MPCA Phosphorus (P) Strategy: NPDES permits[1]

version 000328

- **Discharge to or affecting a lake or reservoir, to Lake Superior Basin, or to or affecting other waters as listed in Minn.R. Ch. 7065**
  - **yes** — P limit (monthly avg); PMP recommended
  - **no** (discharge to other surface water) — Consider whether:
    - **Discharge to or measurable or cumulative impact on ORVW or TMDL reach where TP associated with low DO**
      or Discharge to or upstream of an area of concern with excess P through cumulative sources (determined by water quality modeling or Basin or watershed planning)
      or Discharge to Basin or watershed with a phosphorus protection strategy
      - **yes** — Consider whether:
        - **new or expanded discharge or a significant upgrade**
          - **yes** — Consider whether:
            - **above *de minimus***
              - **yes** — P limit; PMP recommended
              - **no** — Five year monitoring; PMP (A) required if exceeds 4 mg/L
          - **no** — Consider whether:
            - **above *de minimus***
              - **yes** — Consider whether:
                - **Basin Goal and Strategy in place**
                  - **yes** — PMP (B) required plus P limit for next upgrade or expansion
                  - **no** — PMP (B) required; no limit
              - **no** — Five year monitoring; PMP (A) required if exceeds 4 mg/L
      - **no** — Consider whether:
        - **above *de minimus***
          - **yes** — PMP (B) required; no limit
          - **no** — Five year monitoring; PMP (A) required if exceeds 4 mg/L

Footnote to decision-tree:

[1] For water quality segments that are impaired or threatened for phosphorus or phosphorus-related conditions as listed on the 303(d) list, the MPCA shall use its authority to limit point-source discharges, including existing discharges, by including phosphorus limits where appropriate in NPDES permits as part of a TMDL allocation of point and/or nonpoint discharges. This consideration is also included as a part of the permitting checklist.

Acronyms: ORVW = Outstanding Resource Value Water P = Phosphorus TMDL = Total Maximum Daily Load
TP = Total Phosphorus DO = Dissolved Oxygen PMP = Phosphorus Management Plan (A),(B) = permit language

2. DEFINITIONS OF KEY TERMS IN DECISION TREE

Definitions of several of the key terms included in the decision tree are included here: basin/watershed goal and strategy; "measurable impacts" and "affects;" lakes/reservoirs, for purposes of applying 1 mg/L effluent limits in the rule; "*de minimus*," "new or expanded discharges and significant upgrades," "Total Maximum Daily Load (TMDL)," and "Outstanding Resource Value Waters."

Basin/Watershed Strategy. A basin (or watershed) strategy includes an ambient water quality goal for phosphorus, chlorophyll a, or dissolved oxygen (if related to excess P), combined with guidance for limiting or reducing discharges from pollutant sources that are a significant part of an aggregate phosphorus load that affects water quality in the basin (or watershed). The goal can be:

- numeric (as in a % reduction for change from current levels or a target concentration threshold, like ecoregion criteria or water quality standards for DO), or
- narrative (as in "no net increase")

The goal needs to have been adopted by a basin or watershed organization with responsibility for water resource management (a basin planning team, Joint Powers Board, Clean Water Partnership project sponsor, agency or agencies, etc.). If a discharge is to a water with a basin plan, and that basin plan includes a phosphorus strategy, due consideration will be given to promoting the basin goals.

"Affects" and "measurable impact."
a. "affects" is measured in terms of actual or predicted increases in chlorophyll-*a* concentration, increased frequency of nuisance algae blooms, reduced transparency, reduced dissolved oxygen concentrations (attributable to decaying algae) or related adverse responses to phosphorus. An assessment to determine whether the discharge "affects" the receiving water is typically made over a range in flow (runoff) conditions. However low flows (typically flows with a one-in-ten year recurrence) are the primary flow regime of concern. This is because lakes and reservoirs often exhibit stronger eutrophication-related responses (affects) during drier periods when water residence time is increased. This is particularly true for reservoirs that may have very short water residence times during average to high flow regimes.

The assessment includes using standard lake/reservoir eutrophication models, data assessment, scientific research, and other information relating to the lake/reservoir and its tributaries, watershed, and cumulative point and nonpoint source phosphorus loads. It is necessary to also use best professional judgment and consensus building among interested parties to apply limits that help ensure that the lake's water quality standards, trophic state, and water uses will be protected or re-attained (if the lake is already impaired).

b. "Measurable impact" is the individual contribution of the discharge in causing any of the adverse changes in a. (above).

De minimus* phosphorus loadings.** Municipal facilities with a phosphorus load of 1,800 pounds per year or less will ordinarily be considered as *de minimus* facilities for purposes of considering what, if any, phosphorus controls should be required. This is based on MPCA staff's general experience which shows that these small discharges do not have a measurable impact on the environment. However, if under further review of a specific discharge a measurable impact appears likely, appropriate measure will be considered. The *de minimus* criteria would also not apply to facilities with specific demonstrated impacts on a downstream lake or reservoir or facilities covered by other limitations in rule. Further discussion of the de minimus issue is attached on pages 9 through 14.***

Lake. For purposes of applying effluent limitations under MPCA rules, MPCA staff are defining lakes as water bodies with Minnesota Department of Natural Resources lake identification numbers, with some exceptions. For navigation pools, MPCA staff are recommending the use of residence time as the criteria for determining whether a pool should be considered a lake or a river-system. ***Further discussion on this issue is attached on pages 15 through 19.***

New discharge, expanded discharge or significant upgrade: In the decision tree, the MPCA is defining these terms as follows:

<u>New discharge</u> means a facility which was not in previous existence and will commence discharging of one or more pollutants (see Minn. R. 7001.1020 subp. 20 for complete definition).

<u>Expanded discharge</u> means a change in volume, quality or location such that an increased loading of one or more pollutants results.

<u>Significant upgrade</u> means treatment facility modifications which are performed to provide greater benefit or pupose than facilities that are being abandoned, or increase treatment facility life span <u>and</u> relate to treatment processes which are associated with phosphorus removal. The intent is to include new construction which could be adapted for P removal at a significant savings today rather than waiting for future modifications or new permitting requirements. A good example might include construction of a new secondary/biological treatment process which could be modified for biological or chemical nutrient removal at a lower cost today than in the future.

