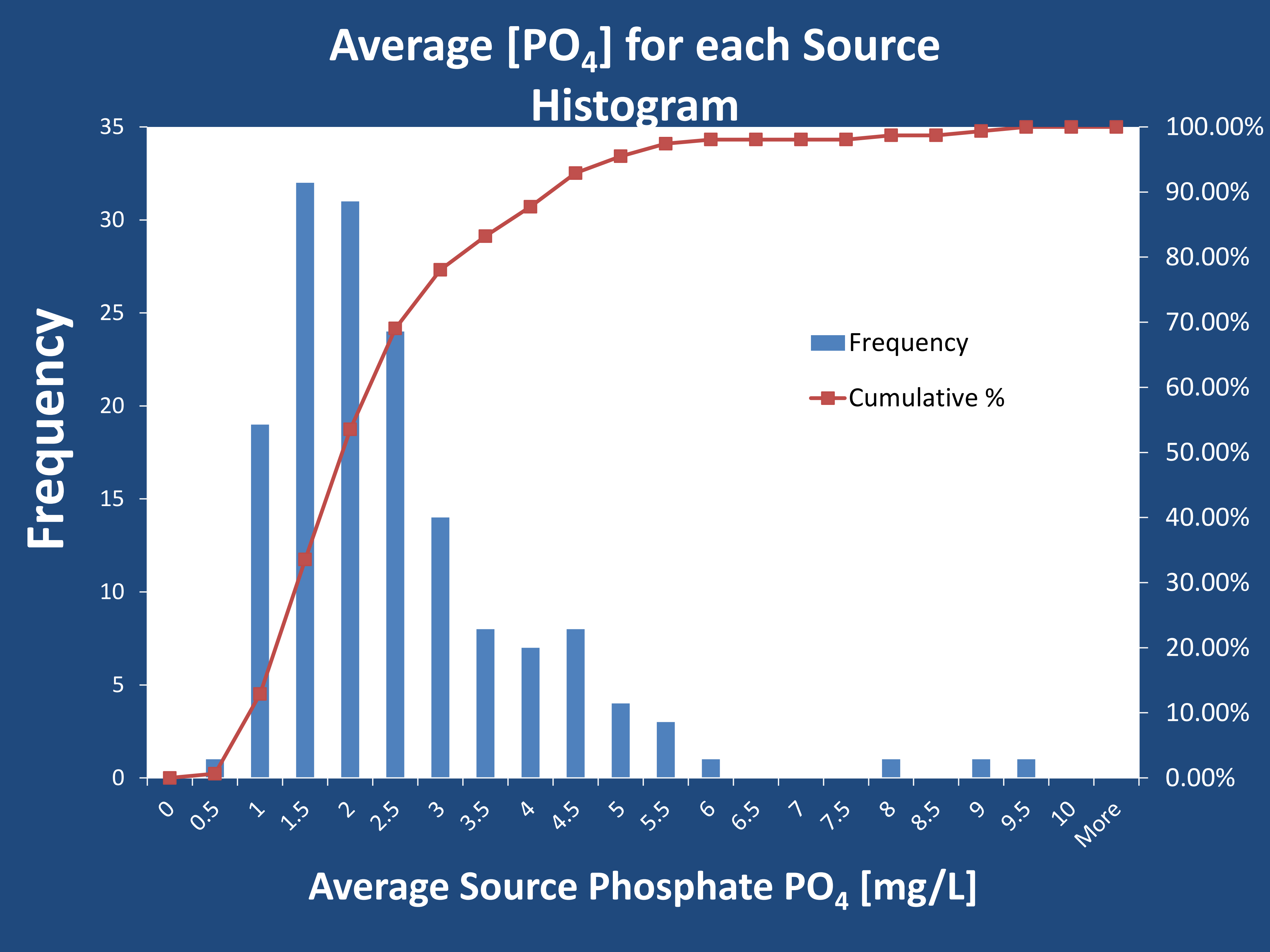
- 156 Data Sources (Cities, Facilities, Hospitals, etc)

