Real People. Real Solutions.

February 7, 2019

# Wastewater Treatment Facility Phosphorus Management Plan

## City of Rushford, MN

**Submitted by:**
Bolton & Menk, Inc.
2900 43rd Street NW
Suite 100
Rochester, MN 55901
P: 507-208-4332
F: 507-508-4155

# Certification

WWTF Phosphorus Management Plan

for

City of Rushford, Minnesota

H19.117947

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

By: _____

Jake R. Pichelmann, P.E.
License No. 54296

Date: February 7, 2019

Signature of City Authorized Agent:

_____

Roger Knutson, Public Works Director

Date: Feb 7, 2019

# Table of Contents


I. INTRODUCTION ..... 2
II. STEP 1 - FACILITY DESCRIPTION & FLOW SCHEMATIC ..... 3
- A. Facility Description ..... 3
- B. Flow Schematic ..... 4
- C. Wastewater Facility Design Data ..... 4

III. STEP 2 - INFLUENT & EFFLUENT PHOSPHORUS CONCENTRATIONS ..... 8
- A. Phosphorus Monitoring Data ..... 8
- B. Phosphorus Removal Calculations ..... 9

IV. STEP 3 - PHOSPHORUS REDUCTION POTENTIAL ..... 10
- A. Pattern and Trends ..... 10
- B. Recommended Actions ..... 10

V. STEP 4 - PHOSPHORUS REDUCTION GOALS ..... 12
VI. STEP 5 - OPTIMIZING THE FACILITY ..... 13
- A. Percent Removal Goal ..... 13

VII. STEP 6 - SUMMARY OF PHOSPHORUS SOURCES ..... 14
- A. Effluent Goals for Users ..... 15

VIII. STEP 7 - IMPLEMENTATION PLAN TO MEET PHOSPHORUS REDUCTION AND REMOVAL GOALS ..... 15
- A. Phosphorus Source Reduction Strategies ..... 15
- B. Phosphorus Removal Strategies ..... 16


# Figures


Figure 1.1 Topographic Site Map ..... 5
Figure 1.2 Treatment Facility Process Flow Schematic ..... 6


# Tables


TABLE 1.1 Wastewater Treatment Design Data ..... 7
TABLE 2.1 Phosphorus Monitoring Data ..... 8
TABLE 2.2 Annual Phosphorus Removal Calculation ..... 9
TABLE 3.1 Recommended Actions ..... 11
TABLE 4.1 Phosphorus Reduction Goals ..... 12
TABLE 6.1 Sources of Phosphorus in Rushford ..... 14


# Appendix


Appendix A: MPCA Table 1.A
Appendix B: Phosphorus Reduction Tips
Appendix C: Setting Phosphorus Goals for Industrial, Commercial, and Institutional Users
Appendix D: MPCA Statewide Phosphorus Removal

# I. INTRODUCTION

The City of Rushford, Minnesota owns and operates a mechanical wastewater treatment facility that is monitored in accordance with National Polutant Discharge Elimination System (NPDES) / State Disposal System (SDS) Discharge Permit No. MN0024678 and regulated by the Minnesota Pollution Control Agency (MPCA). As required by their NPDES permit, the City must prepare and submit a Phosphorus Management Plan (PMP) to the MPCA within 180 days of permit expiration. In fulfillment of this obligation, the City of Rushford has hired Bolton & Menk, Inc. to prepare this document.

The purpose of this PMP is to improve phosphorus management within Rushord's wastewater system. This is accomplished by identifying sources of phosphorus and developing strategies to eliminate phosphorus from wastewater either through source control measures or removal at the City's treatment facility. This report was developed in part by the MPCA and Minnesota Technical Assistance Program (MnTAP) document "*Phosphorus Management Plan Guide*" and uses a similar seven step guideline to evaluate phosphorus management for the City of Rushford's wastewater system:

1. Description of existing facilities and flow schematic;
2. Evaluation of current influent and effluent phosphorus concentrations;
3. Evaluation of phosphorus reduction potential;
4. Determination of phosphorus reduction goals;
5. Optimizing the treatment facility;
6. Phosphorus reduction potential of users;
7. Implementation plan to meet phosphorus reduction and removal goals.

## II. STEP 1 - FACILITY DESCRIPTION & FLOW SCHEMATIC

A. Facility Description

The Rushford Wastewater Treatment Facility was originally constructed in 1983 and utilizes the activated sludge process for biological treatment of municipal wastewater generated by residences and businesses throughout the City of Rushford. The original construction consisted of a single oxidation ditch facility, which was upgraded in 1996 to treat the current average wet weather design flow (AWW) of 0.330 MGD. The Class C facility has a continuous discharge (SD001) to the Root River, which is a Class 2B, 3C, 4A, 4B, 5, 6 surface water suitable for aquatic recreational activities. The current treatment facility consists of the following components:

- *Collection System* – consists of nine (9) lift stations and gravity sewer piping ranging from 6 to 10 inches in diameter (PVC, VCP, and RCP materials). The lift stations and sewer piping have various construction dates.

- *Screening* – the original manual bar screen was installed in 1983. In 1996, a mechanical fine screen was installed while the manual screen is now used as a bypass. The fine screen has ¼" openings and is automatically cleaned.

- *Grit Removal* – consists of a dual-trough system originally installed in 1983.

- *Parshall Flume* – 3-inch flume originally installed in 1983. The flume is rated for a flow rate of 814 gpm and is in good operating condition.

- *Oxidation Ditches* – the original 150,000 gallon single-train oxidation ditch was constructed in 1983. In 1996, an additional oxidation ditch was constructed and increased the overall volume to 330,000 gallons. Each oxidation ditch is equipped with two (2), 10 HP rotors for mixing and aeration.

- *Final Clarifiers* – the two (2) existing 28-foot diameter, center-feed style clarifiers were constructed in 1996 and 2012, respectively. The original 18-foot diameter clarifiers constructed in 1983 were demolished in a recent improvements project.

- *RAS/WAS Pumping* – the existing 7.5 HP RAS pump was installed in 2001 and is used to pump settled mixed liquor from the Final Clarifiers back to the Oxidation

Ditches. The existing 10 HP WAS pump was installed in 1996 and pumps sludge from the Final Clarifiers to the solids processing system.

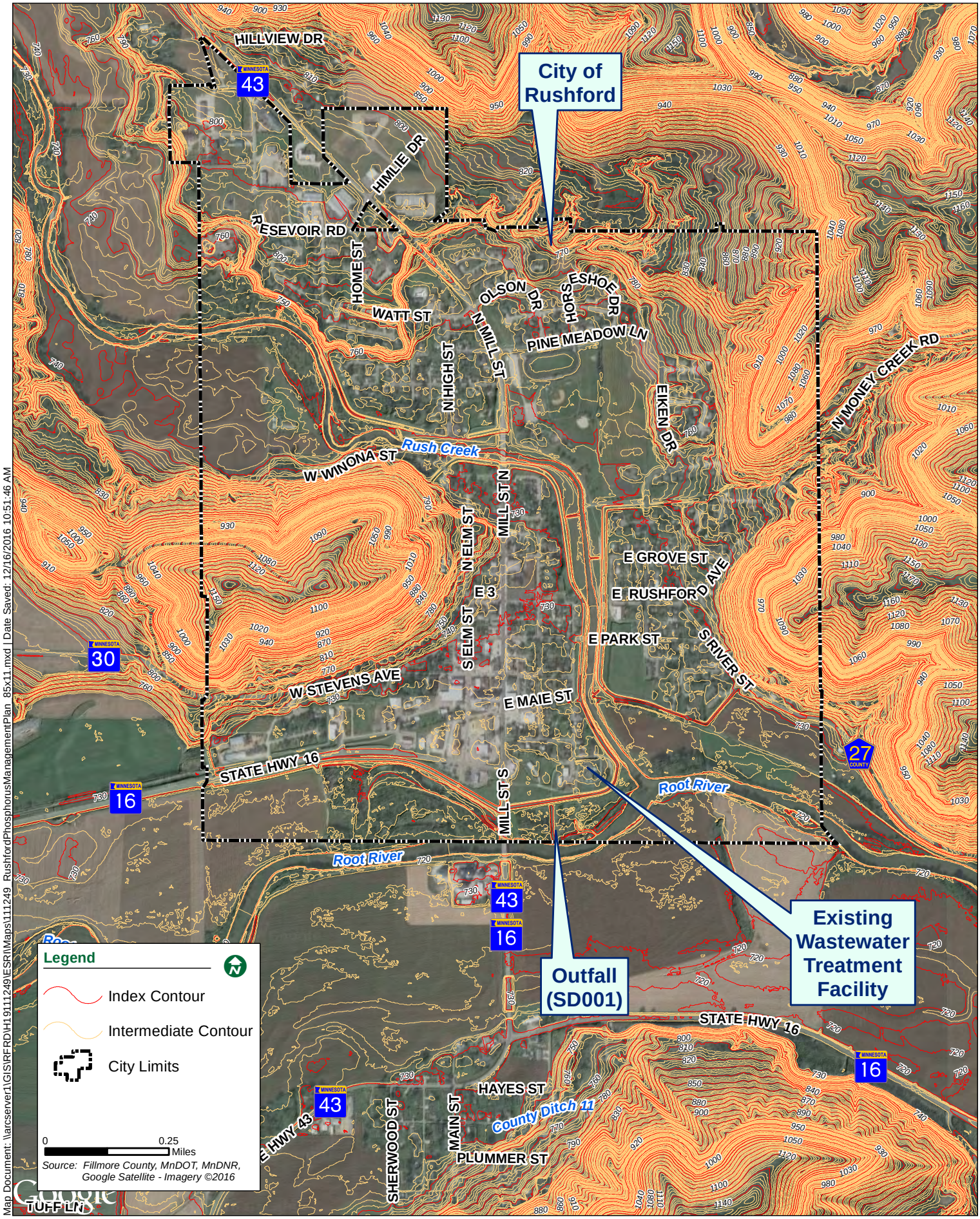
- *UV Disinfection* – consists of a single-channel system originally installed in 1996.
- *Effluent Flow Metering* – 90-degree V-notch weir with ultrasonic level transducer for metering of effluent flow from the treatment process.
- *Influent & Effluent Samplers* – automatic, flow-paced samplers that take 24-hour composite samples of the influent and effluent wastewater.
- *Effluent Lift Station* – consists of two (2) 1,200 gpm pumps originally constructed in 1983.
- *Outfall* – consists of 70 feet of 8-inch cast iron forcemain and 340 feet of 12-inch VCP gravity sewer piping. The outfall discharges to the Root River along the south side of the facility.
- *Aerobic Digesters* – the original 28-foot diameter aerobic digester has a capacity of 30,000 gallons and was constructed in 1983. In 2012, a new 45-foot diameter aerobic digester was constructed to increase biosolids treatment capacity.
- *Sludge Holding Tank* – consists of a 60-foot diameter, 211,500-gallon capacity sludge holding tank. The tank is not aerated.

B. Flow Schematic

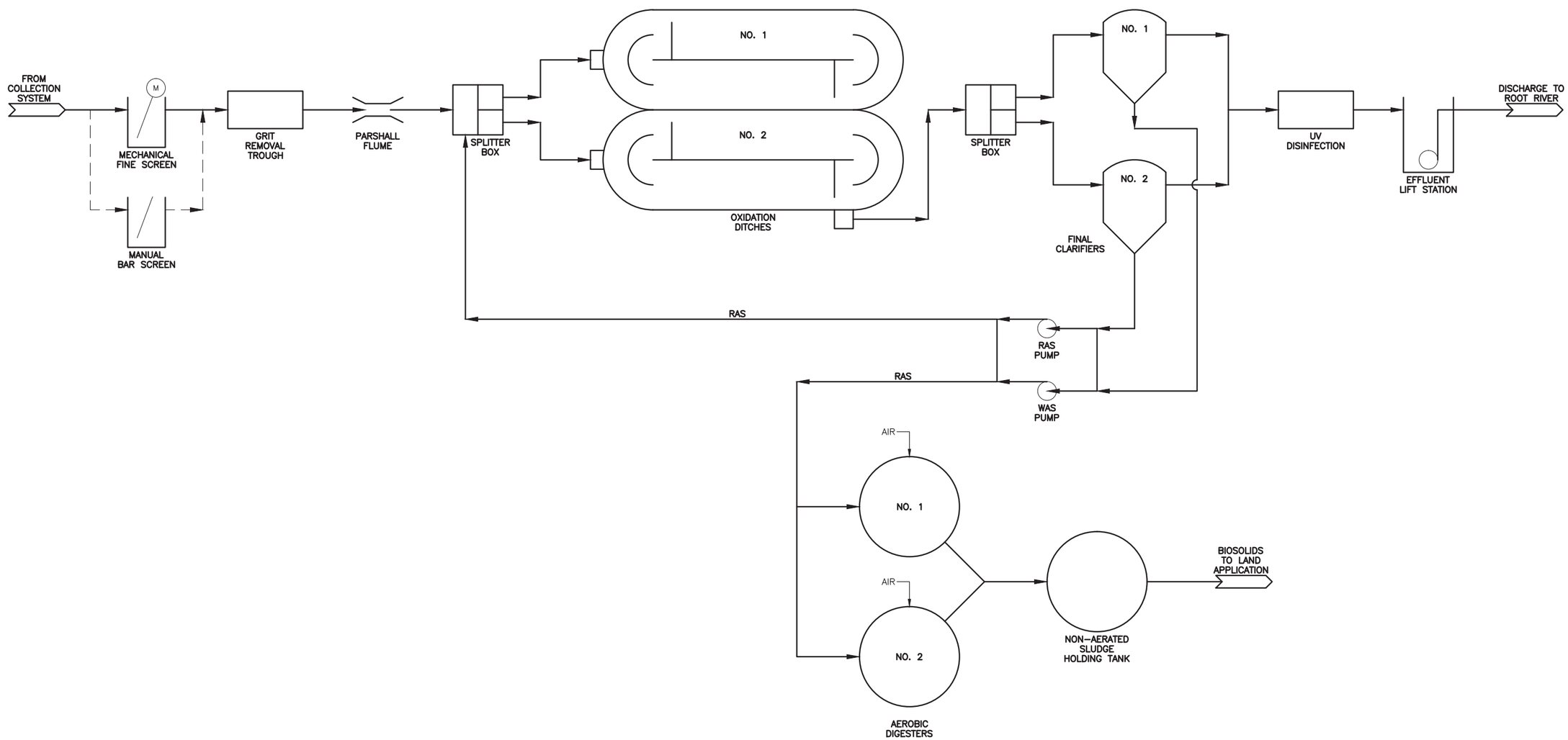
Figure 1.1 provides a topographic site map of the City of Rushford, highlighting the wastewater treatment facility and outfall locations. Figure 1.2 provides a process flow schematic of the wastewater treatment facility.