Replacing existing equipment, not normally associated with P removal, with equipment designed for the same process and sized for the existing facility would not be considered a "significant upgrade." As an example, it would <u>not</u> be considered a significant upgrade to replace chlorine disinfection equipment with ultraviolet light disinfection equipment.

Total Maximum Daily Load (TMDL) reach: a section of river or stream that is on a State, Territory or authorized Tribe list of impaired or threatened waters [Clean Water Act Section 303(d) or TMDL lists] as not meeting its designated uses because of excess pollutants. TMDL studies define the maximum amount of each pollutant that a waterbody can receive and still meet water quality standards such that designated uses are maintained. See the MPCA's TMDL web page: www.pca.state.mn.us/water/tmdl.html.

Outstanding Resource Value Waters (ORVW): Waters of the state with high water quality, wilderness characteristics, unique scientific or ecological significance, exceptional recreational value, or other special qualities that warrant stringent protection from pollution. To preserve the value of these special waters the MPCA prohibits (prohibited discharges) or stringently controls (restricted discharges) new or expanded discharges to such waters (Minn.R. 7050.0180). ***Further discussion on the issue of nondegradation requirements and phosphorus is attached on page 27.***

<u>Prohibited discharges:</u> (Minn.R. 7050.0180 subp.3).
New or expanded discharges are not allowed to the following waters that are within or to:
Boundary Waters Canoe Area Wilderness
Voyageur's National Park
Department of Natural Resources designated scientific and natural areas (as listed in Minn.R. 7050.0470)
Federal or state wild river segments:
Kettle River from (former) dam at Sandstone to confluence with the Saint Croix River
Rum River from Ogechie Lake spillway to the northernmost confluence with Lake Onamia

<u>Restricted discharges:</u> (Minn.R. 7050.0180 subp.6)
New or expanded discharges that result in an increased pollutant loading are not allowed unless there is not a prudent and feasible alternative to the discharge. If such a discharge is allowed, the MPCA shall restrict the discharge to the extent necessary to preserve the existing high quality, or to preserve the wilderness, scientific, recreational, or other special characteristics that make the water an ORVW:

Lake Superior
Lake Trout lakes (as listed in Minn.R. 7050.0470)
Calcareous fens (as listed in Minn.R. 7050.0470)
Mississippi River from Lake Itasca to southerly boundary of Morrison County (included in Mississippi Headwaters Board comprehensive plan of February 12, 1981)
Federal or state designated scenic or recreational river segments:
Saint Croix River (entire length)
Cannon River (from northern city limits of Faribault to confluence with Mississippi R)
North Fork Crow River (from Lake Koronis outlet to Meeker-Wright county line)
Kettle River (from north Pine County line to (former) dam at Sandstone)
Minnesota River (from Lac Qui Parle dam to Redwood County state aid highway 11)
Mississippi River (from county state aid highway 7 bridge in St. Cloud to northwest city limits of Anoka)
Rum River (from state highway 27 bridge in Onamia to Madison and Rice Streets in Anoka)

3. DISCUSSION OF DE MINIMUS FOR POTWS

De minimus is often used as a basis for identifying levels below which there are diminishing returns for applying a rule, treatment, etc. The Wisconsin Department of Natural Resources (WDNR) describe a *de minimus* quantity as "an amount too small to have a demonstrable effect" in their implementation guidance for Chapter NR 217 Phosphorus Effluent Standards and Limitations (WDNR, 1999). They go on to describe a procedure for evaluating cumulative loadings to streams and lakes. Relative to applying phosphorus (P) effluent limits, the State of Wisconsin employs a *de minimus* level of 150 lbs./month (1,800 lbs./yr. or 818 kg P/yr.) for municipal POTWs and a level of 60 lbs./month for other types of facilities. Those facilities above these thresholds are subject to "an effluent limitation equal to 1 mg/L P as a monthly average unless an alternative limitation is provided under subpart (2)."

Many small dischargers in Minnesota do not clearly affect a lake or reservoir except as part of the *cumulative* phosphorus load that may be adversely affecting a lake, or has the potential to adversely affect the lake or reservoir. Many other discharges, not covered by Minn. R. pts. 7065.0010 -.0070 or 7065.0100 - .0160, may individually, or as part of the cumulative load, adversely affect river reaches, including TMDL or ORVW reaches.

The purpose of this discussion is to determine whether there may be some *de minimus* level (expressed in terms of design flow or loading rate) for point source discharges below which the amount of phosphorus generated may be too small to have a quantifiable impact on a downstream lake or reservoir – based on a basin-scale analysis. Facilities falling below this *de minimus* level would, in most cases, not be subject to a phosphorus limitation upon demonstration of meeting the *de minimus* test. Two exceptions would be:

a) Small dischargers covered by Minn. R. 7050.0211 subp. 1, 7065.0070, or 7065.0100 - .0160. In accordance with these rules, all point source discharges directly to, or affecting a lake or reservoir, to the Lake Superior Basin, or directly to or affecting the St. Louis River, the Mississippi River upstream of the Blandin Dam in Grand Rapids, Little Minnesota River, Big Stone Lake, and Albert Lea Lake are required to remove phosphorus to 1 mg/L or less.
b) Dischargers deemed to have a *measurable* effect on a downstream lake or reservoir based on modeling efforts *specific to that resource*.

As a part of our analysis we conducted an initial quantitative basin-scale exercise to evaluate the relative (cumulative) impact of phosphorus loading from publicly–owned treatment works (POTWs) in three basins: Upper Mississippi, Minnesota, and St. Croix basins. It was hoped that results from these basins might be applicable to other basins in Minnesota. Data considered in this assessment include: facility type (mechanical or pond), design flow, measured or estimated effluent P, estimated P loads, and population estimates for the municipalities served by the treatment facility. P loads from all facilities in the basin were compared to P loading rates (flux) at critical integrators for each basin for low, average, and high flows as follows: Upper Mississippi River POTWs were evaluated for their contribution to P flux at Coon Rapids Dam; Minnesota River POTWs were evaluated for their contribution to P flux at Jordan; and St. Croix POTWs were evaluated for their contribution to P flux to Lake St. Croix as measured at Prescott. In addition two subsets of facilities with design flows of : less than or equal to (≤) ≤0.2 mgd and ≤0.1 mgd were evaluated as well for their relative impact on P loading in each basin. A design flow of 0.2 mgd was selected since it is used to define "significant discharge" for the purposes of instituting nondegredation review (Ch. 7050.0185 subp. 2) and applies to "significant" new or expanded discharges. A design flow of ≤0.1 mgd was offered as an additional option. In this summary we present data from all facilities and those ≤ 0.2 mgd. Additional spreadsheets and data summaries are available that include complete results from the overall analysis.