- Approx. 16 measurements per source (mode)

- Summer use ~ 2.5 times winter rate

Phosphate = PO_4

[TP] ~ 1/3 [PO_4]



Average [PO4] for each Source Histogram
Frequency
Cumulative %
0
5
10
15
20
25
30
35
0.00%
10.00%
20.00%
30.00%
40.00%
50.00%
60.00%
70.00%
80.00%
90.00%
100.00%
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8
8.5
9
9.5
10
More
Average Source Phosphate PO4 [mg/L]

Phosphate Data Summary

Mean	**2.29**	**mg/L PO_4**
Median	1.85	mg/L PO_4
Standard Deviation	1.46	mg/L PO_4
COV	0.64	-

Recommended Standards for Water Works[1]

4.6 IRON AND MANGANESE CONTROL

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4.6.6 Sequestration by polyphosphates

This process shall not be used when iron, manganese or combination thereof exceeds 1.0 mg/L. **The total phosphate applied shall not exceed 10 mg/L as PO_4.** Where phosphate treatment is used, satisfactory chlorine residuals shall be maintained in the distribution system. Possible adverse affects on corrosion must be addressed when phosphate addition is proposed for iron sequestering. Polyphosphate treatment may be less effective for sequestering manganese than for iron.

1. Recommended Standards for Water Works (2007 Edition).
Policies for the Review and Approval of Plans and Specifications for Public Water Supplies

A Report of the Water Supply Committee of the Great Lakes--Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers

City of Minneapolis
Draft Assessment Method

Minneapolis Water Works

Annual Production (AP): 21-25 Billion gallons

22% Contribution to Other Cities

City of Minneapolis Use: 16 Billion gallons

City of Minneapolis Use: 16 Billion gallons

14% Estimated System Loss

1% Estimated Flushing Loss

Adjusted Use: 14 Billion gallons

City of Minneapolis Use: 14 Billion gallons

49% Commercial, Institutional, Industrial Use

51% Residential Use

Residential Use: 7 Billion gallons

Summer Use = 71% of use or 5 Billion gallons

Winter Use = 29% of use or 2 Billion gallons

Extra Use in Summer = <u>3 Billion gallons</u>

Metro Area Water Utilities

City:	**Mean TP [mg/L]**
Crystal	0.28
Golden Valley	0.27
Minneapolis	0.27
New Hope	0.27
Columbia Heights	0.27
Coon Rapids	0.42
Plymouth	0.47
Orono	0.52
Wayzata	0.50
Maple Plain	0.52
Blaine	0.58
Hopkins	0.58
Minnetonka	0.60

From 2009-2010

Select Cities with PO4-Treated Drinking Water (ppb)

City	Average PO4	Average TP	Average - Bioavailable Adjusted P
Alexandria	1610	515	994
Baxter	730	234	451
Crosby	670	214	414
Detroit Lakes	1420	454	877
Eveleth	1230	394	760
Glencoe	2700	864	1668
Hackensack	4010	1283	2477
Isle	4580	1466	2829
Long Prairie	2410	771	1488
Minneapolis	820	262	506
Minnetonka	1740	557	1075
Sauk Centre	1890	605	1167
Sauk Rapids	2210	707	1365

Lake Standards 12 – 90 ppb, Stream Criteria 55-150 ppb

Load =

Volume of Runoff x [Concentration of Pollutant]

Surface Water Impact

If Mean Concentration of TP in city supplied water = 0.3 mg/L
And if runoff generated to storm sewers equals:

1% Case	**Annual TP Load:**
1% *Flushing Volume*	346 lbs
1% of *Residential Extra Summer Volume*	63 lbs
1% of *Comm., Institut., Indust. Volume*	144 lbs
Total Load	552 lbs

Surface Water Impact

If Mean Concentration of TP in city supplied water = 0.3 mg/L
And if runoff generated to storm sewers equals:

3% Case	**Annual TP Load:**
1% *Flushing Volume*	346 lbs
3% of *Residential Extra Summer Volume*	189 lbs
3% of *Comm., Institut., Indust. Volume*	432 lbs
Total Load	966 lbs