C. Wastewater Facility Design Data

Table 1.1 summarizes design data for the existing wastewater treatment facility. The City of Rushford's treatment facility is required to meet performance standards in accordance with NPDES Permit No. MN0024678.




Map Document: \\arcserver1\GIS\RFRD\H19111249\ESRI\Maps\111249_RushfordPhosphorusManagementPlan_85x11.mxd | Date Saved: 12/16/2016 10:51:46 AM




SCALES SHOWN ON DRAWINGS ARE FOR 24"x36" SIZE SHEETS ONLY. DRAWINGS PLOTTED ON ANY OTHER SIZE SHEETS NEED TO HAVE SCALES ADJUSTED ACCORDINGLY

© Bolton & Menk, Inc. 2016, All Rights Reserved
H:\RUSHFORD_CL_MN\H19111249\CAD\ENV\111249 Permit Figure.dwg 12/19/16 10:41 am

BOLTON & MENK

www.bolton-menk.com

RUSHFORD, MINNESOTA

WASTEWATER TREATMENT FACILITY

FLOW SCHEMATIC
PHOSPHORUS MANAGEMENT PLAN

FIGURE
1.2

| TABLE 1.1 Wastewater Treatment Design Data | | |
|---|---|---|
| **Parameter** | **Value** | **Unit** |
| *Design Flows* | | |
| Average Dry Weather (ADW) Flow | 0.177 | MGD |
| Average Wet Weather (AWW) Flow | 0.330 | MGD |
| Peak Hourly Wet Weather (PHWW) Flow | 0.625 | MGD |
| *Design Loadings*[1] | | |
| 5-Day Carbonaceous Biochemical Oxygen Demand | 725 (271) | lbs/day (mg/L) |
| Total Suspended Solids (TSS) | 830 (310) | lbs/day (mg/L) |

(1) Design loadings based on 2011 treatment agreement with Rushford Village

## III. STEP 2 - INFLUENT & EFFLUENT PHOSPHORUS CONCENTRATIONS

A. Phosphorus Monitoring Data

Table 2.1 below summarizes influent and effluent phosphorus monitoring data for the past five years (2014-2018). This data was obtained from the MPCA online wastewater data browser. Graphical representations of this data are provided in Appendix A.

**TABLE 2.1 Phosphorus Monitoring Data**

| Month | Influent | | | Effluent | | |
|---|---|---|---|---|---|---|
| | Flow (MGD) | TP Conc. (mg/L) | TP Load (kg/day) | Flow (MGD) | TP Conc. (mg/L) | TP Load (kg/day) |
| Jan-14 | 0.115 | 9.27 | 4.03 | 0.128 | 4.00 | 1.94 |
| Feb-14 | 0.137 | 6.80 | 3.52 | 0.163 | 3.08 | 1.90 |
| Mar-14 | 0.157 | 6.01 | 3.57 | 0.163 | 3.20 | 1.97 |
| Apr-14 | 0.158 | 4.56 | 2.73 | 0.159 | 4.56 | 2.74 |
| May-14 | 0.131 | 6.09 | 3.02 | 0.124 | 3.79 | 1.78 |
| Jun-14 | 0.136 | 5.51 | 2.83 | 0.139 | 7.90 | 4.15 |
| Jul-14 | 0.190 | 8.62 | 6.20 | 0.137 | 5.10 | 2.64 |
| Aug-14 | 0.125 | 8.41 | 3.98 | 0.122 | 6.83 | 3.15 |
| Sep-14 | 0.110 | 7.40 | 3.08 | 0.100 | 4.20 | 1.59 |
| Oct-14 | 0.110 | 6.90 | 2.87 | 0.100 | 4.60 | 1.74 |
| Nov-14 | 0.110 | 8.00 | 3.33 | 0.090 | 4.60 | 1.57 |
| Dec-14 | 0.090 | 8.90 | 3.03 | 0.100 | 4.50 | 1.70 |
| Averages | 0.131 | 7.21 | 3.56 | 0.127 | 4.70 | 2.26 |
| Jan-15 | 0.100 | 8.70 | 3.29 | 0.090 | 3.70 | 1.26 |
| Feb-15 | 0.100 | 9.30 | 3.52 | 0.080 | 0.84 | 0.25 |
| Mar-15 | 0.110 | 7.30 | 3.04 | 0.090 | 1.70 | 0.58 |
| Apr-15 | 0.110 | 7.90 | 3.29 | 0.090 | 1.50 | 0.51 |
| May-15 | 0.110 | 7.80 | 3.25 | 0.080 | 4.20 | 1.27 |
| Jun-15 | 0.100 | 11.00 | 4.16 | 0.080 | 7.60 | 2.30 |
| Jul-15 | 0.100 | 7.90 | 2.99 | 0.080 | 5.30 | 1.60 |
| Aug-15 | 0.100 | 9.00 | 3.40 | 0.084 | 6.20 | 1.97 |
| Sep-15 | 0.103 | 7.90 | 3.08 | 0.088 | 6.00 | 2.00 |
| Oct-15 | 0.104 | 7.80 | 3.07 | 0.088 | 6.70 | 2.23 |
| Nov-15 | 0.105 | 9.40 | 3.73 | 0.090 | 5.20 | 1.77 |
| Dec-15 | 0.109 | 7.70 | 3.18 | 0.096 | 5.80 | 2.11 |
| Averages | 0.104 | 8.48 | 3.34 | 0.086 | 4.56 | 1.49 |
| Jan-16 | 0.105 | 9.30 | 3.69 | 0.087 | 3.90 | 1.28 |
| Feb-16 | 0.105 | 6.90 | 2.74 | 0.087 | 4.00 | 1.32 |
| Mar-16 | 0.103 | 8.00 | 3.12 | 0.087 | 4.30 | 1.42 |
| Apr-16 | 0.103 | 8.30 | 3.23 | 0.076 | 4.30 | 1.24 |
| May-16 | 0.103 | 8.80 | 3.43 | 0.071 | 5.90 | 1.58 |
| Jun-16 | 0.104 | 9.90 | 3.89 | 0.073 | 6.90 | 1.91 |
| Jul-16 | 0.103 | 10.00 | 3.90 | 0.076 | 6.20 | 1.78 |
| Aug-16 | 0.105 | 6.20 | 2.46 | 0.079 | 7.30 | 2.18 |
| Sep-16 | 0.189 | 7.20 | 5.15 | 0.152 | 7.80 | 4.49 |
| Oct-16 | 0.140 | 8.30 | 4.40 | 0.111 | 4.00 | 1.68 |
| Nov-16 | 0.115 | 7.40 | 3.22 | 0.094 | 4.30 | 1.53 |
| Dec-16 | 0.102 | 8.10 | 3.13 | 0.096 | 5.40 | 1.96 |
| Averages | 0.115 | 8.20 | 3.56 | 0.091 | 5.36 | 1.84 |

| TABLE 2.1 (cont.) Phosphorus Monitoring Data | | | | | | |
|---|---|---|---|---|---|---|
| | Influent | | | Effluent | | |
| Month | Flow (MGD) | TP Conc. (mg/L) | TP Load (kg/day) | Flow (MGD) | TP Conc. (mg/L) | TP Load (kg/day) |
| Jan-17 | 0.113 | 11.00 | 4.70 | 0.096 | 3.20 | 1.16 |
| Feb-17 | 0.105 | 8.30 | 3.30 | 0.123 | 4.90 | 2.28 |
| Mar-17 | 0.118 | 7.30 | 3.26 | 0.112 | 4.20 | 1.78 |
| Apr-17 | 0.104 | 7.60 | 2.99 | 0.110 | 6.50 | 2.70 |
| May-17 | 0.119 | 6.40 | 2.88 | 0.124 | 7.20 | 3.38 |
| Jun-17 | 0.108 | 7.60 | 3.11 | 0.106 | 4.80 | 1.92 |
| Jul-17 | 0.098 | 8.30 | 3.08 | 0.092 | 7.70 | 2.68 |
| Aug-17 | 0.090 | 8.10 | 2.76 | 0.089 | 7.20 | 2.42 |
| Sep-17 | 0.092 | 8.90 | 3.10 | 0.094 | 6.70 | 2.38 |
| Oct-17 | 0.101 | 8.80 | 3.36 | 0.104 | 5.40 | 2.12 |
| Nov-17 | 0.096 | 9.70 | 3.52 | 0.098 | 5.40 | 2.00 |
| Dec-17 | 0.103 | 8.60 | 3.35 | 0.101 | 4.90 | 1.87 |
| Averages | 0.104 | 8.38 | 3.30 | 0.104 | 5.68 | 2.23 |
| Jan-18 | 0.102 | 5.80 | 2.24 | 0.107 | 3.80 | 1.54 |
| Feb-18 | 0.093 | 5.80 | 2.04 | 0.096 | 3.80 | 1.38 |
| Mar-18 | 0.092 | 8.30 | 2.89 | 0.091 | 2.60 | 0.90 |
| Apr-18 | 0.091 | 7.20 | 2.48 | 0.091 | 2.60 | 0.90 |
| May-18 | 0.099 | 6.90 | 2.58 | 0.100 | 4.40 | 1.66 |
| Jun-18 | 0.097 | 5.90 | 2.16 | 0.104 | 6.20 | 2.44 |
| Jul-18 | 0.092 | 7.20 | 2.51 | 0.092 | 5.90 | 2.05 |
| Aug-18 | 0.088 | 6.90 | 2.30 | 0.099 | 6.30 | 2.36 |
| Sep-18 | 0.097 | 7.40 | 2.72 | 0.111 | 5.40 | 2.27 |
| Oct-18 | 0.105 | 7.10 | 2.82 | 0.117 | 4.70 | 2.08 |
| Nov-18 | 0.098 | 8.50 | 3.15 | 0.108 | 4.90 | 2.00 |
| Dec-18 | 0.113 | 8.50 | 3.63 | 0.107 | 4.90 | 1.98 |
| Averages | 0.097 | 7.13 | 2.62 | 0.102 | 4.63 | 1.78 |

B. Phosphorus Removal Calculations

Table 2.2 below summarizes annual phosphorus removal calculations for the past five years (2014-2018).

| TABLE 2.2 Annual Phosphorus Removal Calculation | | | | | | |
|---|---|---|---|---|---|---|
| **Parameter** | **2014** | **2015** | **2016** | **2017** | **2018** | **5-Year Average** |
| Influent | | | | | | |
| Annual Flow (MG/yr) | 47.72 | 38.05 | 41.88 | 37.93 | 35.50 | 73.18 |
| TP Conc. (mg/L) | 7.21 | 8.48 | 8.20 | 8.38 | 7.13 | 7.86 |
| TP Loading (kg/yr) | 1,301 | 1,220 | 1,299 | 1,203 | 957 | 2,176 |
| Effluent | | | | | | |
| Annual Flow (MG/yr) | 46.39 | 31.51 | 33.12 | 37.99 | 37.20 | 67.76 |
| TP Conc. (mg/L) | 4.70 | 4.56 | 5.36 | 5.68 | 4.63 | 4.98 |
| TP Loading (kg/yr) | 824 | 544 | 671 | 816 | 651 | 1,276 |
| % Removal (mass-based) | 36.65 | 55.43 | 48.32 | 32.20 | 31.97 | 41.37 |

# IV. STEP 3 - PHOSPHORUS REDUCTION POTENTIAL

A. Pattern and Trends

Over the past five years, average influent total phosphorus (TP) concentration has been 7.86 mg/L, which is on the high end of typical domestic wastewater concentrations that generally range from 4 to 8 mg/L. Over the same timeframe, average effluent phosphorus concentration has been 4.98 mg/L. On a mass-basis (kg/day), annual average removal of influent phosphorus has been **41.4%**, with a yearly range of 32.0% to 55.4% removal. In 2005, a survey of similar facilities (i.e. continuous discharge without phosphorus removal technologies) throughout the State of Minnesota averaged **42%** removal. Thus, the City of Rushford's wastewater treatment facility has performed at the statewide average for removal of influent phosphorus.

The City's current NPDES discharge permit does not have a limit for total phosphorus discharge, although phosphorus must be sampled twice per month. The treatment facility is not designed to biologically remove excess phosphorus and is not equipped with chemical feed of metal salts (ferric chloride or aluminum sulfate) for chemical precipitation. The facility does get some removal from the small amount of phosphorus needed to sustain bacterial metabolism in the oxidation ditches.

B. Recommended Actions

Table 3.1 on the following page compares the City of Rushford's influent and effluent phosphorus concentrations versus similar treatment systems statewide. A brief discussion of observations and recommended actions are provided in the far right column.

| TABLE 3.1 Recommended Actions | | | |
|---|---|---|---|
| **Parameter** | **City of Rushford** | **Statewide Average** | **Recommended Action** |
| Influent TP Conc. (mg/L) | 7.86 | 6.36 | *The City of Rushford's influent TP concentration is above average compared to similar systems. A concentration of 4 to 8 mg/L is highly typical of domestic wastewater – Rushford's wastewater is at the high end of this range.*<br><br>*Influent TP concentration is generally inversely correlated with wastewater flow. At higher flows, TP concentration decreases and vice versa. Rushford's wastewater follows this pattern. Mass loadings have been relatively consistent over the past five years, although 2018 saw a notable decrease.*<br><br>*As discussed in Step 7 of this Phosphorus Management Plan, source reduction strategies are the only option to potentially reduce influent phosphorus loading.* |
| Effluent TP. Conc. (mg/L) | 4.98 | 3.68 | *The City of Rushford's effluent TP concentration is above average compared to similar systems. The existing treatment facility is not designed to remove phosphorus, neither biologically or through chemical addition of metal salts. A small fraction of phosphorus is removed in the oxidation ditches in order to sustain bacterial metabolism.*<br><br>*If phosphorus discharge limits are imposed in the future, the existing facility could be renovated to achieve phosphorus removal. Otherwise, there are limited operational adjustments available to improve phosphorus removal with the existing treatment technologies. Without infrastructure upgrades, the City should expect the current removals to remain in the 40 to 50% range, or less.* |

## V. STEP 4 - PHOSPHORUS REDUCTION GOALS

Table 4.1 provides phosphorus reduction goals for the City of Rushford's wastewater treatment facility over the next five years. Reduction goals are contingent on the City's NPDES permit requirements for phosphorus discharge. Currently, the City is only required to monitor phosphorus. If a future NPDES permit renewal imposes phosphorus discharge limits, reduction goals would be to comply with permit limits.