All flux estimates for the "basin integrators" were derived from flow-weighted means as calculated by Met Council Environmental Services. P concentration data were derived from a previously compiled database that included POTW monitoring data and estimates when no data were available. Average wet-weather design flow was used to represent flow from the facility. Population estimates were derived from map census data and do not necessarily reflect actual population served by the POTW. Supporting data is provided in three appendices to this memorandum. A summary of our findings follows:

Table 1. Number of and hydraulic design size of facilities by basin.

	Upper Mississippi	Minnesota	St. Croix
Total	123	133	23
≤ 0.2 mgd	69 (56 %)	85 (64 %)	17 (74 %)

A majority of the POTWs in each of these basins has a design flow less than (<) 0.2 mgd. Of those < 0.2 mgd, ponds were the predominant POTW in each basin. Distribution of facility type by basin is as follows: – *Upper Mississippi River*: of 65 mechanical POTWs 24 were ≤ 0.2 mgd and of 57 ponds 45 were ≤ 0.2 mgd. *Minnesota River*: of 56 mechanical POTWs 25 were ≤ 0.2 mgd and of 77 ponds 60 were ≤ 0.2 mgd. *St Croix River*: of 6 mechanical POTWs 2 were ≤ 0.2 mgd and of 17 ponds 11 were ≤ 0.2 mgd.

Table 2. Median P concentration for facilities < 0.2 mgd

	Upper Miss.	Minnesota	St. Croix
Mechanical	4.0 mg/L	4.0 mg/L	
Ponds	2.0 mg/L	2.0 mg/L	2.0 mg/L

In terms of concentration, no difference in performance was evident between basins. Mechanical facilities exhibited higher and less consistent concentrations than ponds.

Typical P concentrations for mechanical POTWs are on the order of 3 – 5 mg/L, while ponds typically range from 1 – 3 mg/L and average 2 mg/L. P concentrations above about 4 to 5 mg/L may be indicative of elevated concentrations and may be an appropriate trigger for implementing a "P management plan" that would require the facility to evaluate sources of P in the influent stream and opportunities for pretreatment.

Table 3. Median P loading rate (lb./yr.) for POTWs < 0.2 mgd

	Upper Miss.	Minnesota	St. Croix
Mechanical	371	940	
Ponds	346	199	214

As with concentration, P loading rates from mechanical POTWs were higher and more variable than ponds. The median for ponds was about 200 to 350 lbs./yr., and the majority of ponds in all three basins discharged < 1,000 lbs./yr. Mechanical POTWs were on the order of 400 – 900 lbs./yr., with the majority discharging < about 1,800 – 2,000 lbs./yr.

Table 4. Median population and per capita loading rates for POTWs < 0.2 mgd

	Upper Miss.		Minnesota		St. Croix	
	Pop.	**lbs./cap.**	**Pop.**	**lbs./cap.**	**Pop**	**lbs./cap.**
Mechanical	714	1.6#	591	1.3#		
Ponds	518	0.7#	430	0.6#	380	1.1#

POTWs ≤ 0.2 mgd typically serve populations of < 1,000 persons. Mechanical POTWs often service larger populations than ponds, typically are on the order of 400 – 600 persons. Per capita loading rates for mechanical POTWs ≤ 0.2 mgd were generally < 2 lbs./cap/yr. and more commonly 1.3 – 1.6 lbs./cap. /yr. Rates for ponds were generally < 1 lbs./cap. / yr. Rates above these levels may indicate the presence of industrial contributions to the influent.

Table 5. Relative P contribution of ≤ 0.2 mgd facilities to basin-wide P loading.

(Estimate at current concentration / estimate @ 1 mg/L P)

	Upper Miss.	Minnesota	St. Croix
Low flow	6.5 % / 1.8 %	8.2 % / 1.3 %	2 % / 1 %
Average flow	1.8 % / 1.1 %	1.3 % / 0.2 %	1 % / 0.5 %

Based on Table 5, POTWs with design flows ≤ 0.2 mgd represent a very small percentage of the basin-wide loading rates at low flow (~ 8 percent or less) and an extremely small percentage at average flows (< 2 percent). The estimates in Table 5 should be considered maximum contributions rather than actual since flows from POTW's during low flow are often much lower than average wet-weather design flows. Also, during low-flow periods there will be inadequate "energy" in the river system to transport these loads to the downstream integrators used in this analysis (though subsequent high flow events will most likely transport the P downstream).

Low-flow estimates of P contribution to basin-wide loading range from a high of 8.2 percent in the Minnesota Basin to a low of 2.0 percent in the St. Croix Basin. At average flows, contributions are < two percent in each basin. If we assume P removal to 1.0 mg/L for all POTWs with design flows ≤ 0.2 mgd, on average, the percent contributions at low flow range from 1.8 percent in the Mississippi to 1 percent in the St. Croix Basin. Because of the larger number of facilities, reductions would be greater in the Mississippi and Minnesota Basins as compared to the St. Croix. The relatively small reductions in P loading is in part a function of the relatively low concentrations (2 mg/L on average) in ponds, which are the predominant type of POTW for facilities with design flows < or equal to 0.2 mgd. It is also important to note that most pond discharges occur seasonally, typically in the spring and fall when the production of nuisance blooms of blue-green algae are not common.

Based on stakeholder discussion and the importance of P loading as a measure in assessing the affect of P on receiving waters, it appears that a load-based *de minimus* would be more appropriate than a flow-based *de minimus*. With this information in mind, and in view of Wisconsin's *de minimus* level, we would recommend a *de minimus* level of 1,800 lbs P/yr (818 kg P/yr) as a general guideline for assigning P effluent limits. This level would be considered absent specific demonstrated impacts on a downstream lake or reservoir or rule conditions which would not allow for a *de minimus* level.