Surface Water Impact

2X

Case:	TP Load [lb/yr]	Bio-Available Load [lbs/yr]	BAE* [lb/acre-yr]**
1%	552	1104	0.03
3%	966	1932	0.05

*Bio-Available Equivalent Loading Rate

**City of Minneapolis ≈ 37,400 acres

Surface Water Impact

Lake	External Load** [lb/yr]	Sensitivity	Watershed Area [ac]
Cedar	485	Very high	1956
Isles	370	High	735
Calhoun	1182	Very high	2992
Harriet*	441	Very high	1139

* Barr, 1982, MPLS chain of lakes Clean Water Partnership Stormwater Monitoring Study
**From stormwater (Lee, 1998)

Surface Water Impact

1% Case, BAE = 0.03 lb/ac-yr

Lake	Utility Contribution* [lb/yr]	% of External Load
Cedar	59	12%
Isles	22	6%
Calhoun	90	8%
Harriet	34	8%

*City Water Utility Contribution = BAE x Watershed Area

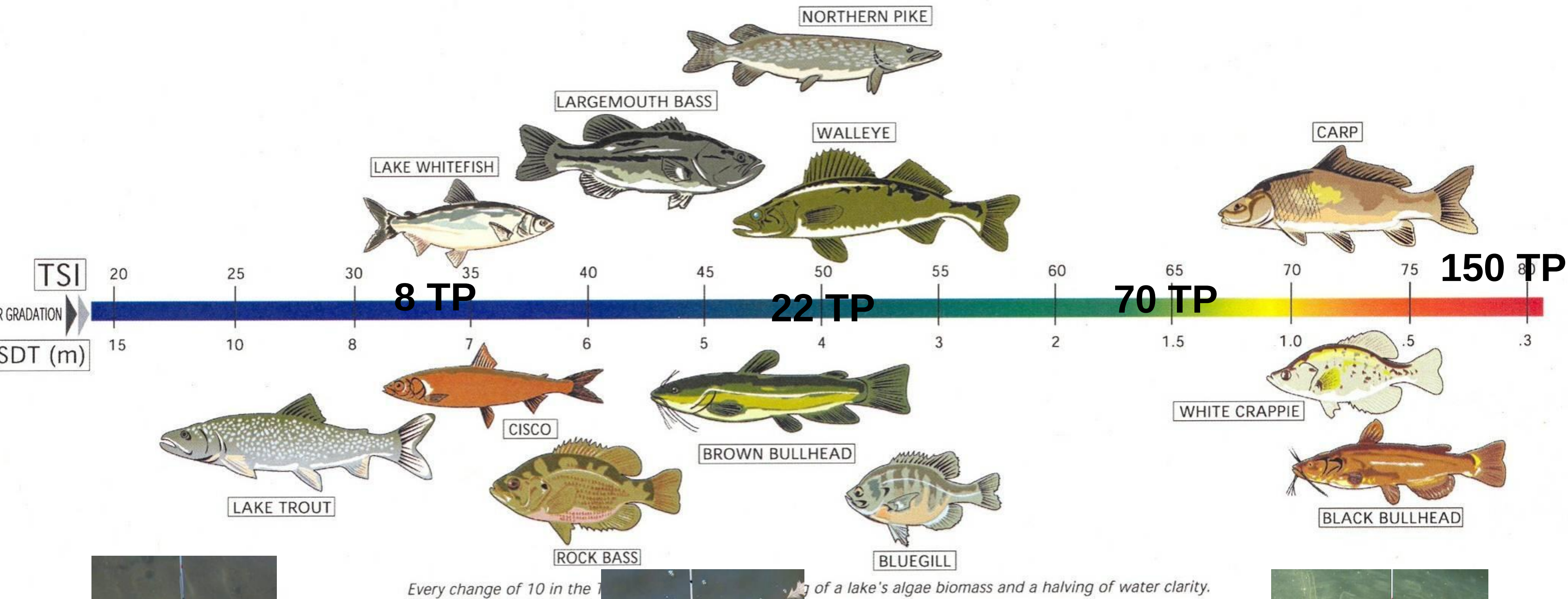
Surface Water Impact

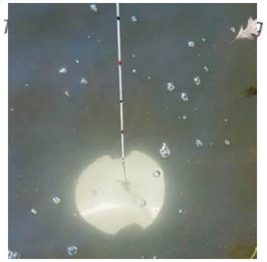
3% Case, BAE = 0.05 lb/ac-yr

Lake	Utility Contribution* [lb/yr]	% of External Load
Cedar	98	20%
Isles	37	10%
Calhoun	150	13%
Harriet	57	13%

*City Water Utility Contribution = BAE x Watershed Area

Fish species vary relative to lake trophic status (Carlson's TSI)

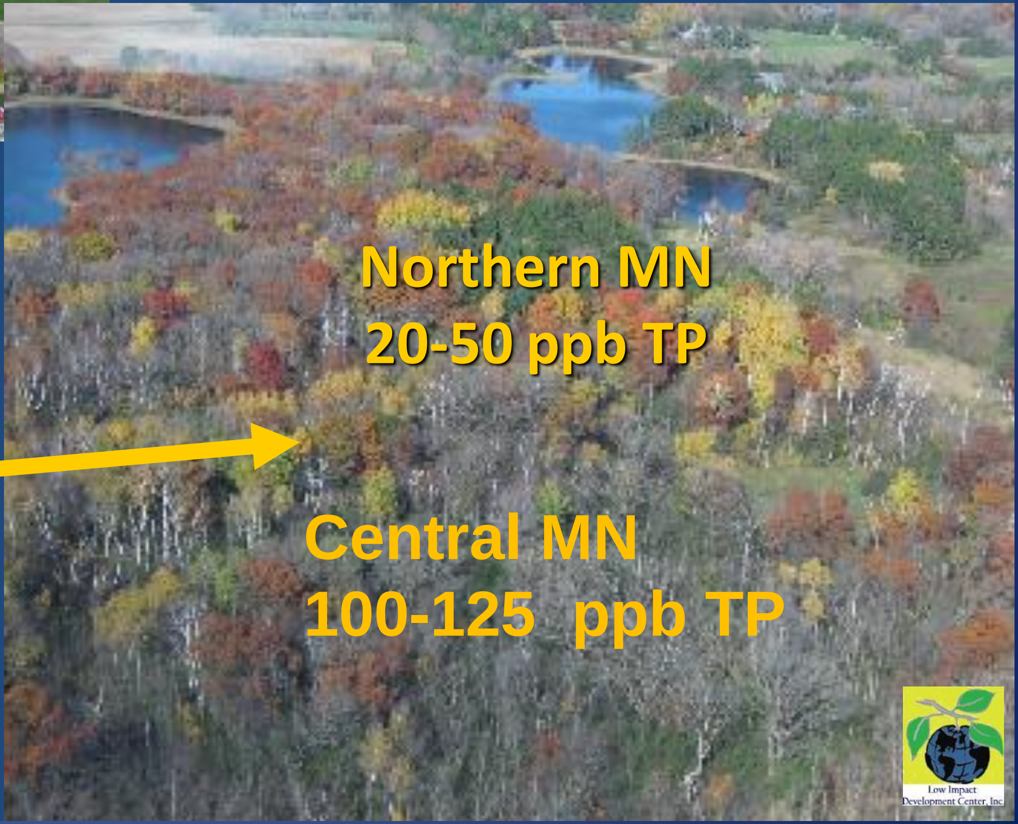




Schupp & Wilson 1993

How do you make this…

function like this?



Minnesota's Lake Eutrophication Standards.
Based on multiple lines of evidence.