**TABLE 4.1 Phosphorus Reduction Goals**

| Parameter | Current Concentration (mg/L) | 5-Year Goal (mg/L) | Explanation |
|---|---|---|---|
| Influent TP Conc. (mg/L) | 7.86 | 6.81 | *Over the next five years, the City of Rushford should aim to lower influent TP concentrations to the statewide average of 6.81 mg/L.*<br><br>*Influent phosphorus concentration is solely a function of the type of users discharging to the wastewater system. Source reduction measures are most effective when targeting the highest dischargers of phosphorus. Steps 6 and 7 of this plan discuss phosphorus sources and an implementation plan for source control.* |
| Effluent TP Conc. (mg/L) | 4.98 | 3.68 | *Over the next five years, the City of Rushford should aim to lower effluent TP conentrations to the statewide average of 3.68 mg/L for similar systems, or less.*<br><br>*Without upgrading the existing treatment facility to achieve phosphorus removal, the City should expect removals to be in the range of 40-50% of influent TP. Reducing influent phosphorus through source reduction measures may be enough to achieve the 5-year goal of 3.68 mg/L for effluent phosphorus.* |

# VI. STEP 5 - OPTIMIZING THE FACILITY

A. Percent Removal Goal

Based on past performance and the 5-year goals summarized in Table 4.1, the minimum goal is to maintain the current average removal rate of roughly 41 percent, which is very close to the statewide average for similar facilities. The treatment facility cannot reasonably achieve higher phosphorus removals on a consistent basis without installing additional infrastructure.

The biological reactions occurring in the oxidation ditches consume a small portion of the influent phosphorus. Maintaining a healthy biological environment in the oxidation ditches is necessary to ensure this portion of phosphorus is removed. Otherwise, there are limited operational adjustments that could be made to improve phosphorus removal with the City's existing treatment technologies. Potential adjustments could be made to the supernatant return off the biosolids treatment processes. Supernantant is generally highly concentrated with phosphorus; therefore, introducing a large volume back into the system too quickly can result in higher concentrations of soluble phosphorus in the effluent.

As previously discussed, reduction goals are contingent on the City's NPDES permit requirements for phosphorus removal. Currently, the City is only required to monitor phosphorus in their influent and effluent wastewater. If a future NPDES permit renewal imposes phosphorus discharge limits, reduction goals would be to comply with permit limits.

## VII. STEP 6 - SUMMARY OF PHOSPHORUS SOURCES

Table 6.1 summarizes phosphorus sources in the City of Rushford. Phosphorus reduction tips are provided in Appendix B.

**TABLE 6.1 Sources of Phosphorus in Rushford**

| Location | Phosphorus Sources | Assessment (Reduction Potential) |
|---|---|---|
| *Commerical:*<br>- Litscher Meat Processing<br>- Rushford Foods IGA | -Food processing waste<br>-Cleaning/sanitizing chemicals | Low |
| - D&D Car Wash<br>- Good Shepherd Nursing Home<br>- Hoff Funeral Home<br>- Riverstar Production Facility<br>- Rushford Dental Clinic<br>- Valley Veterinary Clinic<br>- Dahl's Auto Works<br>- Hair salons (various) | -Cleaning/sanitizing chemicals | Low |
| - The Creamery<br>- Stumpy's<br>- Shawnee's Bar & Grill<br>- Norsland Lefse<br>- Jessie Street Java<br>- Il Luigi Italian Restaurant<br>- Other food services | -Food disposal wastes<br>- Cleaning/sanitizing chemicals | Low |
| *Institutional:*<br>-Rushford-Peterson School | -Human waste<br>-Cleaning/sanitizing chemicals | Medium |
| *Municipal:*<br>-City Hall<br>-City garage | -Human waste<br>- Cleaning/sanitizing chemicals | Low |
| *Satellite Communities:*<br>City of Rushford Village<br>Population = 808 (2010 Census)<br>Households = 305 (2010 Census) | -Human waste<br>-Cleaning/sanitizing chemicals<br>-Garbage disposal waste | Low |
| *Domestic:*<br>City of Rushford<br>Population = 1,731 (2010 Census)<br>Households = 706 (2010 Census) | -Human waste<br>-Cleaning/sanitizing chemicals<br>-Garbage disposal waste | Low |

A. Effluent Goals for Users

Phosphorus contributions to the City of Rushford's wastewater system are generated from residential and small commercial users. The City does not have any businesses or industries that are considered Significant Industrial Users (SIUs) to the wastewater system. The City does have a formal treatment agreement with the City of Rushford Village (population of 834), which also consists of residential and commercial users. This agreement specifies a total phosphorus concentration limit of 8.1 mg/L and a loading limit of 1.57 lbs./day. This loading limit constitutes 9.4% of the total design phosphorus loading to the treatment facility per the 2011 agreement. If the facility receives a phosphorus discharge limit in the future, the treatment agreement with Rushford Village should be re-evaluated in order to minimize phosphorus discharge to the wastewater system.

Sources of phosphorus from residential and commercial users are primarily from human waste, garbage disposal waste, and cleaning and sanitizing products. Ultimately, effluent goals for these users are difficult to define as the phosphorus contributions are largely unavoidable (i.e. natural) and difficult to monitor on a large scale. Individual monitoring is generally not worthwhile unless there is strong suspicion of a significant contribution.

## VIII. STEP 7 - IMPLEMENTATION PLAN TO MEET PHOSPHORUS REDUCTION AND REMOVAL GOALS

A. Phosphorus Source Reduction Strategies

1. Businesses – Industrial, Commercial, and Institutional Users:

*Past five years*: Upon completion of the original Phosphorus Management Plan in 2008 and subsequent update in September 2011, the City sent mailers and conducted walkthroughs at local businesses in order to identify opportunities for phosphorus reduction.

*Next five years*:

- Re-visit businesses and institutions thought to be significant contributors of phosphorus (see Table 6.1) and re-evalute ways to minimize or eliminate phosphorus sources such as phosphorus-based cleaning/sanitation products and excess food and disposal waste.

- Send a general mailer to all local businesses and institutions as an educational tool on the importance of phosphorus management.

- If necessary, monitor and inspect businesses and institutions that may be significant contributors of phosphorus.

- Appendix C provides a MPCA document on how to set effluent goals for industrial, commercial, and institutional users.

2. Municipal Sources:

   *Past five years:* None.

   *Next five years*: Evaluate potential phosphorus sources generated from municipal facilities such as cleaning and sanitizing products. Evaluate ways to eliminate phosphorus sources.

3. Satellite Communities:

   *Past five years*: In 2011, the City established a new treatment agreement with the City of Rushford Village. This agreement specifies a total phosphorus concentration limit of 8.1 mg/L and a loading limit of 1.57 lbs./day. This loading limit constitutes 9.4% of the total design phosphorus loading to the treatment facility.

   *Next five years:*

   - If the facility receives phosphorus limits in a future NPDES permit renewal, the treatment agreement with Rushford Village should be re-evaluated in order to minimize phosphorus discharge to the wastewater system.

   - Continue to inform the public in Rushford Village on the importance of phosphorus management.

   - Evaluate ways to communicate phosphorus reduction strategies to domestic users in Rushford Village, such as eliminating phosphate-containing cleaning products and detergents.

4. Domestic Sources:

   *Past five years*: The City has provided educational materials on the City website, public access television stations, and in the local newspaper.

   *Next five years*: Continue to provide avenues for public education of phosphorus management through local media outlets and the City website. Consider including educational materials with utility bills once or twice per year in order to increase exposure and awareness of phosphorus management.

B. Phosphorus Removal Strategies

1. Removal at Wastewater Treatment Facility

*Past five years*: As required by the City of Rushford's NPDES discharge permit, total phosphorus is monitored twice per month at the influent and effluent sampling locations. City officials use this data to monitor the performance of the treatment facility. The treatment facility performed near the statewide average (compared to similar facilities) for removing influent phosphorus over the past five years.

In 2012, the City upgraded the treatment facility to include a new final clarifier, aerobic digester, and modified clarifier splitter box. The City hoped these improvements would have a positive impact on the overall phosphorus removal at the treatment facility; however, based on historical monitoring data, these upgrades did not improve phosphorus removal.

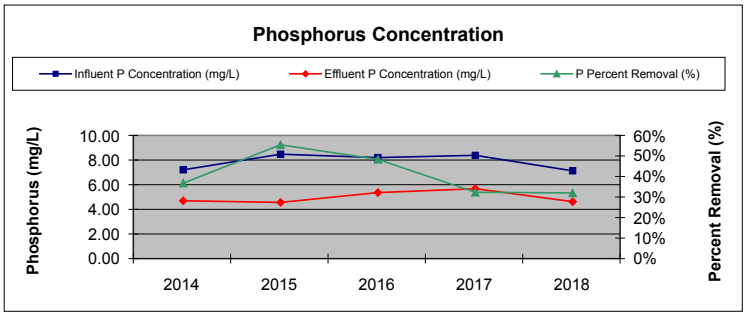
*Next five years*: The City should continue to evaluate influent and effluent phosphorus concentrations and loadings at the wastewater treatment facility on an annual basis. As previously discussed, there are limited operational adjustments that can be made to improve phosphorus removal with the existing treatment technologies. Without phosphorus removal technologies in place, the best way to reduce effluent phosphorus is to continue to push source control measures as described in Step 7.1 above.

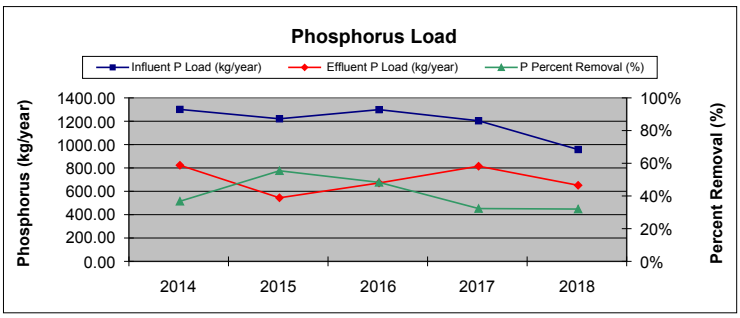
If the treatment facility receives phosphorus limits in a future NPDES permit renewal, the City will need to evaluate alternatives to renovate the facility to remove phosphorus. Potential solutions may include chemical addition of metal salts for precipitation of phosphorus in the Final Clarifiers, or infrastructure improvements to achieve biological removal of excess phosphorus. The second option would likely require construction of new process tanks and additional pumping and recirculation streams. A detailed evaluation would need to be conducted to determine the best possible solution for the City of Rushford.

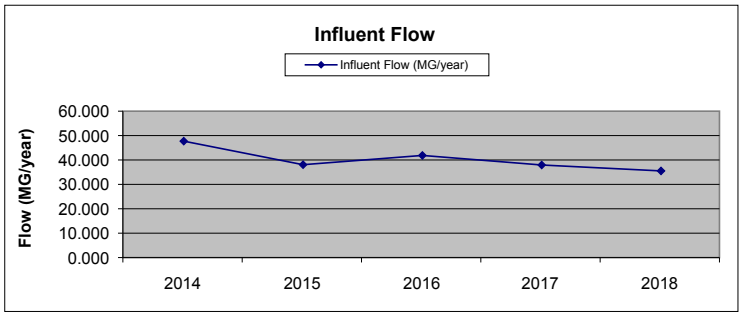
# Appendix A: MPCA Table 1.A

Table 1A: WWTF Annual Summary Data

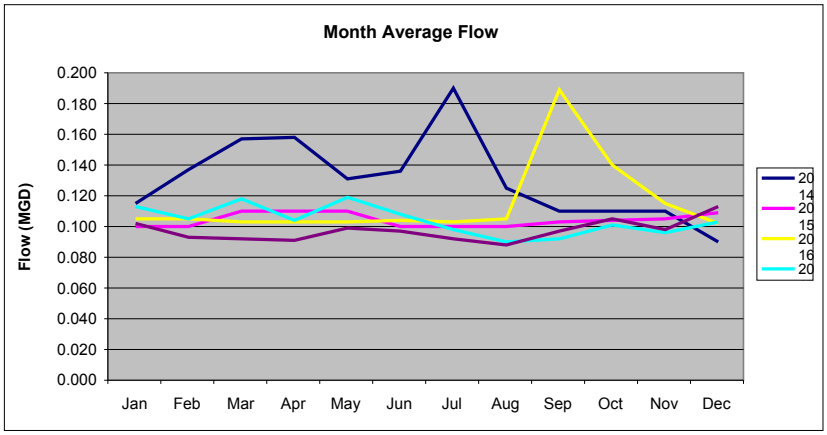
| | Influent Flow (MG/year) | Influent P Concentration (mg/L) | Effluent P Concentration (mg/L) | Influent P Load (kg/year) | Effluent P Load (kg/year) | P Percent Removal (%) |
|---|---|---|---|---|---|---|
| *2014* | *47.714* | *7.21* | *4.70* | *1301.36* | *823.03* | *37%* |
| *2015* | *38.063* | *8.48* | *4.56* | *1220.98* | *544.36* | *55%* |
| *2016* | *41.861* | *8.20* | *5.36* | *1299.24* | *671.37* | *48%* |
| *2017* | *37.942* | *8.38* | *5.68* | *1203.93* | *814.99* | *32%* |
| *2018* | *35.515* | *7.13* | *4.63* | *957.77* | *651.40* | *32%* |