Further, it may be reasonable to use an average effluent concentration of 4 mg/L as a trigger above which consideration would be given to the P management plan (PMP) process. Most ponds and many mechanical facilities (Table 2) readily achieve a concentration of 4 mg/L or less. The PMP process would require facilities to monitor influent and effluent and determine where sources of excess P are entering the waste stream. This provides the opportunity for source controls to be instituted to reduce P loading to the POTW and hence the receiving waters. A load-based *de minimus* and a 4 mg/L trigger will favor ponds over mechanical facilities given that the vast majority of the small (<0.2 mgd) ponds in this analysis generate < 1,800 lbs P/yr. A loading rate of 1,800 lbs P/yr is approximately equivalent to 0.2 mgd at 3 mg/L – a concentration most ponds can readily achieve. However, 3 mg/L is rather low for a mechanical facility and more typical concentrations of 4 or 5 mg/L at 0.2 mgd would translate to about 2,400 to 3,600 lbs/yr (Table 6). As wet-weather design flows exceed about 0.3 mgd it will be difficult for most facilities to remain below a 1,800 lb./yr. *de minimus* level (absent additional P removal at the facility) based on typical concentration ranges (2 mg/L for ponds and 4 mg/L for mechanical).

Table 6. P loading as a function of flow and concentration.

(combinations of flow and concentration at or below the *de minimus* guideline are in bold and shaded)

Flow mgd	Concentration mg/L	Load Kg P/yr	Load Lbs P/yr
0.1	**2**	**276**	**607**
0.1	**3**	**414**	**911**
0.1	**4**	**553**	**1,217**
0.2	**1**	**276**	**607**
0.2	**2**	**553**	**1,217**
0.2	**3**	**829**	**1,824**
0.2	4	1,105	2,431
0.2	5	1,658	3,648
0.3	**2**	**829**	**1,824**
0.3	3	1,242	2,732
0.3	4	1,656	3,643
0.4	2	1,105	2,431
0.4	3	1,656	3,643
0.4	4	2,208	4,858
0.5	2	1,658	3,648

In summary, a load-based *de minimus* level of $\leq$ 1,800 lbs./yr. has been proposed for use by MPCA staff in considering whether small POTW's should or should not receive P effluent limits as a part of this overall strategy. As noted previously, in general MPCA staff experience shows that discharges < 1,800 lbs./yr do not have a measurable impact on the environment and as a result such discharges will not ordinarily be subject to phosphorus limits. However, if under further review of a specific discharge a measurable impact appears likely, appropriate measures will be considered. In addition, safeguards are built in to allow for limits where it has been shown that the facility may have a demonstrable adverse impact, individually or as part of a cumulative P load to a specific downstream lake or reservoir.

4. DISCUSSION OF DE MINIMUS FOR INDUSTRIAL FACILITIES

Based on our analysis of the available data, current industrial facilities with design flows ≤0.20 mgd discharge a small fraction of basin-wide P mass even during low flow years (when the contribution of point source discharges is relatively high), and have low effluent phosphorus concentrations. *All facilities evaluated had loading rates < the proposed 1,800 lb. P/yr. de minimus for POTWs*. A memorandum is available which includes the industrial facility data and our analysis.

The P mass loads from all industrial dischargers in the Upper Mississippi, Minnesota, St. Croix, Cedar and Des Moines River basins were compared to basin-wide P loading rates (flux) at critical integration points. The data suggest that, at this time, it may be reasonable to use the *de minimus* of 1,800 lb. P/yr as a general guideline for industrial facilities, absent specific demonstrated impacts on downstream lake or reservoir or other rule limitations. Our findings are summarized below:

- There are two, or fewer, industrial facilities with design flows ≤ 0.20 mgd in any basin
- The median and mean effluent P concentrations of facilities with design flows ≤0.20 mgd were below 1.0 mg/L, and no facility showed an effluent P concentration ≥1.0 mg/L
- The P mass discharged by the combined industrial facilities with design flows ≤ 0.2 mgd in any basin was < 0.1 percent of the cumulative basin P load (Table 1).

Table 1. Industrial facilities- % contribution to basin P mass in a low flow year (Estimate at current concentration/estimate @1 mg/L P)

	Upper Miss.	Lower Miss.	Minne-sota	St. Croix	Cedar	Des Moines
All Ind.	0.7/2.3	0.8/3.8	17.8/4.0	0.6/1.4	4.1/5.7	90/5.3
≤0.2 mgd	<0.1/<0.1	<0.1/<0.1	<0.1/<0.1	0.0/0.0	0.0/0.0	0.0/0.0

5. DISCUSSION OF DEFINITION OF “LAKE”

Minn. Rule 7050.0211 subp. 1 (referred to as the phosphorus rule) reads, “Where the discharge of effluent is directly to or affects a lake or reservoir, phosphorus removal to 1 milligram per liter shall be required…In addition, removal of nutrients from all wastes shall be provided to the fullest practicable extent wherever sources of nutrients are considered to be actually or potentially detrimental to the preservation or enhancement of designated water uses.” The first portion of this rule was intended to be applied strictly to lakes and reservoirs while the latter, narrative portion could potentially be applied to all waters where it has been demonstrated that nutrients are impairing a designated use.

When this rule was originally crafted in the 1970’s little or no attention was paid to the impact of nutrients on flowing waters (i.e., rivers) because it was believed that the very short residence time or high turnover rates did not allow algae to fully utilize available nutrients and produce nuisance blooms. In recent years, other researchers (and we) have begun to take a closer look at nutrient impacts on flowing waters and have recognized that excess nutrients will contribute to algal growth in rivers. However, questions remain on: what concentrations represent nuisance conditions, what algal forms dominate river blooms (blue-green algae for instance which commonly are associated with nuisance blooms in lakes do not fare well in a turbulent river environment), and how the production of excess algae may lead to impairment of use through the production of excess Biological Oxygen Demand (BOD) and resulting violations of dissolved oxygen water quality standards – which may be a problem in slow moving reaches of some rivers.

One key factor that separates lakes and reservoirs from rivers is <u>residence time</u>. Natural lakes generally have very long residence times, typically measured in terms of months to decades, and hence residence time is more than adequate to allow for growth of algae. Reservoirs, on the other hand, may vary substantially with residence times measured in terms of weeks, months, or years. Lake Pepin (a run-of-the-river reservoir), for example, exhibits residence times of about 19 days on average but may range from a low of 5 - 6 days at high flow to over 60 days at very low flows.