Ecoregion	TP	Chl-a	Secchi
(classification)	ppb	ppb	meters
NLF – Lake trout (Class 2A)	12	3	4.8
NLF – Stream trout (Class 2A)	20	6	2.5
NLF – Aquatic Rec. Use (Class 2B)	30	9	2.0
CHF – Stream trout (Class 2a)	20	6	2.5
CHF – Aquatic Rec. Use (Class 2b)	40	14	1.4
CHF – Aquatic Rec. Use (Class 2b) Shallow lakes	60	20	1.0
WCP & NGP – Aquatic Rec. Use (Class 2B)	65	22	0.9
WCP & NGP – Aquatic Rec. Use (Class 2b) Shallow lakes	90	30	0.7

Draft Stream and River P Standards

Table 20. Summary of total phosphorus concentrations from all Minnesota stream sites in STORET. Mean values calculated based on samples collected from 1995-2009 for 595 AUIDs sorted by RNR.

TP	North	Central	South
Criteria (µg/L)	55	100	150
25th %ile	33	77	147
median	48	122	218
75th %ile	70	225	308

Minnesota's Eutrophication Criteria.

Based on multiple lines of evidence.

Table 2. Draft criteria for main-stem rivers, Mississippi River pools and Lake Pepin. Concentrations expressed as summer averages. Source of data for assessment noted. Assumes aquatic recreational and aquatic life uses are maintained if TP and Chl-a are at or below criteria levels.

River/Pool	Site	Data source	TP µg/L	Chl-a µg/L
Miss. @Anoka[1]	UM-872	MCES	100	20
Pool 1[2]	UM-847	MCES	100	35
Lake St. Croix[3]		MCES	40	14
Minn. @Jordan[1]	MI-39	MCES	150	40
Pool 2[4]	UM-815	MCES	125	35
Pepin[5]	4 fixed sites	LTRMP	100	28
Pools 5-8[6]	Near-dam	LTRMP	100	35

[1] River eutrophication criteria-based. Based on modeling UM-872 & MI-3.5 will meet Pepin requirements.
[2] Minimize frequency of severe blooms. Upstream criteria provide additional protection for Pool 1.
[3] MN lake eutrophication criteria-based. Based on modeling St. Croix outlet (SC-0.3) would meet Pepin requirements.
[4] Minimize frequency of severe blooms & meet Pepin requirements
[5]. TP consistent with WI standard. Lake Pepin criteria assessed based on lake-wide mean from 4 monitoring sites.
[6] Minimize frequency of severe blooms; upstream P requirements benefit lower pools. WI standard of 100 µg/L may apply to Pools 5-8

Typical Stormwater Runoff Reductions for Lakes & Streams

- Typical Stormwater P range : 300 – 600 ppb P
  - Lake standards 12 to 90 ppb
  - Stream and river draft P criteria 55, 100 & 150 ppb
    - Consistent with 30 year of watershed project experience

MIDS Proposed Flexible Treatment for Cases with Restrictions

– Proposed Flexible Treatment Goal = 75%

– Antidegradation (protection)

– Restoration (TMDLs)

MIDS Proposed
Flexible Treatment Goal = 75%
Antidegradation & Restoration

- Reductions needed to achieve stream P levels
  - 55 ug P/L requires 73 % to 91% reductions (North)
    - Average Reduction = 84 %
  - 100 ug P/L requires 67% to 83% reductions (Central)
    - Average reduction = 76%

- High soluble P will require greater reductions (affects algae and related oxygen changes and fisheries)
- Sensitive Lakes may require further reductions

Special Thanks To Nick Olson for Analyses & Lih-in Rezania (MDH) for data.

Suggestions & comments appreciated

Drinking Water P Treatment Summary

- Phosphate corrosion control for drinking water treatment contributes ~ 9% of wastewater "P" loading

City Averages

	Mean PO_4 [mg/L]
Alexandria	1.61
Baxter	0.73
Crosby	0.67
Detroit Lakes	1.42
Eveleth	1.23
Glencoe	2.70
Hackensack	4.01
Isle	4.58
Long Prairie	2.41
Minneapolis	0.82
Minnetonka	1.74
Sauk Centre	1.89
Sauk Rapids	2.21