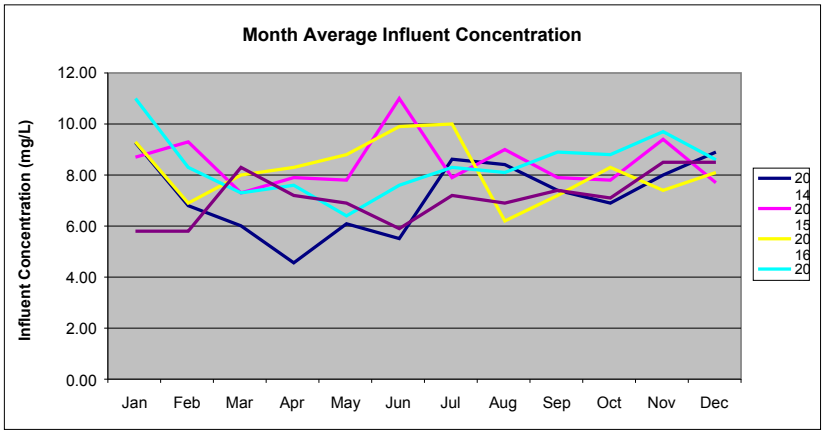



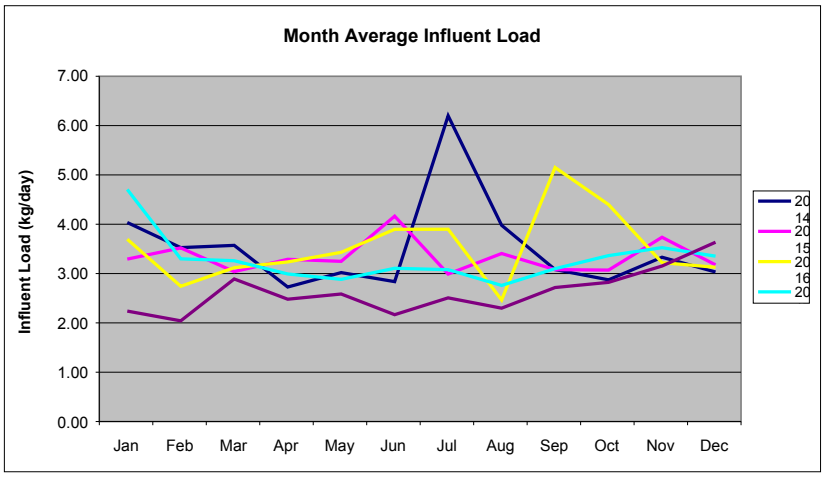
| | Month Average Flow (MGD) | | | | |
|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 |
| Jan | 0.115 | 0.100 | 0.105 | 0.113 | 0.102 |
| Feb | 0.137 | 0.100 | 0.105 | 0.105 | 0.093 |
| Mar | 0.157 | 0.110 | 0.103 | 0.118 | 0.092 |
| Apr | 0.158 | 0.110 | 0.103 | 0.104 | 0.091 |
| May | 0.131 | 0.110 | 0.103 | 0.119 | 0.099 |
| Jun | 0.136 | 0.100 | 0.104 | 0.108 | 0.097 |
| Jul | 0.190 | 0.100 | 0.103 | 0.098 | 0.092 |
| Aug | 0.125 | 0.100 | 0.105 | 0.090 | 0.088 |
| Sep | 0.110 | 0.103 | 0.189 | 0.092 | 0.097 |
| Oct | 0.110 | 0.104 | 0.140 | 0.101 | 0.105 |
| Nov | 0.110 | 0.105 | 0.115 | 0.096 | 0.098 |
| Dec | 0.090 | 0.109 | 0.102 | 0.103 | 0.113 |



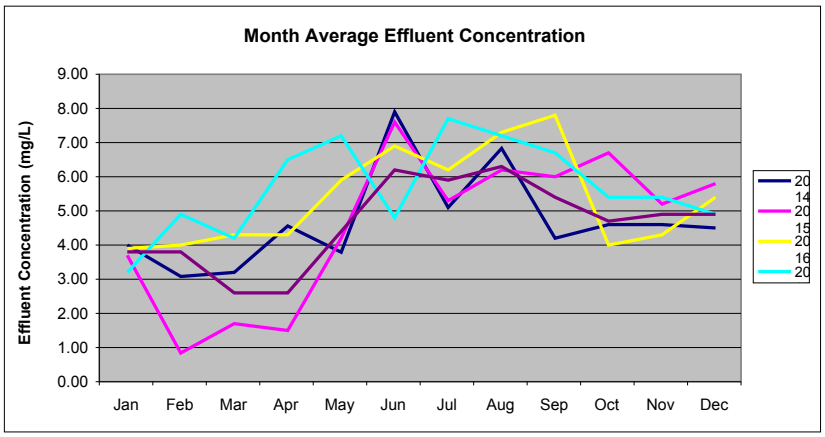

| | Month Average Influent Concentration (mg/L) | | | | |
|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 |
| Jan | 9.27 | 8.70 | 9.30 | 11.00 | 5.80 |
| Feb | 6.80 | 9.30 | 6.90 | 8.30 | 5.80 |
| Mar | 6.01 | 7.30 | 8.00 | 7.30 | 8.30 |
| Apr | 4.56 | 7.90 | 8.30 | 7.60 | 7.20 |
| May | 6.09 | 7.80 | 8.80 | 6.40 | 6.90 |
| Jun | 5.51 | 11.00 | 9.90 | 7.60 | 5.90 |
| Jul | 8.62 | 7.90 | 10.00 | 8.30 | 7.20 |
| Aug | 8.41 | 9.00 | 6.20 | 8.10 | 6.90 |
| Sep | 7.40 | 7.90 | 7.20 | 8.90 | 7.40 |
| Oct | 6.90 | 7.80 | 8.30 | 8.80 | 7.10 |
| Nov | 8.00 | 9.40 | 7.40 | 9.70 | 8.50 |
| Dec | 8.90 | 7.70 | 8.10 | 8.60 | 8.50 |



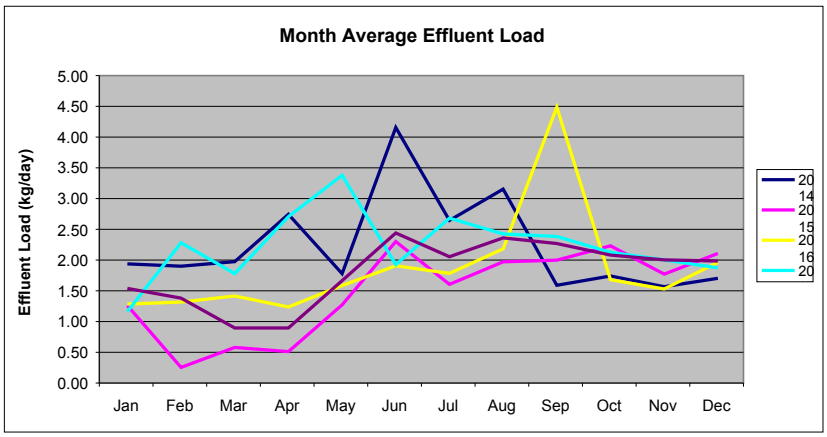
| | Month Average Influent Load (kg/day) | | | | |
|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 |
| Jan | 4.03 | 3.29 | 3.70 | 4.70 | 2.24 |
| Feb | 3.53 | 3.52 | 2.74 | 3.30 | 2.04 |
| Mar | 3.57 | 3.04 | 3.12 | 3.26 | 2.89 |
| Apr | 2.73 | 3.29 | 3.24 | 2.99 | 2.48 |
| May | 3.02 | 3.25 | 3.43 | 2.88 | 2.59 |
| Jun | 2.84 | 4.16 | 3.90 | 3.11 | 2.17 |
| Jul | 6.20 | 2.99 | 3.90 | 3.08 | 2.51 |
| Aug | 3.98 | 3.41 | 2.46 | 2.76 | 2.30 |
| Sep | 3.08 | 3.08 | 5.15 | 3.10 | 2.72 |
| Oct | 2.87 | 3.07 | 4.40 | 3.36 | 2.82 |
| Nov | 3.33 | 3.74 | 3.22 | 3.52 | 3.15 |
| Dec | 3.03 | 3.18 | 3.13 | 3.35 | 3.64 |



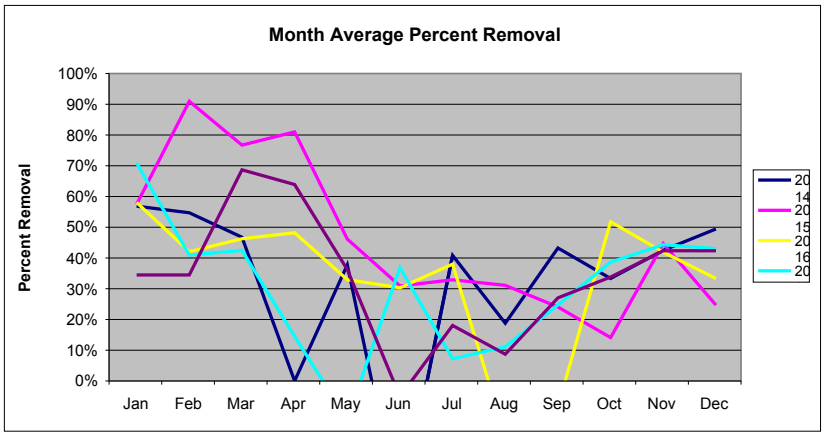

| | Month Average Effluent Concentration (mg/L) | | | | |
|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 |
| Jan | 4.00 | 3.70 | 3.90 | 3.20 | 3.80 |
| Feb | 3.08 | 0.84 | 4.00 | 4.90 | 3.80 |
| Mar | 3.20 | 1.70 | 4.30 | 4.20 | 2.60 |
| Apr | 4.56 | 1.50 | 4.30 | 6.50 | 2.60 |
| May | 3.79 | 4.20 | 5.90 | 7.20 | 4.40 |
| Jun | 7.90 | 7.60 | 6.90 | 4.80 | 6.20 |
| Jul | 5.10 | 5.30 | 6.20 | 7.70 | 5.90 |
| Aug | 6.83 | 6.20 | 7.30 | 7.20 | 6.30 |
| Sep | 4.20 | 6.00 | 7.80 | 6.70 | 5.40 |
| Oct | 4.60 | 6.70 | 4.00 | 5.40 | 4.70 |
| Nov | 4.60 | 5.20 | 4.30 | 5.40 | 4.90 |
| Dec | 4.50 | 5.80 | 5.40 | 4.90 | 4.90 |



| | Month Average Effluent Load (kg/day) | | | | |
|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 |
| Jan | 1.94 | 1.26 | 1.28 | 1.16 | 1.54 |
| Feb | 1.90 | 0.25 | 1.32 | 2.28 | 1.38 |
| Mar | 1.97 | 0.58 | 1.42 | 1.78 | 0.90 |
| Apr | 2.74 | 0.51 | 1.24 | 2.71 | 0.90 |
| May | 1.78 | 1.27 | 1.59 | 3.38 | 1.67 |
| Jun | 4.16 | 2.30 | 1.91 | 1.93 | 2.44 |
| Jul | 2.64 | 1.60 | 1.78 | 2.68 | 2.05 |
| Aug | 3.15 | 1.97 | 2.18 | 2.43 | 2.36 |
| Sep | 1.59 | 2.00 | 4.49 | 2.38 | 2.27 |
| Oct | 1.74 | 2.23 | 1.68 | 2.13 | 2.08 |
| Nov | 1.57 | 1.77 | 1.53 | 2.00 | 2.00 |
| Dec | 1.70 | 2.11 | 1.96 | 1.87 | 1.98 |




| | Month Average Percent Removal (%) | | | | |
|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 |
| Jan | 57% | 57% | 58% | 71% | 34% |
| Feb | 55% | 91% | 42% | 41% | 34% |
| Mar | 47% | 77% | 46% | 42% | 69% |
| Apr | | 81% | 48% | 14% | 64% |
| May | 38% | 46% | 33% | -13% | 36% |
| Jun | -43% | 31% | 30% | 37% | -5% |
| Jul | 41% | 33% | 38% | 7% | 18% |
| Aug | 19% | 31% | -18% | 11% | 9% |
| Sep | 43% | 24% | -8% | 25% | 27% |
| Oct | 33% | 14% | 52% | 39% | 34% |
| Nov | 43% | 45% | 42% | 44% | 42% |
| Dec | 49% | 25% | 33% | 43% | 42% |



# Appendix B: Phosphorus Reduction Tips

APPENDIX B

# Phosphorus Reduction Tips at a Glance

**Prevention First** Here are some quick tips for selecting phosphorus reduction strategies for business users—commercial, industrial and institutional operations; your wastewater treatment facility (WWTF); residential or domestic sources and the drinking water treatment plant that prevent or minimize phosphorus releases. The Minnesota Pollution Control Agency (MPCA) and the Minnesota Technical Assistance Program (MnTAP) have a number of fact sheets that offer guidance on reduction and best management practices.

| Phosphorus Contributors | Tips to Reduce Phosphorus |
|---|---|
| **All business users—**<br>**Industrial, commercial and institutional**<br><br>Including agricultural co-ops, car/truck washing facilities, dairies, food processing plants, meat packing and locker plants, metal finishing facilities, municipal water treatment plants that add phosphorus to drinking water, nursing homes, restaurants, schools and other businesses or institutions with phosphorus sources. | **Cleaning & sanitizing**<br>• Establish purchasing criteria for cleaning products<br>• Use low or non-phosphorus cleaners and detergents<br>• Use proper concentrations of cleaners and detergents<br>• Use cleaners and detergents as directed by manufacturer<br>• Do not accept sample cleaners from vendors<br><br>MnTAP fact sheet: *Phosphorus: Reducing Releases from Industrial Cleaning and Sanitizing Operations* [#11] |
| **Industrial / metal finishers** | **Metal preparation, finishing & painting**<br>• Evaluate low- and non-phosphorus systems<br>• Reuse water where it will enhance cleaning<br>• Maintain proper levels of phosphate in the bath<br>• Keep process solutions in their tanks by reducing carryover<br>• Use deionized reverse osmosis water for process baths and rinses<br>• Ensure all process controls are properly set, calibrated and maintained<br>• Keep spray nozzles cleaned and maintained<br><br>MnTAP fact sheet*: Metal Phosphatizing Operations* [#64] |
| **Industrial / food processors**<br><br>Including dairies, meat packing and locker plants. | **Food processing**<br>• Keep food by-products off the floor and out of drains<br>• Use dry cleanup practices prior to wet cleaning<br>• Reduce spills, leaks and tank overflows<br>• Use an automatic clean-in-place (CIP) system<br>• Reuse food by-products for animal feed, composting or land spreading<br><br>MnTAP fact sheets: *Phosphorus: Reducing Releases from Dairy Operations*[#116], Phosphorus: *Reducing Releases from Meat Packing Operations* [#118] and *Phosphorus:* |

| Phosphorus Contributors | Tips to Reduce Phosphorus |
|---|---|
| | *Reducing Releases from Poultry Processing Plants* [#71] |
| **Municipal sources** | • Institute environmentally preferred purchasing with policies to limit phosphorus containing products for your municipal operations<br>• Institute a public education campaign to raise awareness about phosphorus issues and sources<br>• Optimize the addition of phosphorus to the drinking water supply to prevent pipe corrosion.<br>• Evaluate the use of water treatment plant filter backwash residuals as a possible mechanism for phosphorus removal at the WWTF<br>• Optimize stormwater management policies, such as minimizing run-off from parking lots and other surfaces |
| **Domestic** | • Institute environmentally preferable purchasing in your household. Find sources for low- or non-phosphorus dishwashing liquids and soaps<br>• Use laundry detergent purchased in Minnesota or other states in which only low- and non-phosphorus detergent is sold<br><br>Prevent phosphorus from entering storm sewers<br>• Wash the car on the lawn to prevent phosphorus-laden rinse water from running into stormwater sewers<br>• Collect organic material (leaves, grass clippings, etc.) from street drains and gutters. Check fall leaf pick-up dates to take advantage of composting services<br>• Use phosphorus-free lawn fertilizer<br>• Restore natural shoreland or streambank habitat to prevent phosphorus-laden runoff from entering surface water<br>• Use lawn mowers that chop up grass clippings and leave them on the lawn. These mulching mowers reduce the need for fertilizers |
| **Your WWTF** | • Optimize the WWTF operations for phosphorus removal<br>• Improve phosphorus removal using biological or chemical treatment methods<br>• Feed supernatant back to the plant at a rate the phosphorus can be removed<br><br>MPCA fact sheet: *WWTF Optimization for Phosphorus Removal* and *Phosphorus Treatment and Removal Technology* |

**Water Conservation** Reducing effluent flows from businesses may reveal hidden phosphorus concentrations. See the MnTAP fact sheet *Water Use Tips* [#119] for water conservation idea for businesses.