Soballe and Kimmel (1987) in their study on factors influencing phytoplankton abundance in rivers, lakes and reservoirs noted residence time as a critical factor. In their study of over 600 systems the average residence times for the three waterbody types were as follows: rivers 18 (±1.2) days, reservoirs 529 (±85) days and lakes 1,073 (±185) days. They note further that reservoirs and natural lakes showed parallel behavior with respect to algal production and numerous other variables. Numerous authors note the significance of residence time on the prediction of algal biomass in rapidly flushed impoundments and rivers. Dillon (1975) notes that phytoplankton are removed from rapidly flushed systems before standing crop has reached the level determined by the concentration of the limiting nutrient. Pridmore and McBride (1984) note that typical (lake-derived) chlorophyll-a nutrient relationships tend not to work in impoundments with short residence times (< 14 days). Walker (1985) also notes that at residence times < about 14 days flushing may be an important factor to include in chlorophyll-a predictive models. This was shown to be the case in modeling conducted for Lake Pepin (Heiskary and Walker, 1995). Thus, where we have questions as to whether an impounded reach of river should be considered a reservoir, for the purpose of strictly applying the monthly average portion of the phosphorus rule, it would seem that residence time should be considered.

Historically, our primary basis for defining lakes and reservoirs has been to refer to Minnesota Department of Natural Resources Bulletin 25 (1968). This publication provides unique identification numbers to all lakes in the state based on Division of Waters (DOW) interpretation. For purposes of applying the "phosphorus rule" this has generally provided an adequate basis for defining lakes and reservoirs in most instances.

However, there have been exceptions to this as in the case of waters such as mine-pit lakes, which may not have an assigned DOW ID number (at the time of our analysis) but have become recognized as lakes. Hence, we have been concerned about discharges that may impact these waters. Another pertinent (to this discussion) exception has been the navigation pools on the Mississippi River, most specifically Pools 2 and 3 (immediately above and below the Hastings dam). These pools have long been deemed to be river-like in nature and hence strict application of the numeric portion of the phosphorus rule has not been applied to discharges directly to these pools.

Recently, however, questions have been raised as to whether the navigational pools on the Mississippi River and a few other very short residence time impoundments on the St. Croix and other rivers should be considered reservoirs for the purpose of applying the rule. In addition to very short residence times, which will limit the amount of algae produced relative to the amount of phosphorus available, these impoundments often receive exceedingly high P loading rates (flux) because of their extremely large watersheds relative to their size. As such it is often difficult to define "affects," either individually or cumulatively relative to background loadings.

The following preliminary analysis attempts to explore residence time in a subset of the navigational pools on the Mississippi River – specifically Pools 1 through 8. In this exercise, data were assembled for Pools 2 through 5. The purpose of this exercise was to review pool morphometry (specifically volume) and estimate water residence time during average and low flow conditions and determine whether residence times of these pools are more characteristic of large rivers (short, on order of 18 days or less) or more characteristic of reservoirs (longer, on the order of 14 – 18 days or more). Pool morphometry was summarized from U.S. Army Corps of Engineers (USACE) Water Control Storage Tables by Gordy Heitzman, USACE, and transmitted verbally in a phone conversation. Flow information was summarized from the USACE Web site from representative discharge points for each pool.

The critical summer months corresponding to the "growing season" (June, July, August, and September) were used for this purpose. For each month median and 90 percentile flows (flows that are exceeded 90 percent of the time) were averaged to provide an estimate of summer median and summer low flow (with one in ten year recurrence) for each pool. These flows were compared to pool volumes and residence times were estimated. Pool morphometry is summarized in Table 1 for select pools and summer flow characteristics for each pool are summarized in Table 2.

Based on pool volumes and estimated median and 90th percentile flows, summer residence times were estimated for each pool as follows:

Pool volume (a-f) / (Flow (cfs) x 1.99) = residence time (days)

Pool	**Median (50th percentile)**	**Low (90th percentile)**
Pool 2	2.8 days	11. 4 days
Pool 3	0.6 days	1.5 days
Pool 4 (Pepin)	15.0 days	26.0 days
Pool 5	1.2 days	3.1 days

If we use 14 days as an indicator of the minimum residence time associated with "reservoir" conditions these initial estimates of residence time suggest that Pools 2, 3, and 5 have residence times more characteristic of large rivers than reservoirs. This is because of their relatively small volumes relative to the discharge of the river. Based on this cursory examination of these navigation pools it may not be appropriate to treat them as reservoirs, for the purpose of imposing the numeric portion (effluent limitation) of the phosphorus rule.

In contrast Pool 4, which contains Lake Pepin (a natural lake by definition), is much larger and hence exhibits longer residence time. In addition, Spring Lake, a side channel lake in Pool 2, has demonstrated significant algal growth during low flow periods and water quality modeling suggests it is a major contributor to the algal problems in Lake Pepin. Based on an analysis of water circulation in Spring Lake (Stefan and Dematracopoulus, 1979) water residence time is likely on the order of 9 – 35 days under low flow conditions (and is somewhat dependant on wind speed and direction).

Thus wastewater treatment facility (WWTF) discharges directly to these pools, with the exception of Lake Pepin and Spring Lake, should not be treated as a discharge to a "lake or reservoir" and automatically be required to treat to a *monthly* 1 mg/L. For WWTF discharges in the Lower Mississippi River Basin (and potentially other basins as well), above Lake Pepin, the phosphorus effluent rule will be applied in terms of "affects" on Lake Pepin.

WWTF discharges which go directly to backwater lakes in these pools, however, could be considered as direct discharges if these lakes have been defined as separate lakes based on their MDNR DOW number and there is some demonstration that the hydrology (e.g., residence time) of the lake is substantially different from the overall pool of which it is a part. Baker and Baker (1979) demonstrated that significant differences in residence time can be anticipated in backwater lakes adjacent to or a part of the navigation pools. This increased residence time can contribute to a higher standing crop of algae (and hence greater sensitivity to nutrient inputs than the main pool). It will be important, whenever possible, to attempt to describe water residence time in these backwater lakes as a part of the assessment of the effects of a specific discharge.

A more complete assessment of these pools should be conducted (e.g. include all pools) as a part of the Lower Mississippi River Basin Information Document (BID). This information may shed new light on this issue. As a part of the BID and overall phosphorus reduction plan for the basin, this may cause us to revisit the issue and make a more informed decision on the water quality impacts to and appropriate levels of protection needed for these pools.

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Table 1. Navigation Pool Volumes (acre-feet)

Pool	Portion	Volume
Pool 2	Minnesota River	12,000 a-f
	Upper Pool	10,000 a-f
	Lower Pool	64,000 a-f
	Sum (Miss portion)	74,000 a-f
Pool 3	Lower Pool (excludes St. Croix)	21,000 a-f
Pool 4	Pepin	448,100 a-f
	Entire Pool	480,000 a-f
Pool 5	Entire pool	73,000 a-f

Table 2. USCE and USGS Flow Data for Control Points on Select Navigation Pools [in cubic feet per second (cfs)]

Control Point	Month	June	July	August	September	Mean
St. Paul	Median	20,000	16,000	10,000	8,000	13,500
(Lock & Dam 2)	Low (90%)	5,000	4,000	2,000	2,000	3,250
		June	July	August	September	Mean[2]
Prescott	Median	28,000	20,000	15,000	13,000	19,000
(Lock & Dam 3)	Low (90%)	10,000	8,000	5,000	5,000	7,000
		June	July	August	September	Mean
Alma[1]	Median	40,000	30,000	23,000	24,000	29,000
(Lock & Dam 4)	Low (90%)	15,000	10,000	10,000	11,000	11,500
		June	July	August	September	Mean
Wabasha	Median	40,000	33,000	25,000	25,000	30,750
(Lock & Dam 5)	Low (90%)	15,000	10,000	10,000	12,000	11,750

[1] includes Chippewa River which enters at outlet (sand delta forms outlet of Pepin) of Pepin
[2] calculated values from Lake Pepin reports: 13,700 cfs (median) and 5,750 cfs (90 %tile)

6. PHOSPHORUS MANAGEMENT PLANNING GUIDANCE (including permit language and monitoring frequency guidance)

Phosphorus management planning (PMP) will be recommended or required in all new or reissued wastewater treatment facility (WWTF) National Pollutant Discharge Elimination System (NPDES) permits. PMPs are a tool being used to determine if publicly owned treatment works (POTW) and industrial wastewater dischargers contribute substantial loads of total phosphorus (TP) that could be reduced through pollution prevention or improved wastewater treatment methods. The phosphorus strategy "Decision Tree" will be used to determine which facilities require a P limit and which facilities are recommended or required to complete a PMP. It is important to note that phosphorus limits may become future permit requirements regardless of management plan efforts taken. Therefore, it is recommended that you consider phosphorus reduction strategies with your industrial users and/or treatment options at your WWTF.

In general, if your WWTF discharge volume is low and TP concentration is low, we do not expect you to invest much time or money developing a PMP. It is important, however, to consider your TP input to the environment and not neglect the value of cost effectively reducing your phosphorus discharge. We expect to see the most value from PMPs, in terms of reducing phosphorus discharge, from facilities that: 1) are discharging moderate to high levels of phosphorus effluent; and/or 2) have high phosphorus discharging industries such as food processing and metal fabrication which contribute to influent wastewater. See Tables 2 and 3 for effluent TP concentration comparisons.

> Minn. R. 7001.1080 subp. 3 provides the authority to require permit conditions, such as PMPs, as a part of a NPDES permit. The requirement for PMPs will be included in the Special Requirements Section of your permit. There will be two forms of permit language. One will address permittees who will be required to immediately enter into a PMP. The other language will address permittees that will enter into a PMP after it is determined that the yearly average effluent phosphorus concentration is above a 4 mg/l. The permit language is attached at the end of this section as permit language A and B.

PHOSPHORUS MANAGEMENT PLANNING GUIDANCE:

The purpose of the following information is to provide suggestions on how to prepare a phosphorus management plan. Your individual PMP may include all or just some of the elements described below.

A. Collect Background Information

1. Monitor wastewater treatment facility influent and effluent for TP at the frequency required by your permit.

2. Collect available information regarding wastewater flow rates and phosphorus loadings from existing industrial contributors (defined as anything not domestic).

3. Where existing information is not available, monitor effluent TP of industrial contributors.

B. Review Background Information

1. Summarize and document items A. (1-3) above which defines your current wastewater phosphorus concentrations and loadings against which future goals could be compared. Useful information may include total phosphorus annual average values, calendar month average values, as well as minimum and maximum values. These values can be reported in concentrations (milligram/liter) and mass loading (pounds/day).

2. Determine your sources of influent TP load. For example, what portion of the load comes from industrial users and what portion comes from domestic sources.

C. Develop A Phosphorus Management Plan

Use the information and ideas generated through completing items A. and B. above, with the following steps to prepare a PMP. Use only those steps which best fit your situation.

1. **Establish a phosphorus goal**. An overall phosphorus reduction goal can be determined by comparing influent and effluent monitoring data for the POTW and contributing industries with concentrations listed in Tables 1-3 below. The concentrations are based on textbook information as well as recent statewide phosphorus monitoring. The concentrations in these Tables are meant to help wastewater facility operators and managers to identify the need for action to reduce abnormally high phosphorus loads being sent to or from your wastewater treatment system. For example, the goal can be determined by:

   a. Comparing WWTF influent and industrial user discharge phosphorus data to the TP monitoring data collected statewide (Tables 1 and 2) giving consideration to "Recommended Goals"; and

   b. Comparing WWTF effluent TP concentrations to the TP data collected statewide (Table 3) giving consideration to "Recommended Goals".

   (Note: this overall goal is not to be confused with a NPDES permit limit that is established as a compliance condition for a new or upgraded wastewater treatment facility.)

2. **Evaluate phosphorus reduction alternatives.** Alternatives which should be considered include encouraging industrial users to look for process improvements that could reduce phosphorus loads to WWTFs. For example, industries should consider the value of product recovery, or chemical substitutions. In addition, waste pretreatment or WWTF improvements should be evaluated such as chemical or biological treatment for phosphorus removal. Improved operation and maintenance may also be effective at your WWTF.

3. **Develop a plan for achieving your goals**. The plan may include a mix of education, economic incentives, industrial reduction strategies, improved wastewater treatment options and industrial user regulation to achieve your phosphorus goal. Your plan should include a PMP implementation schedule that utilizes specific POTW and industrial user monitoring so that you can track performance. Don't forget to include comments on schedule barriers, such as equipment constraints or funding, which can ultimately impact the schedule.