# Appendix C: Setting Phosphorus Goals for Industrial, Commercial, and Institutional Users

# Setting Effluent Phosphorus Goals for Multiple Industrial, Commercial and Institutional Users

You set an influent phosphorus goal for your wastewater treatment facility (WWTF) as part of your Phosphorus Management Plan (PMP) that you believe will allow your facility to achieve its effluent phosphorus goal. Now, work with your business users—industrial, commercial and institutional operations—that have phosphorus sources to evaluate and implement suitable strategies for them to reduce their phosphorus discharge.

Business users can be significant contributors to your WWTF's phosphorus levels. The portion of your WWTF's influent originating from businesses is referred to as the total allowable phosphorus. To help your WWTF meet its effluent goal, you should allocate portions of your WWTF's influent reduction goal to your business users. Recommend a business effluent goal for each business, reflecting its fair share of the total allowable phosphorus. Work with them to select numeric phosphorus reduction goals for their facilities to help meet your WWTF's effluent goal. Selecting a business effluent goal can be difficult because of the many variables in business and WWTF operations.

**Share the Phosphorus Reduction Responsibility**

If you have multiple business users, the procedure outlined in this worksheet for portioning out responsibility to reduce phosphorus can help you meet your WWTF's influent goal.

1. Determine domestic total phosphorus.
2. Calculate total allowable phosphorus.
3. Allocate fair share to businesses.
4. Record your results in your PMP.

## Effluent Goal for Multiple Business Users

The calculations in this worksheet only yield estimates. When establishing business effluent goals, you and your businesses should use the calculation results to support the other information you have gathered. Using this systematic approach, you and your businesses will have greater confidence in decisions regarding the desired results and implementation of phosphorus reduction strategies.

### 1. Domestic Total Phosphorus

Measure the actual domestic total phosphorus or calculate an estimate. To calculate domestic total phosphorus multiply your municipal population by 0.8 kilograms (kg) per year per person then divide by 365 days.

$$\text{Domestic total phosphorus (kg/day)} = \frac{\text{Municipal population x (0.8 kg/year/person)}}{\text{365 days}}$$

### 2. Total Allowable Phosphorus

To calculate total allowable phosphorus subtract the domestic total phosphorus (determined above) from your WWTF's influent goal (determined in Step 4 of the *PMP Guide*).

Total allowable phosphorus = WWTF's influent goal (kg/day) – domestic total phosphorus (kg/day)

### 3. Allocate Fair Share

Allocate a fair share of the total allowable phosphorus to each industrial, commercial and institutional contributor. To select the business effluent goals consider whether your phosphorus contributors have significant differences in concentration or flow.

**No significant differences.** If allocating between multiple business users that have no significant differences in concentration or flow, divide the total allowable phosphorus equally between all users.

**Significant differences.** Evaluating all businesses using the same scale is not always appropriate. Size does not always indicate the ability to reduce. In many situations only certain businesses are able to achieve significant reduction. Some businesses inherently discharge more phosphorus than others.

**Complete the Effluent Goal for Multiple Business Users on page 10 of the PMP Guide using the steps below.**

## Greatest Potential for Phosphorus Reduction

Use the chart at the right along with business phosphorus data recorded in Table 3: Summary of Phosphorus Sources in the *PMP Guide* to identify the business users with the greatest potential for phosphorus reduction.

When comparing the relative performance of each business, remember to account for how varying production rates and the business's specific processes affect phosphorus levels. Comparisons between similar production levels and processes are the strongest. Evaluate the potential for phosphorus reduction at a business based on the ability to achieve the least expensive and easiest reductions first.

### Prioritizing Business Users for Effluent Reduction Goals

The higher the concentration and flow of the business's effluent, the greater the potential for phosphorus reduction.

| Flow level | | |
|---|---|---|
| High | **Low concentration High flow**<br>A reduced flow may reveal hidden concentrations. | **High concentration High flow**<br>May provide best reduction opportunities. |
| Low | **Low concentration Low flow**<br>May be operating efficiently already. | **High concentration Low flow**<br>Reduce concentration to reduce loading. |

**Concentration level**

**Low** ——— **High**

**Phosphorus reduction potential**

**Rate business phosphorus reduction potential as high, medium or low in Table 3 on page 10 of the PMP Guide.**

# Appendix D: MPCA Statewide Phosphorus Removal

APPENDIX C

# Phosphorus Removal by Minnesota Municipal Wastewater Treatment Facilities

## Introduction:

This appendix presents a comparison of total phosphorus processed by Minnesota municipal wastewater treatment facilities (WWTFs) for the 2005 calendar year. Site specific differences between WWTFs, including influent characteristics, unit sizing, facility configurations and remaining hydraulic and organic treatment capacity are such that each WWTF's situation is unique and it is not possible to generalize about any individual facility's treatment capabilities. The average, minimum and maximum total phosphorus influent, effluent and percent removal reported here are intended to provide an overview of the range of performance reported by municipal wastewater treatment facilities in 2005. These comparisons may be useful for wastewater treatment facility operators seeking to benchmark the performance of their systems with respect to other similar types of WWTFs.

## Data Collection:

The following is a comparison of total phosphorus influent, effluent and percent removal performance of 284 municipal wastewater treatment facilities. Data reported here represent annual averages calculated from monthly average data reported to the Minnesota Pollution Control Agency (MPCA). Only WWTFs that reported twelve months worth of monthly average data are included in this analysis.

Percent removal data has been calculated based on reported influent and effluent concentrations. This is particularly significant for controlled discharge stabilization pond WWTFs because the volumes of water received and discharged during one calendar year can vary substantially. A load based percent removal calculation for these types of facilities would be significantly biased by any difference between influent and influent flow volumes during the calendar year.

Continuously discharging WWTFs (mechanical facilities and aerated ponds) have been listed separately from controlled discharge WWTFs (stabilization ponds). WWTFs that include phosphorus removal processes (biological and/or chemical) were listed separately from WWTFs that do not incorporate specific phosphorus treatment processes.

Facilities providing phosphorus treatment are separated into biological and chemical treatment categories. No attempt has been made to determine whether combined biological/chemical phosphorus removal is being provided although it is likely that most biological phosphorus removal systems have the capability to provide supplemental chemical treatment.

WWTF type has been established on the basis of the MPCA's records of the major secondary treatment unit (activated sludge, trickling filter, etc.) in place for each WWTF. These data were derived from an incomplete MPCA database which may have resulted in the misclassification of some types of WWTFs.

## Summary by WWTF Category:

Tables 1A through 1E report average Total Phosphorus values reported for the 2005 calendar year. These are the arithmetic mean, minimum and maximum annual average values calculated for the entire group of facilities and in each category. WWTFs are listed by continuously discharging and controlled discharge categories, both with and without phosphorus treatment. The average value represents the arithmetic mean. Unusually high or low values contained in the data set will tend to skew the arithmetic mean up or down. The minimum and maximum values show the range of the data set.

Influent concentrations for all 284 WWTFs average 5.86 mg/L. Projected to an average annual per capita influent phosphorus loading value, assuming a discharge rate of 100 gallons/capita/day, it is equivalent to 0.81 Kg/capita/year. This correlates well with the MPCA's predicted annual per captia phosphorus load of 0.8 Kg/capita/year. Any specific commercial, industrial or institutional phosphorus contribution to these WWTFs has not been take into account.

| Table 1A: All 284 WWTFs | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 5.86 mg/L | 2.23 mg/L | 61% |
| Minimum | 1.17 mg/L | 0.08 mg/L [1] | -17% |
| Maximum | 25.05 mg/L | 15.38 mg/L | 99% |

| Table 1B: 53 Continuous Discharge With Phosphorus Removal | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 6.28 mg/L | 0.75 mg/L | 88% |
| Minimum | 2.77 mg/L | 0.13 mg/L | 45% |
| Maximum | 14.99 mg/L | 7.17 mg/L | 98% |

| Table 1C: 12 Controlled Discharge With Phosphorus Removal | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 5.18 mg/L | 0.68 mg/L | 85 % |
| Minimum | 1.23 mg/L | 0.08 mg/L [1] | 71% |
| Maximum | 10.88 mg/L | 1.75 mg/L | 99% |

| Table 1D: 99 Continuous Discharge Without Phosphorus Removal | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 6.36 mg/L | 3.68 mg/L | 42% |
| Minimum | 2.63 mg/L | 0.95 mg/L | 0% |
| Maximum | 25.05 mg/L | 15.38 mg/L | 77% |

| Table 1E: 120 Controlled Discharge Without Phosphorus Removal | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 5.34 mg/L | 1.84 mg/L | 63% |
| Minimum | 1.17 mg/L | 0.17 mg/L | -17% |
| Maximum | 14.31 mg/L | 5.93 mg/L | 96% |

[1] The minimum value of 0.08 mg/L is well below the minimum expected range of effluent concentrations.

## Summary by WWTF Type:

The following figures and tables report average, minimum and maximum influent and effluent concentrations and percent removal by WWTF type. All continuously discharging WWTFs with phosphorus removal have been listed as either biological or chemical phosphorus removal facilities regardless of any other type of treatment provided. All controlled discharge WWTFs with phosphorus removal provide chemical treatment.

Continuously discharging WWTFs without phosphorus treatment have been separated based on the major secondary treatment technology in use at the facility. Trickling filter facilities that also operate rotating biological contactors (RBCs) or activated sludge units have been listed separately.

A few general observations:

For all WWTF types higher influent concentrations seem to be associated with higher effluent concentrations and lower removal efficiencies. Although the degree to which this occurs varies by facility type, the trend highlights the value of source reduction work.

Of the 65 WWTFs that provide phosphorus removal, only 6 of the chemical removal facilities reported annual average effluent values below 0.3 mg/L. This is significant because 0.3 mg/L is currently the lowest phosphorus effluent limitation currently in effect in the state (Ely and Bemidji WWTFs).

Controlled discharge stabilization ponds have excellent phosphorus removal capabilities. 19% of the stabilization ponds without phosphorus treatment had annual average effluent concentrations of less than 1 mg/L and 62% had effluent concentrations of less than 2 mg/L.

Of the various activated sludge configurations, extended air facilities showed relatively high and stable removal efficiencies throughout a range of influent concentrations. Percent removal averaged 53% and ranged from 44% to 62%.

The various configurations of trickling filter facilities showed the lowest removal efficiencies of all types of WWTFs reviewed. It is interesting to note that the group of trickling filter/RBC facilities combined the lowest removal efficiencies (averaging 28%) with some of the highest influent concentrations (averaging 8.58 mg/L). As a group these facilities produced some of the worst effluent quality averaging 6.10 mg/L total phosphorus.

Figure 1A:

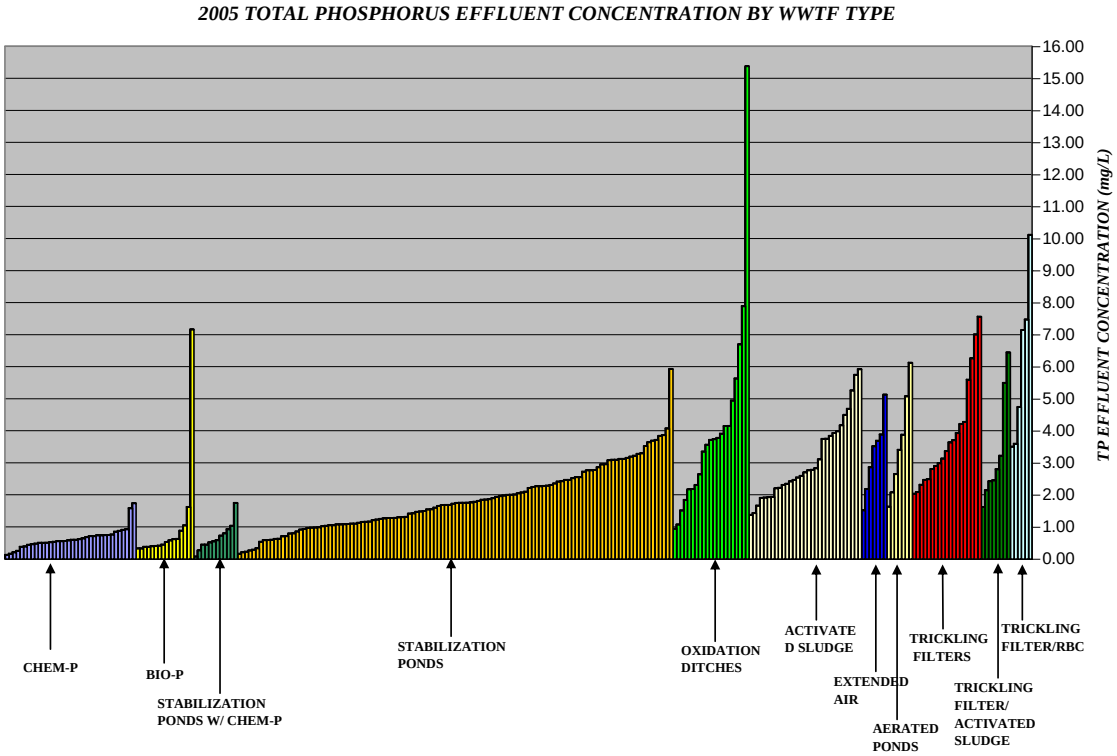



Figure 1B:

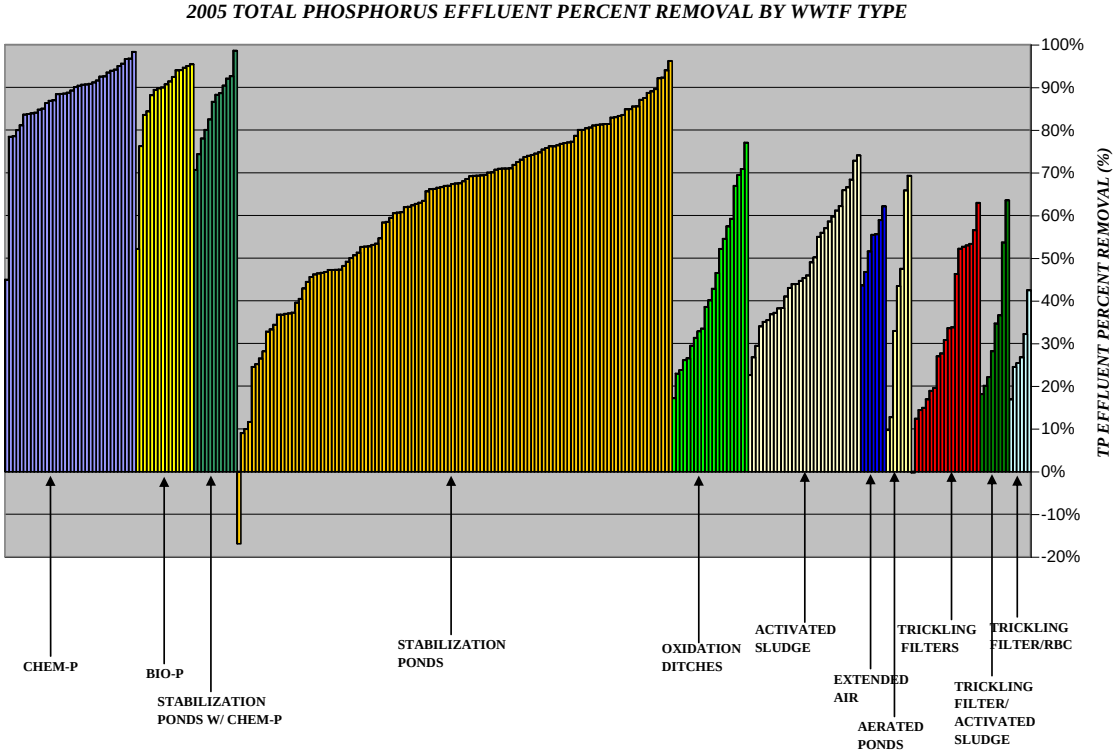


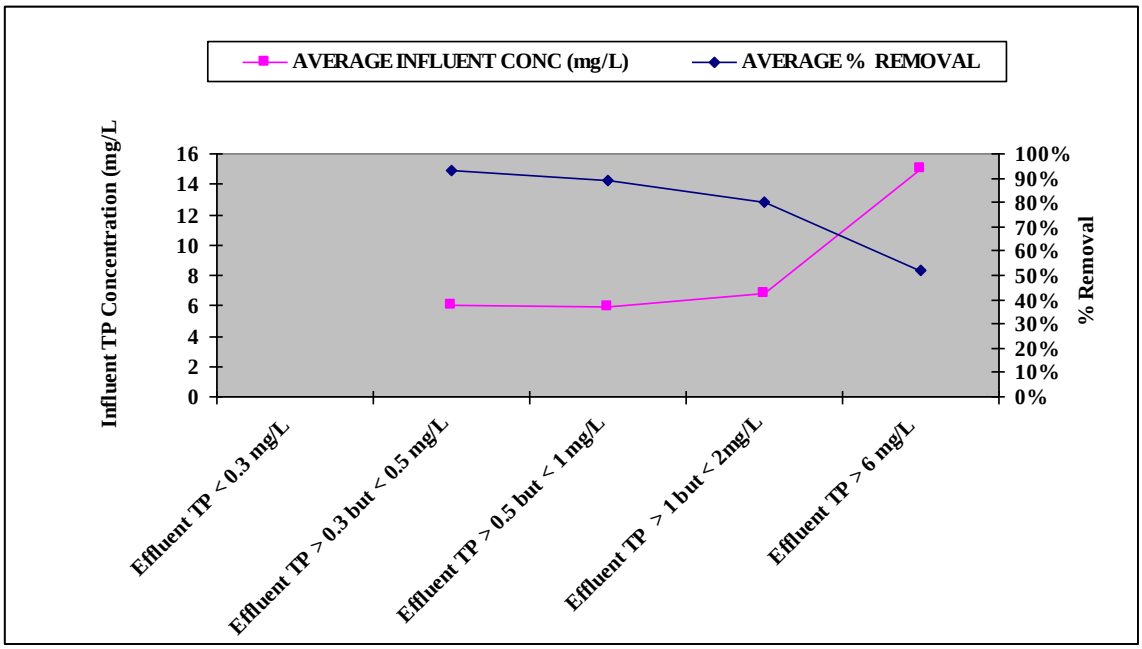
Table 2A: CONTINUOUS DISCHARGE BIOLOGICAL PHOSPHORUS REMOVAL

| | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 6.66 mg/L | 1.01 mg/L | 88% |
| Minimum | 3.22 mg/L | 0.33 mg/L | 52% |
| Maximum | 14.99 mg/L | 7.17mg/L | 95% |

Table 2B: CONTINUOUS DISCHARGE BIOLOGICAL PHOSPHORUS REMOVAL

| | NUMBER OF WWTPs | % OF TOTAL | AVERAGE INFLUENT CONC. (mg/L) | AVERAGE % REMOVAL |
|---|---|---|---|---|
| Effluent TP < 0.3 mg/L | 0 | 0% | | |
| Effluent TP 0.3 to 0.5 mg/L | 8 | 50% | 6.06 | 93% |
| Effluent TP 0.5 to 1.0 mg/L | 5 | 31% | 5.89 | 89% |
| Effluent TP 1.0 to 2.0 mg/L | 2 | 13% | 6.79 | 80% |
| Effluent TP > 6 mg/L | 1 | 6% | 14.99 | 52% |
| Total | 16 | | | |
| Average | | | 6.66 | 88% |

Figure 2: CONTINUOUS DISCHARGE BIOLOGICAL PHOSPHORUS REMOVAL




Observations:

- All Bio-P WWTFs exceeded 0.3 mg/L effluent TP annual average.
- 50% report effluent TP annual averages of less than 0.5 mg/L.
- 81% report effluent TP annual averages of less than 1.0 mg/L.
- Percent removal range from 52% to 95%.
- The facility reporting an annual average total phosphorus concentration of 7.17 mg/L has experienced significant operational difficulties in 2005.

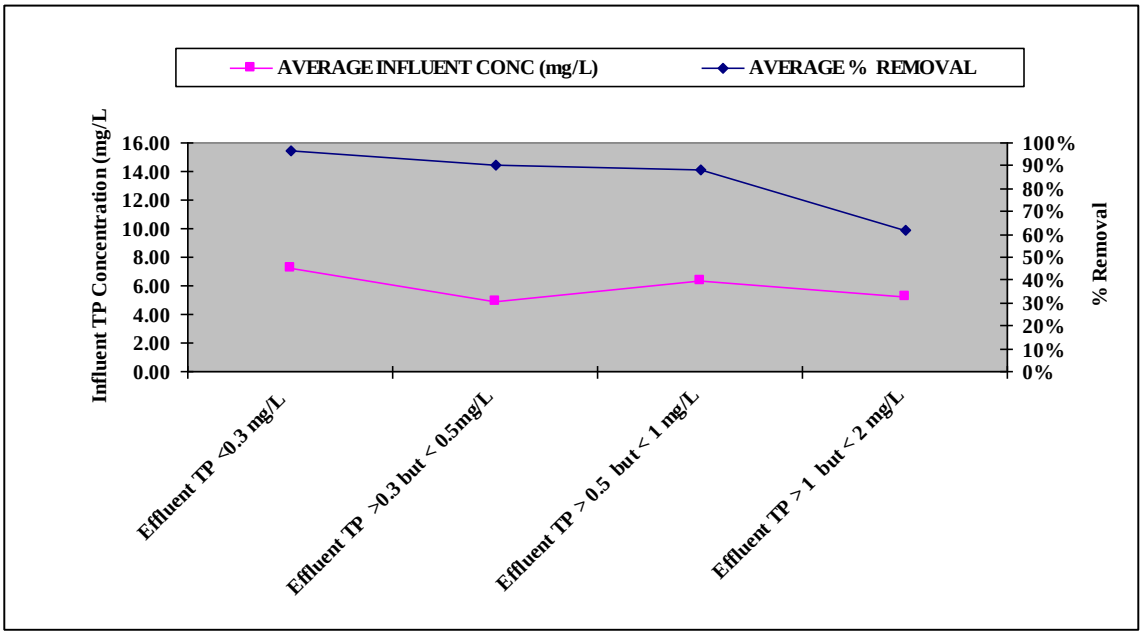
Table 3A: CONTINUOUS DISCHARGE CHEMICAL PHOSPHORUS REMOVAL

| | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 6.12 mg/L | 0.63 mg/L | 88% |
| Minimum | 2.77 mg/L | 0.13 mg/L | 45% |
| Maximum | 12.85 mg/L | 1.75 mg/L | 98% |

Table 3B: CONTINUOUS DISCHARGE CHEMICAL PHOSPHORUS REMOVAL

| | NO. OF WWTPs | % OF TOTAL | AVERAGE INFLUENT CONC. (mg/L) | AVERAGE PERCENT REMOVAL |
|---|---|---|---|---|
| Effluent TP < 0.3 mg/L | 4 | 11% | 7.19 | 97% |
| Effluent TP 0.3 to 0.5 mg/L | 6 | 16% | 4.88 | 90% |
| Effluent TP 0.5 to 1.0 mg/L | 25 | 68% | 6.31 | 88% |
| Effluent TP 1.0 mg/L to 2.0 mg/L | 2 | 5% | 5.27 | 62% |
| Total | 37 | | | |
| Average | | | 6.12 | 88% |

Figure 3: CONTINUOUS DISCHARGE CHEMICAL PHOSPHORUS REMOVAL




Observations:

- ⊕ 11% report effluent TP annual averages of less than 0.3 mg/L.
- ⊕ 27% report effluent TP annual averages of less than 0.5 mg/L.
- ⊕ 95% report effluent TP annual averages of less than 1.0 mg/L.
- ⊕ Percent removal range from 45% to 98%.
- ⊕ Very low effluent concentrations can be achieved through chemical addition.

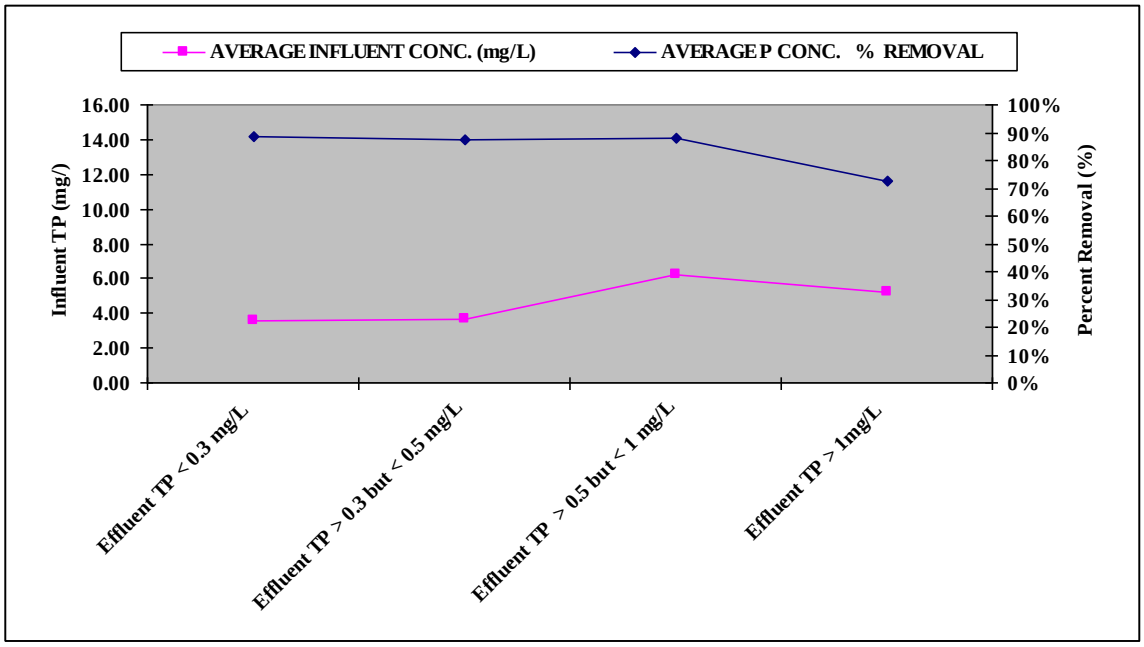
Table 4A: CONTROLLED DISCHARGE CHEMICAL PHOSPHORUS REMOVAL

| | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 5.18 mg/L | 0.68 mg/L | 85% |
| Minimum | 1.23 mg/L | 0.08 mg/L | 71% |
| Maximum | 10.88 mg/L | 1.75 mg/L | 99% |

Table 4B: CONTROLLED DISCHARGE CHEMICAL PHOSPHORUS REMOVAL

| | NO. OF WWTPs | % OF TOTAL | AVERAGE INFLUENT CONC. (mg/L) | AVERAGE P CONC. % REMOVAL |
|---|---|---|---|---|
| Effluent TP < 0.3 mg/L | 2 | 17% | 3.54 | 88% |
| Effluent TP 0.3 to 0.5 mg/L | 2 | 17% | 3.67 | 88% |
| Effluent TP 0.5 to 1.0 mg/L | 6 | 50% | 6.22 | 88% |
| Effluent TP > 1.0 mg/L | 2 | 17% | 5.19 | 72% |
| Total | 12 | | | |
| Average | | | 5.18 | 85% |

Figure 4: CONTROLLED DISCHARGE CHEMICAL PHOSPHORUS REMOVAL




Observations:

- ⊕ 17% report effluent TP annual averages of less than 0.3 mg/L.
- ⊕ 34% report effluent TP annual averages of less than 0.5 mg/L.
- ⊕ 84% report effluent TP annual averages of less than 1.0 mg/L.
- ⊕ Percent removal range from 45% to 98%.
- ⊕ The combination of relatively low influent concentrations, long detention times and chemical addition can achieve extremely good phosphorus removal.