Additional Help is available

The Minnesota Technical Assistance Program (MnTAP), a University of Minnesota program affiliated with the Office of Environmental Assistance, is available to work directly with POTWs and industries to conduct preliminary evaluations of industrial phosphorus sources and opportunities for reduction or pollution prevention. Municipalities and industries can use this evaluation in developing phosphorus management plans. MnTAP can also assist with implementation of reduction strategies for industrial users. If you have questions contact Cindy McComas at (612) 624-4678 or (800) 247-0015.

Table 1. Municipal Wastewater Influent
Total Phosphorus

Concentration	Evaluation	Recommended Goal
< 4 mg/L	Low	Maintain or improve performance
4-8 mg/L	Medium	Determine if high-concentration industries exist. Take corrective action where needed.
> 8 mg/L	High	Identify high-concentration industries. Take corrective action where needed.

Table 2. Industrial Total Phosphorus Contributions To Municipal WWTF Or Lift Stations

Concentration	Evaluation	Recommended Goal
<4 mg/L	Low	Maintain or improve performance
4-8 mg/L	Medium	Corrective action may be needed, depending on flow
>8 mg/L	High	Pretreatment needed

Table 3. Municipal WWTF Effluent Phosphorus Concentrations (without phosphorus removal technologies)

Concentration	Evaluation	Recommended Goal
Stabilization Ponds		
1.5 mg/L	Low	Maintain or improve performance
>1.5 mg/L	Med-High	Investigate. Take corrective action as needed.
Aerated Ponds		
5 mg/L	Normal	Maintain or improve performance
>5 mg/L	High	Investigate. Take corrective action as needed.
Activated Sludge and Oxidation Ditches		
2-4.5 mg/L (3.5=ave.)	Normal	Maintain or improve performance
>4.5 mg/L	High	Take corrective action
Facilities with Biological Phosphorus Removal		
<1 mg/L	Normal	Maintain or improve performance
>l mg/L	High	Take corrective action
All Other Mechanical Facilities-No Phosphorus Removal Technology		
<4 mg/L	Normal	Maintain or improve performance
>4 mg/L	High	Take corrective action

PERMIT LANGUAGE FOR PHOSPHORUS MANAGEMENT PLANS

Phosphorus Management Plan A (for Permittees entering into a PMP after determination that the effluent concentration is above 4 mg/l annual average).

The Permittee shall summarize the phosphorus monitoring required by this permit and determine the average influent and effluent phosphorus concentrations based on the monitoring frequencies contained in the permit. If after two years of monitoring, the effluent exceeds a 4 mg/L yearly average phosphorus concentration, the Permittee shall develop and implement a Phosphorus Management Plan (PMP). If applicable, the PMP shall be submitted with the application for permit reissuance. At a minimum, the PMP shall include an evaluation of the following:

a) Identify sources of high phosphorus loading to the facility and develop a plan for reducing phosphorus loading which includes an evaluation of industrial contributors and industrial pretreatment. When necessary, require industries to submit phosphorus management plans that include identification of opportunities to reduce phosphorus loads to the wastewater treatment facility.

b) How does the operation of the facility provide phosphorus removal to the fullest practicable extent.

c) Provide information and data relating to potential wastewater treatment expansions or significant modifications, population growth, and potential phosphorus removal plans that will help to evaluate the current and potential effects of the facility on the __________. (fill in receiving water)

Phosphorus Management Plan B (for permittees required to immediately enter into a PMP).

The Permittee shall prepare and submit to the MPCA, with the permit application for reissuance, a Phosphorus Management Plan which includes:

1. A summary of recent influent and effluent phosphorus concentrations and mass loadings.

2. An identification of sources of high phosphorus loading to the facility and development of a plan for reducing phosphorus loading. This plan shall include an evaluation of industrial contributors and industrial pretreatment facilities. When necessary, require industries to submit phosphorus management plans that include identification of opportunities to reduce phosphorus loads to the wastewater treatment facility.

3. An evaluation of how the operation of the facility provides phosphorus removal to the fullest practicable extent.

4. Information and data related to potential wastewater treatment expansions or significant modifications, population growth, and potential phosphorus removal plans that will help to evaluate the current and potential effects of the facility on the __________. (fill in receiving water)

PHOSPHORUS MONITORING FREQUENCY GUIDANCE

As a result of the increased concern regarding phosphorus in receiving waters, MPCA has determined that there is a need to obtain more information from dischargers. The following total phosphorus monitoring and sampling frequencies will be included in NPDES permits, if the permit does not contain an effluent limitation, as they are reissued. If the permit already has or will be getting a new effluent limitation, the monitoring frequency should be the same as the conventional parameters contained in the permit. The monitoring applies to both the facility influent and effluent for all municipal/domestic facilities. Monitoring frequencies will vary depending on the type of facility being permitted. Use the following chart to determine what frequency applies to the permit being developed.

Municipal/Domestic

Facility Type	Monitoring Frequency
Class A Mechanical Major	1 x week
Class A Mechanical Minor	1 x week
Class B Mechanical Major	1 x week
Class B Mechanical Minor	1 x week
Class C Mechanical	2 x month
Ponds controlled discharge	Influent sampling should be quarterly which is the same frequency for the other monitored parameters. The effluent monitoring should be 2 x week during discharge.
Aerated Pond Continuous	2 x month

Monitoring frequencies for **industrial facilities** will be determined on an individual basis. The determination will be made based on the industrial facility process and whether phosphorus is present or used in the production. If it is determined phosphorus is present, the monitoring in the permit will be consistent with all the other monitored parameters.

7. PHOSPHORUS AND NONDEGRADATION REQUIREMENTS

Included in primary elements of the Minnesota Pollution Control Agency phosphorus reduction strategy are recommendations to clarify and broaden interpretations of the existing rule and to incorporate phosphorus reduction strategies in basin plans, i.e., reducing the aggregate loading from both point and nonpoint sources of phosphorus in a basin. Subsequent discussion of phosphorus issues in the Water Quality Standards Advisory Committee (WQSAC) resulted in a recommendation for the MPCA to consider phosphorus removal as a treatment option in facility planning and in nondegradation reviews for wastewater discharges to Outstanding Resource Value Waters (ORVWs) and non-ORVW waters.

To be consistent with our phosphorus reduction strategy and recommendations from the WQSAC, the review of nondegradation issues for ***new or expanding*** discharges should be sensitive to potentials for cost-effective phosphorus reduction, such as biological phosphorus (Bio-P) removal technologies at mechanical wastewater treatment facilities.