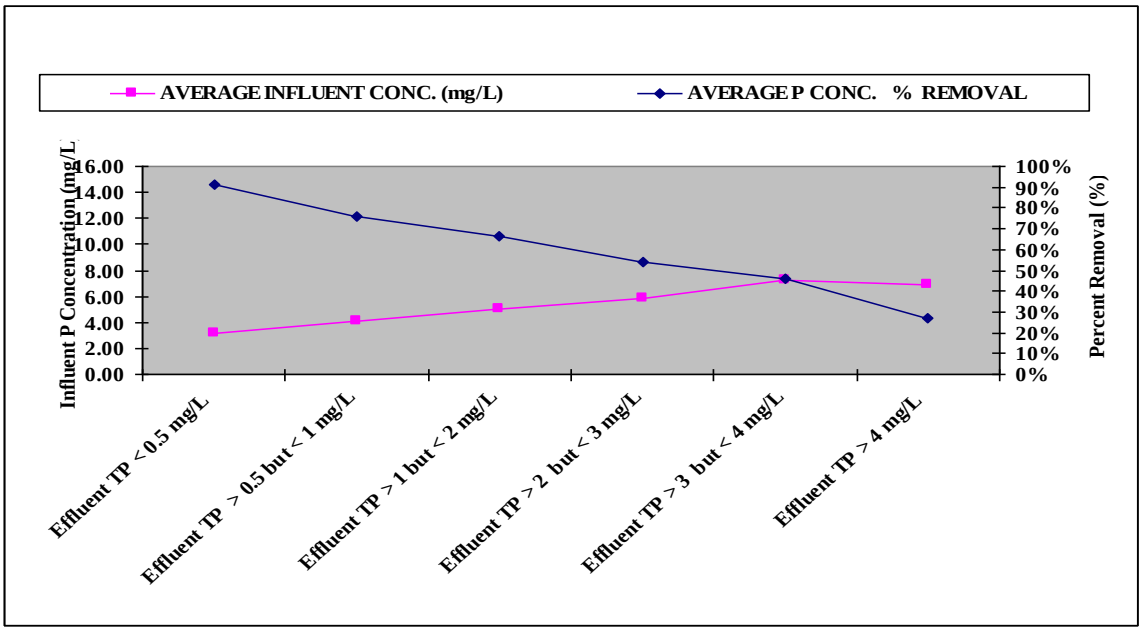
Table 5A: CONTROLLED DISCHARGE NO PHOSPHORUS TREATMENT

| | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 5.34 mg/L | 1.84 mg/L | 63% |
| Minimum | 1.17 mg/L | 0.17 mg/L | -17% |
| Maximum | 14.31 mg/L | 5.93 mg/L | 96% |

Table 5B: CONTROLLED DISCHARGE NO PHOSPHORUS TREATMENT

| | NUMBER OF WWTPs | % OF TOTAL | AVERAGE INFLUENT CONC. (mg/L) | AVERAGE P CONC. % REMOVAL |
|---|---|---|---|---|
| Effluent TP < 0.5 mg/L | 6 | 5% | 3.18 | 91% |
| Effluent TP 0.5 to 1.0 mg/L | 17 | 14% | 4.08 | 76% |
| Effluent TP 1.0 to 2.0 mg/L | 51 | 43% | 5.05 | 66% |
| Effluent TP 2.0 to 3.0 mg/L | 28 | 23% | 5.87 | 54% |
| Effluent TP 3.0 to 4.0 mg/L | 16 | 13% | 7.27 | 46% |
| Effluent TP > 4.0 mg/L | 2 | 2% | 6.93 | 27% |
| Total | 120 | | | |
| Average | | | 5.34 | 62.62% |

Figure 5: CONTROLLED DISCHARGE NO PHOSPHORUS TREATMENT




Observations:

- ⊕ 5% report effluent TP annual averages of less than 0.5 mg/L.
- ⊕ 19% report effluent TP annual averages of less than 1.0 mg/L.
- ⊕ 62% report effluent TP annual averages of less than 2.0 mg/L.
- ⊕ Percent removal range from -17% to 96%.
- ⊕ Overall stabilization ponds provide excellent treatment TP treatment.
- ⊕ The facility reporting an annual average -17% removal rate experienced construction related operational problems in 2005.

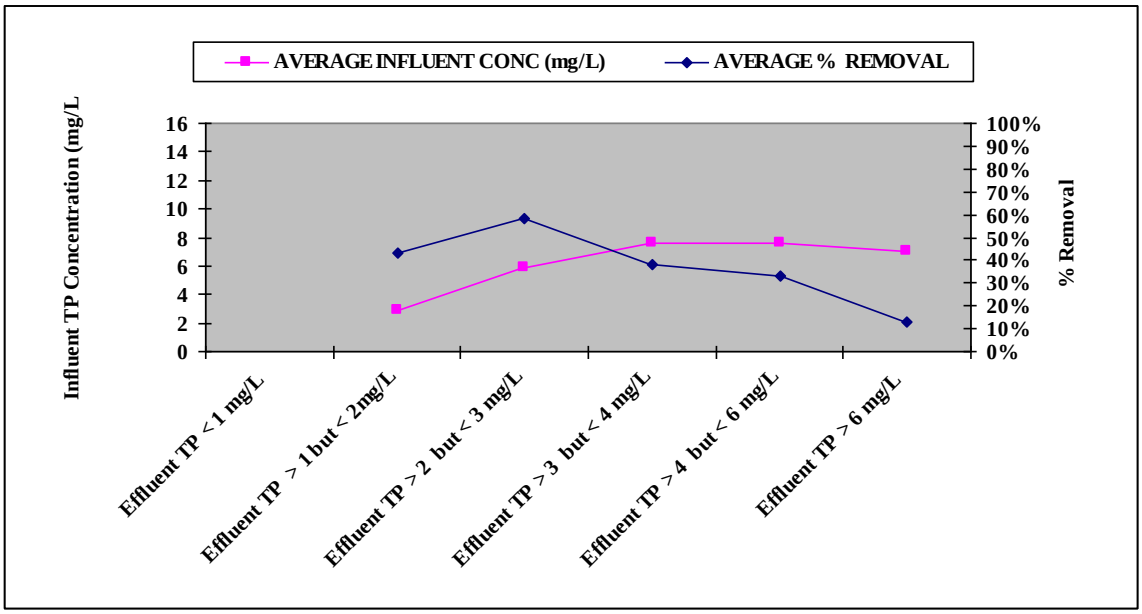
Table 6A: AERATED PONDS

| | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 6.35 mg/L | 3.55 mg/L | 40% |
| Minimum | 2.90 mg/L | 1.64 mg/L | 10% |
| Maximum | 11.37 mg/L | 6.13 mg/L | 69% |

Table 6A: AERATED PONDS

| | NO. OF WWTPs | % OF TOTAL | AVERAGE INFLUENT CONC. (mg/L) | AVERAGE PERCENT REMOVAL |
|---|---|---|---|---|
| Effluent TP < 1 mg/L | 0 | 0% | | |
| Effluent TP 1.0 to 2.0 mg/L | 1 | 14% | 2.90 | 43% |
| Effluent TP 2.0 to 3.0 mg/L | 2 | 29% | 5.92 | 58% |
| Effluent TP 3.0 to 4.0 mg/L | 2 | 29% | 7.58 | 38% |
| Effluent TP 4.0 to 6.0 mg/L | 1 | 14% | 7.58 | 33% |
| Effluent TP > 6.0 mg/L | 1 | 14% | 7.02 | 13% |
| Total | 7 | | | |
| Average | | | 6.36 | 40% |

Figure 6: AERATED PONDS




Observations:

- All exceeded effluent TP annual averages of 1.0 mg/L.
- 14% report effluent TP annual averages of less than 2.0 mg/L.
- 43% report effluent TP annual averages of less than 3.0 mg/L.
- 72% report effluent TP annual averages of less than 4.0 mg/L.
- Percent removal range from 10% to 69%.

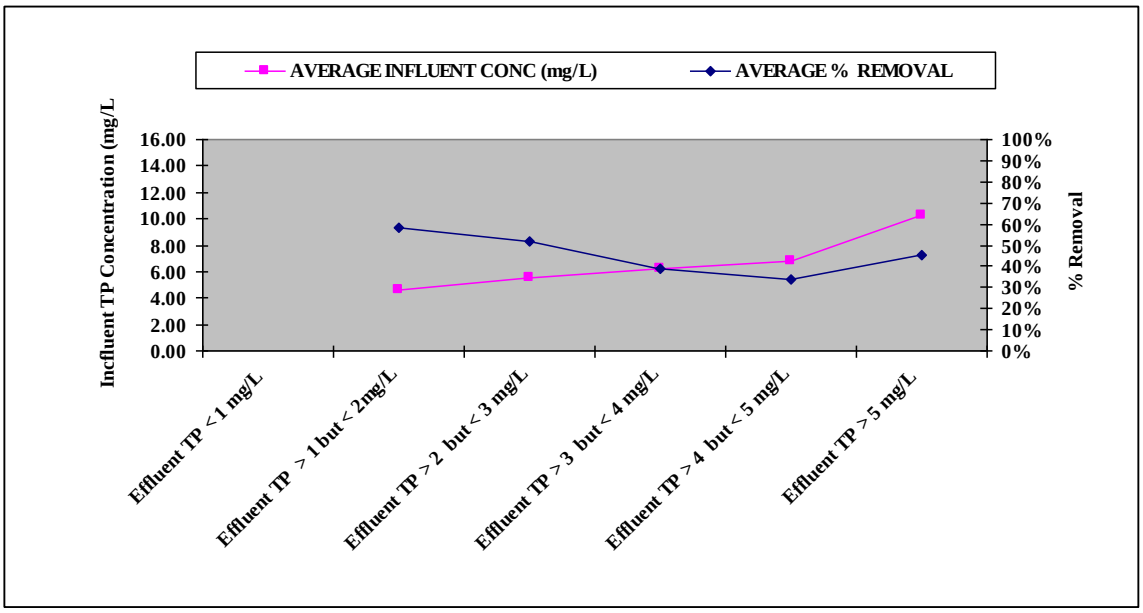
Table 7A: ACTIVATED SLUDGE

| | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 5.99 mg/L | 3.07 mg/L | 48% |
| Minimum | 2.63 mg/L | 1.38 mg/L | 23% |
| Maximum | 10.53 mg/L | 5.93mg/L | 74% |

Table 7B: ACTIVATED SLUDGE

| | NO. OF WWTPs | % OF TOTAL | AVERAGE INFLUENT CONC. (mg/L) | AVERAGE PERCENT REMOVAL |
|---|---|---|---|---|
| Effluent TP < 1 mg/L | 0 | 0% | | |
| Effluent TP 1.0 to 2.0 mg/L | 7 | 23% | 4.55 | 58% |
| Effluent TP 2.0 to 3.0 mg/L | 12 | 39% | 5.48 | 52% |
| Effluent TP 3.0 to 4.0 mg/L | 6 | 19% | 6.18 | 39% |
| Effluent TP 4.0 to 5.0 mg/L | 3 | 10% | 6.75 | 34% |
| Effluent TP > 5.0 mg/L | 3 | 10% | 10.30 | 45% |
| Total | 31 | | | |
| Average | | | 5.99 | 48% |

Figure 7: ACTIVATED SLUDGE




Observations:

- All exceeded effluent TP annual averages of 1.0 mg/L.
- 23% report effluent TP annual averages of less than 2.0 mg/L.
- 62% report effluent TP annual averages of less than 3.0 mg/L.
- 81% report effluent TP annual averages of less than 4.0 mg/L.
- Percent removal range from 23% to 74%.

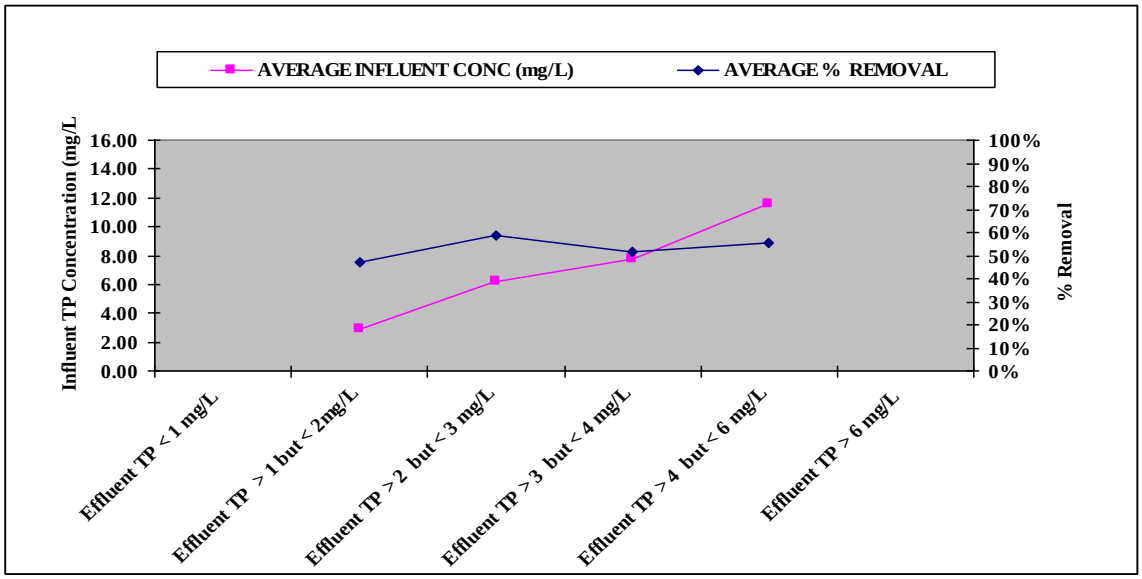
Table 8A: EXTENDED AIR

| | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 7.18 mg/L | 3.26 mg/L | 53 % |
| Minimum | 2.86 mg/L | 1.52 mg/L | 44% |
| Maximum | 11.57 mg/L | 5.13 mg/L | 62 % |

Table 8B: EXTENDED AIR

| | NO. OF WWTPs | % OF TOTAL | AVERAGE INFLUENT CONC. (mg/L) | AVERAGE PERCENT REMOVAL |
|---|---|---|---|---|
| Effluent TP < 1 mg/L | 0 | | | |
| Effluent TP 1.0 to 2.0 mg/L | 1 | 14% | 2.86 | 47% |
| Effluent TP 2.0 to 3.0 mg/L | 2 | 29% | 6.24 | 59% |
| Effluent TP 3.0 to 4.0 mg/L | 3 | 43% | 7.78 | 51% |
| Effluent TP 4.0 to 6.0 mg/L | 1 | 14% | 11.57 | 56% |
| Effluent TP > 6.0 mg/L | 0 | | | |
| Total | 7 | | | |
| Average | | | 7.18 | 53% |

Figure 8: EXTENDED AIR




Observations:

- All exceeded effluent TP annual averages of 1.0 mg/L.
- 14% report effluent TP annual averages of less than 2.0 mg/L.
- 43% report effluent TP annual averages of less than 3.0 mg/L.
- 86% report effluent TP annual averages of less than 4.0 mg/L.
- Percent removal range from 44% to 62%.
- Robust TP removal throughout range of influent concentrations.

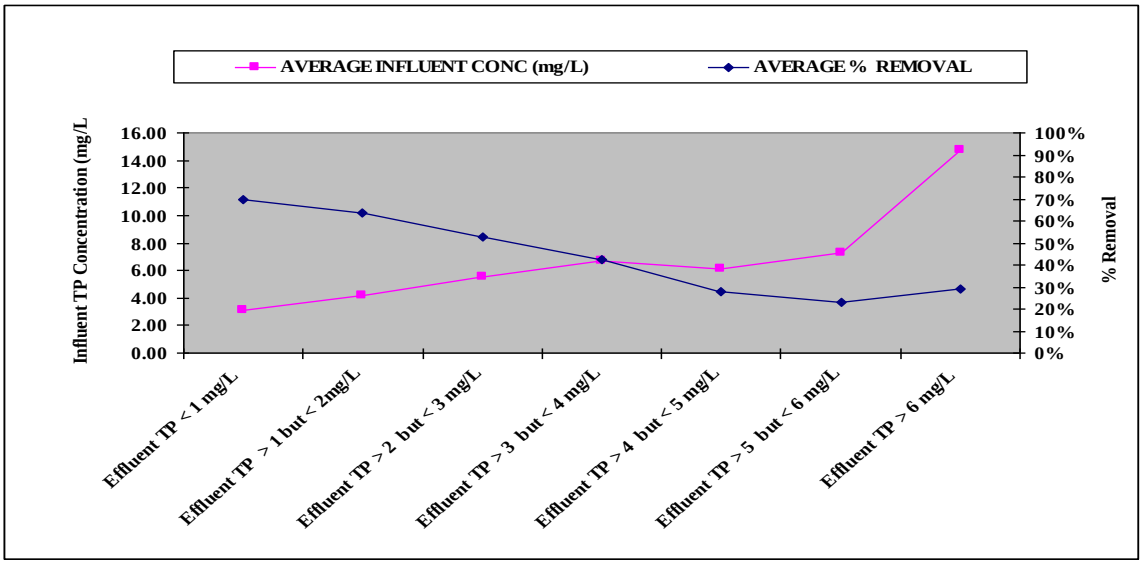
Table 9A: OXIDATION DITCHES

| | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 7.03 mg/L | 4.08 mg/L | 44% |
| Minimum | 3.11 mg/L | 0.95 mg/L | 17% |
| Maximum | 25.05 mg/L | 15.38 mg/L | 77% |

Table 9B: OXIDATION DITCHES

| | NO. OF WWTPs | % OF TOTAL | AVERAGE INFLUENT CONC. (mg/L) | AVERAGE PERCENT REMOVAL |
|---|---|---|---|---|
| Effluent TP < 1 mg/L | 1 | 5% | 3.11 | 69% |
| Effluent TP 1.0 to 2.0 mg/L | 3 | 14% | 4.16 | 64% |
| Effluent TP 2.0 to 3.0 mg/L | 4 | 19% | 5.49 | 53% |
| Effluent TP 3.0 to 4.0 mg/L | 6 | 29% | 6.66 | 42% |
| Effluent TP 4.0 to 5.0 mg/L | 3 | 14% | 6.12 | 28% |
| Effluent TP 5.0 to 6.0 mg/L | 1 | 5% | 7.31 | 23% |
| Effluent TP > 6.0 mg/L | 3 | 14% | 14.78 | 29% |
| Total | 21 | | | |
| Average | | | 7.03 | 44% |

Figure 9: OXIDATION DITCHES




Observations:

- ⊕ 5% report effluent TP annual averages of less than 1.0 mg/L.
- ⊕ 19% report effluent TP annual averages of less than 2.0 mg/L.
- ⊕ 38% report effluent TP annual averages of less than 3.0 mg/L.
- ⊕ 67% report effluent TP annual averages of less than 3.0 mg/L.
- ⊕ Percent removal range from 17% to 77%.

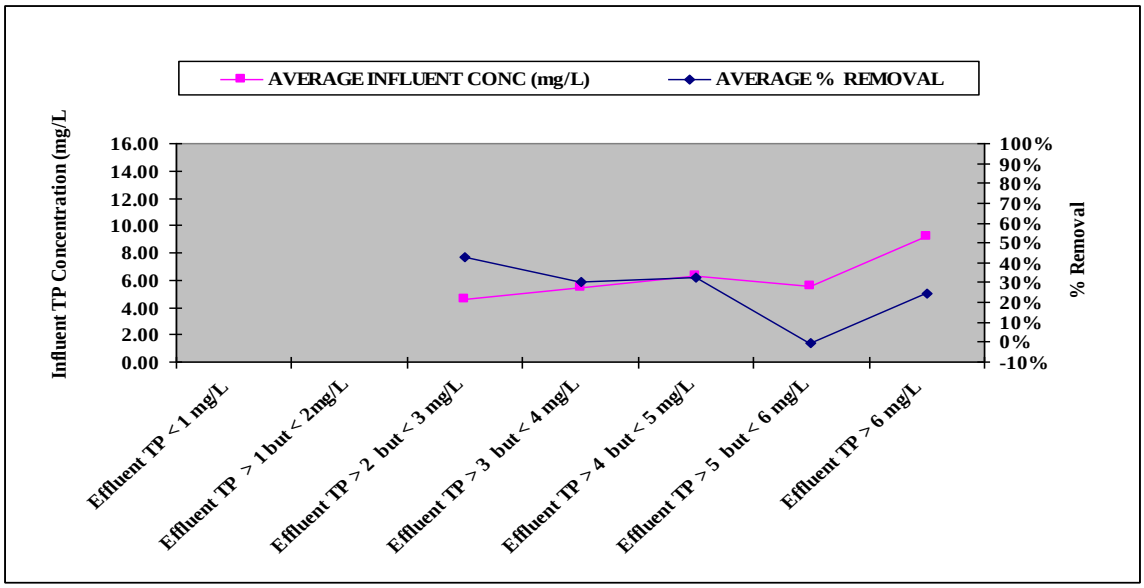
Table 10A: TRICKLING FILTERS

| | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 5.78 mg/L | 3.83 mg/L | 33% |
| Minimum | 3.30 mg/L | 2.04 mg/L | 0% |
| Maximum | 10.58 mg/L | 7.56 mg/L | 63% |

Table 10B: TRICKLING FILTERS

| | NO. OF WWTPs | % OF TOTAL | AVERAGE INFLUENT CONC. (mg/L) | AVERAGE PERCENT REMOVAL |
|---|---|---|---|---|
| Effluent TP < 1 mg/L | 0 | | | |
| Effluent TP 1.0 to 2.0 mg/L | 0 | | | |
| Effluent TP 2.0 to 3.0 mg/L | 8 | 42% | 4.61 | 43% |
| Effluent TP 3.0 to 4.0 mg/L | 5 | 26% | 5.47 | 30% |
| Effluent TP 4.0 to 5.0 mg/L | 2 | 11% | 6.28 | 32% |
| Effluent TP 5.0 to 6.0 mg/L | 1 | 5% | 5.58 | 0% |
| Effluent TP > 6 mg/L | 3 | 16% | 9.16 | 33% |
| Total | 19 | | | |
| Average | | | 5.78 | 33% |

Figure 10: TRICKLING FILTERS




Observations:

- All exceeded effluent TP annual averages of 2.0 mg/L.
- 42% report effluent TP annual averages of less than 3.0 mg/L.
- 68% report effluent TP annual averages of less than 4.0 mg/L.
- Percent removal range from 0% to 63%.
- Extreme variability in removal efficiency

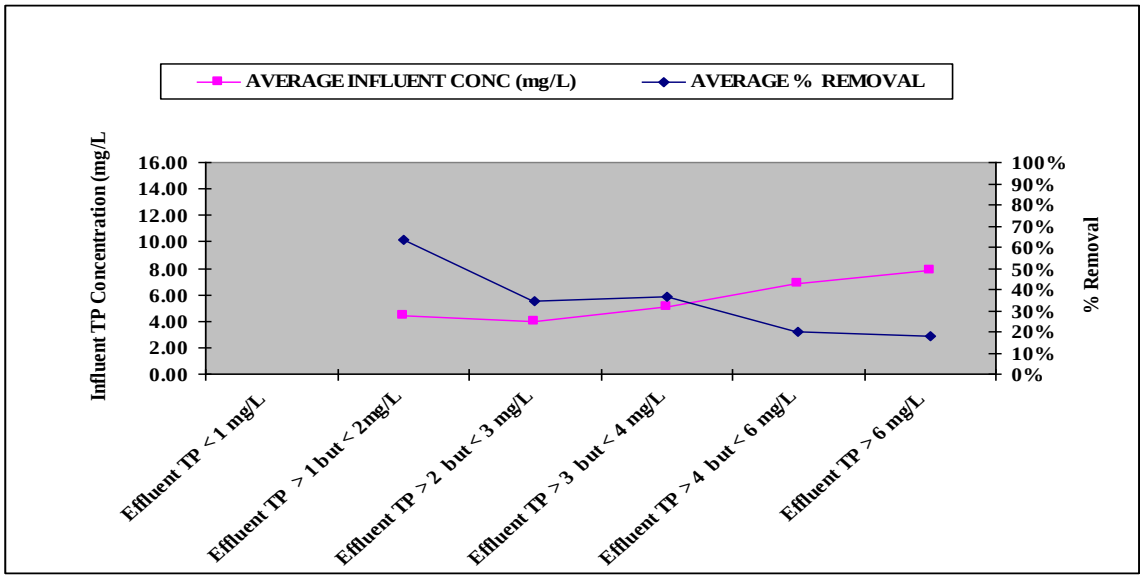
Table 11A: TRICKLING FILTER/ACTIVATED SLUDGE

| | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 5.00 mg/L | 3.33 mg/L | 35% |
| Minimum | 2.99 mg/L | 1.62 mg/L | 18% |
| Maximum | 7.88 mg/L | 6.45 mg/L | 64% |

Table 11B: TRICKLING FILTER/ACTIVATED SLUDGE

| | NO. OF WWTPs | % OF TOTAL | AVERAGE INFLUENT CONC. (mg/L) | AVERAGE PERCENT REMOVAL |
|---|---|---|---|---|
| Effluent TP < 1 mg/L | 0 | | | |
| Effluent TP 1.0 to 2.0 mg/L | 1 | 13% | 4.45 | 64% |
| Effluent TP 2.0 to 3.0 mg/L | 4 | 50% | 3.92 | 35% |
| Effluent TP 3.0 to 4.0 mg/L | 1 | 13% | 5.09 | 37% |
| Effluent TP 4.0 to 6.0 mg/L | 1 | 13% | 6.88 | 20% |
| Effluent TP > 6.0 mg/L | 1 | 13% | 7.88 | 18% |
| Total | 8 | | | |
| Average | | | 5.00 | 35% |

Figure 11: TRICKLING FILTER/ACTIVATED SLUDGE




Observations:

- All exceeded effluent TP annual averages of 1.0 mg/L.
- 13% report effluent TP annual averages of less than 2.0 mg/L.
- 63% report effluent TP annual averages of less than 3.0 mg/L.
- 76% report effluent TP annual averages of less than 4.0 mg/L.
- Percent removal range from 18% to 64%.
- Extreme variability in removal efficiency.

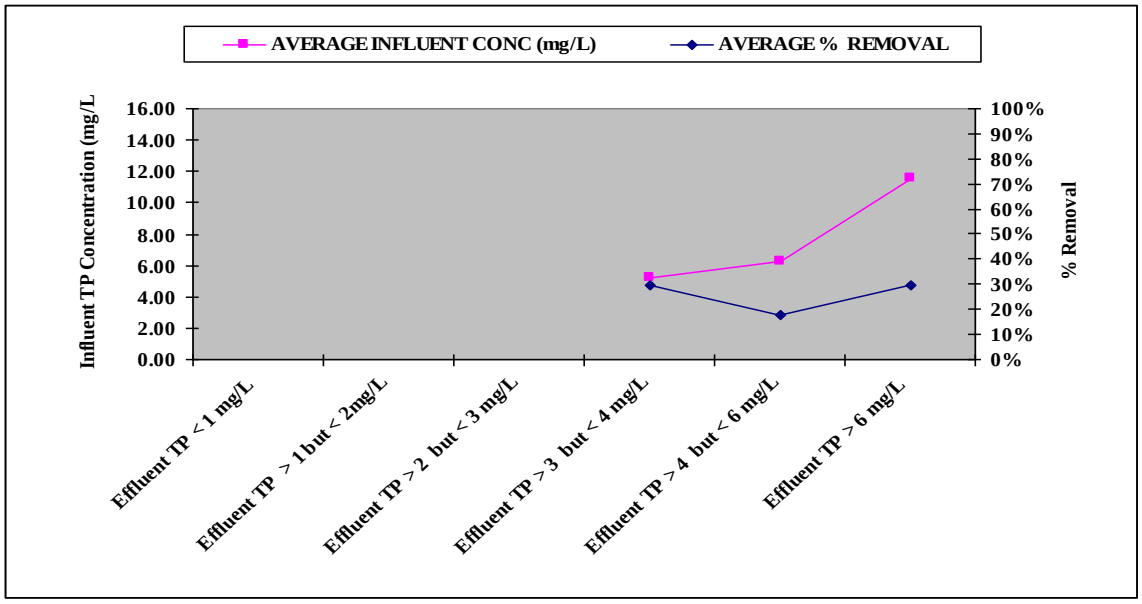
Table 12A: TRICKLING FILTER/RBC

| | Influent Concentration | Effluent Concentration | Percent Removal |
|---|---|---|---|
| Average | 8.58 mg/L | 6.10 mg/L | 28% |
| Minimum | 4.23 mg/L | 3.51 mg/L | 17% |
| Maximum | 14.93 mg/L | 10.12 mg/L | 43% |

Table 12B: TRICKLING FILTER/RBC

| | NO. OF WWTPs | % OF TOTAL | AVERAGE INFLUENT CONC. (mg/L) | AVERAGE PERCENT REMOVAL |
|---|---|---|---|---|
| Effluent TP < 1 mg/L | 0 | | | |
| Effluent TP 1.0 to 2.0 mg/L | 0 | | | |
| Effluent TP 2.0 to 3.0 mg/L | 0 | | | |
| Effluent TP 3.0 to 4.0 mg/L | 2 | 33% | 5.24 | 30% |
| Effluent TP 4.0 to 6.0 mg/L | 1 | 17% | 6.28 | 18% |
| Effluent TP > 6 mg/L | 3 | 50% | 11.57 | 30% |
| Total | 6 | | | |
| Average | | | 8.58 | 28% |

Figure 12: TRICKLING FILTER/RBC




Observations:

- All exceeded effluent TP annual averages of 3.0 mg/L.
- Only 33% report effluent TP annual averages of less than 4.0 mg/L.
- Influent concentrations tend to be higher than other WWTF categories.
- Percent removal range from 17% to 43%.
- Lowest removal efficiencies of all facility types reviewed.