I. ORVW Projects

A. Phosphorus Limit Required (by implementation of current Rules): For a proposed new/expanded discharge to a restricted-discharge-ORVW that also requires effluent limitations for phosphorus, the discharger must demonstrate that no prudent and feasible (P/F) alternatives are available. If allowed, the discharge must be restricted to the extent necessary to preserve the existing high quality, or to preserve the wilderness, scientific, recreational, or other special characteristics that make the water an ORVW. Such restrictions could include freezing phosphorus loadings or otherwise reducing effluent phosphorus concentrations to meet water body or basin-wide objectives.

B. Phosphorus Limit Not Currently Required: As above, the discharger must provide a P/F argument to justify a new or expanded discharge. And if allowed, the discharge must be restricted to the extent necessary to preserve the ORVW. However, our response to the project proposer would include the standardized phosphorus language (see below) that puts the discharger on notice to design treatment facilities that are adaptable to cost-effective, phosphorus removal technology that may be needed in the future to meet a phosphorus limitation supported by a basin plan. In addition, the discharger should provide a discussion of phosphorus removal feasibility when evaluating discharge and treatment alternatives under nondegradation.

"At this time the Minnesota Pollution Control Agency (MPCA) does not propose to include a phosphorus limit for the *proposed/expanded* discharge. Phosphorus has been identified as a pollutant of concern in the *XXXX* Basin (as well as other Basins of the state) because of effects on receiving waters and downstream impacts resulting from increased nutrient loadings. The MPCA is in the process of developing strategies to minimize the impact of phosphorus on surface waters, and there is the potential that phosphorus limits may be assigned to river discharges in the future. Treatment facilities should be designed so that phosphorus removal can be cost effectively provided to meet an assigned limit."

II. Non-ORVW Projects / Significant Discharges

A. Phosphorus Limit Required (by implementation of current Rules): If "significant" by nondegradation rule definition, proposers of new or expanded discharges must provide social and economic information to justify why the discharge and resulting degradation is necessary. At a minimum, the discharger must provide treatment to comply with all effluent and water quality based limitations, including a 1.0 mg/L (or more stringent) total phosphorus concentration limit or a maximum load limit based on discharge mass. The MPCA also considers what additional control measures beyond these minimum treatment requirements can reasonably be taken to minimize water quality impacts. Requirements for additional control measures should be supported by a basin plan and could include freezing phosphorus loadings or otherwise reducing effluent phosphorus concentrations.

B. Phosphorus Limit Not Required: As in part II.A above, the discharger must provide the socio-economic justification for a new or expanded "significant" discharge. The MPCA considers what additional control measures beyond the minimum treatment requirements can reasonably be taken to minimize water quality impacts. Our initial response to the project proposer would include the standardized phosphorus language that puts the discharger on notice to design treatment facilities adaptable to cost-effective, phosphorus removal technology that may be needed in the future to meet a phosphorus limitation supported by a basin plan. As part of our requests for information to evaluate nondegradation, the discharger should be instructed to provide a discussion of phosphorus removal feasibility for the proposed new/expanded discharge.

III. Non-ORVW / Non-significant Discharges

Proposed new or expanding discharges not found to be "significant" under nondegradation definitions:

- will be assigned a 1.0 mg/L (or more stringent) phosphorus limit if required by Rule, or
- if no phosphorus limit is currently required by Rule, will receive the standardized phosphorus language (see below) in our response to a request for effluent limits.

"At this time the Minnesota Pollution Control Agency (MPCA) does not propose to include a phosphorus limit for the *proposed/expanded* discharge. Phosphorus has been identified as a pollutant of concern in the *XXXX* Basin (as well as other Basins of the state) because of effects on receiving waters and downstream impacts resulting from increased nutrient loadings. The MPCA is in the process of developing strategies to minimize the impact of phosphorus on surface waters, and there is the potential that phosphorus limits may be assigned to river discharges in the future. Treatment facilities should be designed so that phosphorus removal can be cost effectively provided to meet an assigned limit."

8. CHANGE TO THE AVERAGING PERIOD FOR THE 1 MG/L PHOSPHORUS EFFLUENT LIMIT
in Minnesota Rules part 7050.0211, subp. 1a

In January 2000 the MPCA completed several changes to Minnesota's water quality standards in Minn. R. ch. 7050. One of the changes will allow a longer averaging period, up to one year, for the 1 mg/L phosphorus effluent limit, in certain situations. Previously the phosphorus limit was specified as a calendar month average. No other aspect of the 1 mg/L phosphorus limit was changed, only the averaging period. The new language includes two criteria the MPCA staff will use to determine when it is appropriate to apply a longer averaging period. It is the MPCA's position that the majority of dischargers that currently have calendar month phosphorus limits will not qualify for limits with a longer averaging period. The MPCA will re-evaluate this position as it gains more information on the performance of the biological phosphorus removal technology (Bio-P) in both large and small facilities.

The new Minn. R. pt. 7050.0211, subpart 1a is shown below:

Subp. 1a. Total phosphorus effluent limits.
Where the discharge of effluent is directly to or affects a lake or reservoir, phosphorus removal to one milligram per liter shall be required. The limit must be a calendar month arithmetic mean unless the Commissioner finds, after considering the criteria listed in items A and B, that a different averaging period is acceptable. In no case shall the one milligram per liter limit exceed a moving mean of 12 monthly values reported on a monthly basis, or a simple mean for a specified period, not to exceed 12-months. Calendar month effluent limits in effect on the effective date of this part must remain in effect unless an assessment of the criteria listed in items A and B indicate a different averaging period is acceptable. A different averaging period is acceptable when:

A. *the effect of the phosphorus loading from the facility on the receiving water or downstream water resources is generally not measurable; and*
B. *the treatment technologies being considered offer environmental, financial, or other benefits.*

Purpose and Implementation of the Longer Averaging Period:

1. Provide flexibility in how the 1 mg/L phosphorus limit is implemented.
2. Facilitate phosphorus reduction in nutrient-sensitive watersheds, and implementation of MPCA phosphorus strategy.
3. Facilitate consideration of Bio-P as a treatment option.
4. Longer averaging period will typically apply where phosphorus removal below 1 mg/L each and every month is not needed, but where some nutrient reduction is needed or desirable.
5. Facilities that currently have calendar month limits will retain their monthly limits, in most cases.
6. Calendar month limits will continue to be applied to new or expanding facilities that discharge directly to, or affect, a lake or reservoir.